Feed the Future Innovation Lab for Food Security Policy

Research Paper 99 May 2018

FTF Tanzania – ASPIRES Project

The Challenge of Substituting Sunflower Oil for Imported Palm Oil: Evidence from Tanzania

By

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Food Security Policy *Research Papers*

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Authors' Acknowledgments

We thank Rahul Dhar for his research assistance. The authors acknowledge financial assistance from the Food Security Policy Innovation Lab's Agriculture Sector Policy and Institutional Reforms Strengthening (ASPIRES) Project in Tanzania. We also thank Patricia Johannes for formatting assistance.

This study is made possible by the generous support of the American people through the United States Agency for International Development (USAID) under the Feed the Future initiative. The contents are the responsibility of the study authors and do not necessarily reflect the views of USAID or the United States Government

Published by the Department of Agricultural, Food, and Resource Economics, Michigan State University, Justin S. Morrill Hall of Agriculture, 446 West Circle Dr., Room 202, East Lansing, Michigan 48824, USA

ABSTRACT

Edible oil imports to Africa grew over 10% per year from 2006 to 2015, and accounted for 34% of the continent's total growth in food imports over this period—the highest share of any food group. In the same period, several African countries experienced a boom in the local production and processing of oil-seeds. The combination of import growth and domestic production booms reveals a gap in the literature on the characteristics of edible oil demand in Africa. We begin to fill this gap by estimating own-price, cross-price, and expenditure elasticities of demand for palm, sunflower, and other edible oils in Tanzania. We apply a QUAIDS model to detailed household level data - focusing on palm and sunflower oil, because for the most part, palm oil is imported and sunflower is domestically produced. Our main finding is a surprisingly low level of substitution between the domestic and imported edible oils. Simulated budget shares from our estimates suggest that a 10% tariff increase on palm oil leads to less than a 0.06% change in the budget share of domestically produced sunflower oil. We identify other potential policy implications from our findings and highlight steps for further research.

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ACRONYMS

AIDS	Almost Ideal Demand System model
CET	Common External Tariff
COICOP	Classification of Individual Consumption by Purpose (UN Statistics Division).
CPO	Crude palm oil
EAC	East Africa Community
GoT	Government of Tanzania
HBS	Household Budget Survey
HH	Households
OLS	Ordinary Least Squares
QUAIDS	Quadratic Almost Ideal Demand System model
SUR	Seemingly Unrelated Regression
VAT	Value-Added Tax

1. INTRODUCTION

Income growth and rapid urbanization are driving deep changes in African agrifood systems. These changes are occurring throughout the system, from input and service supply to farmers, through on-farm production, into the transport, wholesaling, packaging, branding, and retailing in the vast and rapidly growing midstream of these systems, and on to consumers and what they eat and how they obtain it. The demand side changes amount to a diet transformation in which food is becoming more purchased, more perishable, more processed, and more prepared for consumption outside the home (Tschirley et al. 2015a; Reardon et al. 2013). While more pronounced in urban areas, these changes are occurring also in rural areas, where for example the share of food that is purchased hovers around 50% in East and Southern Africa (Tschirley et al. 2015a).

The rapid rise in demand for food through markets, compounded by the increase in value added due to perishability and processing and preparation, creates huge opportunities for local agribusiness, on the order of 6% to 7% per year overall for processed and prepared foods, and far higher in particular product categories (Tschirley et al., 2015a; Tschirley et al. 2015b).[1] To capture these opportunities, however, local agribusiness must produce at sufficient scale and at sufficiently competitive prices, qualities and timeliness to satisfy this demand.

Doing so is crucial, because we know that food imports are rising rapidly in Africa. Annual overall growth in food imports for the continent were 3.4% from 1999 to 2013, faster than the rate of population growth. Optimism about agribusiness opportunities on the continent (e.g., Reardon et al. 2013; Byerlee and Haggblade 2013; Tschirley et al. 2015b) and concern about its ability to feed itself in an increasingly globalized economy (e.g., Dorosh and Babu 2017; Zerbe 2004; Devereux et al. 2001; Maxwell 1999) are simultaneously widespread.

Edible oils encapsulate both the optimism and concern. Demand for these oils is rising rapidly on the continent, at about 2% per capita per year from 1999 to 2013 (per UN COMTRADE), and they can be produced from a wide range of crops, many of which are grown in Africa. The agribusiness potential is thus clear. Yet at the same time edible oil imports have been increasing at about 10% per year, and accounted for 34% of the growth in food imports in Africa from 1999 to 2013, the highest share of any food category.[2]

We also know that palm oil accounts for about 65% of all edible oil imports to the continent. Nearly all these imports come from two countries, Malaysia and Indonesia (45% and 37% respectively, per UN COMTRADE data). Competing with these two massive producers of low-cost palm oil is a tall order for local firms depending on domestic raw material supplies, often primarily from large numbers of dispersed smallholder farmers, in under-developed supply chains.

Understanding whether and how African farmers and entrepreneurs might capture a meaningful share of this growing demand requires, among other things, a much better understanding of consumer demand, broadly for edible oils, and for the various types of oils that make-up the *edible oil* market. Almost no work has been done on this topic in Africa, indicating a major gap in the literature.[3]

[1] Expenditure elasticities for these types of products range from 1.1 to 1.3: [(1.02*1.03)-1]*1.03=1.066, or roughly 7% growth.

[2] Sugars and sweets were second, accounting for 30% of import growth, while cereals other than wheat and rice accounted for 26%. No other commodity group accounted for more than 6%. All calculations from COMTRADE data.

[3] The only literature we find on edible oil consumption in Africa relates to the nutrition transition (various by Popkin), and none of this provides analysis of edible oil demand *per se*.

Tanzania provides an ideal setting for exploring this issue, for three reasons. First, it looks much like the rest of Africa in terms of the rapid growth in edible oil consumption and imports and the domination of imports by palm oil from Malaysia and Indonesia: per capita consumption grew 2% per year from 1995 to 2013, edible oil imports were 25% of all food imports during that time, and palm oil accounted for 98% of all edible oil imports. Second, the country stands out for its dramatic rise in local production and processing of sunflower oil; since 2000, sunflower production has increased as much as 10 times, placing the country second in Africa after South Africa (Food and Agriculture Organisation of the United Nations 2018). As this has happened, local sunflower oil has become widely available in rural and urban markets. Finally, Tanzania's Household Budget Survey (HBS) provides a large, nationally representative data set that includes expenditure on several types of vegetable oils, along with over 200 other food items—far more than most other expenditure data sets offer, which allows the reliable estimation of income, own-price, and cross-price elasticities of demand for various oils and other food groups.

We ask the following questions: 1. Can tariffs on imported edible oils be used to stimulate demand for homegrown oil varieties? To address this question, we first descriptively characterize household oil consumption, then we estimate cross-price elasticities of demand between the types of oils; 2. How is demand for edible oil linked to income growth? Answering this question can inform policy makers' expectations about how demand will evolve as incomes grow; and 3. Is urbanization driving the demand for edible oils? Between 1990 and 2015, Tanzania's urban population share grew from 19% to 32%, placing it among the top ten most rapidly urbanizing countries on the continent (United Nations 2014). Given this, policy makers should like to know how Tanzania's rapid urbanization contributes to changes in households' edible oil demand.

This paper's primary contribution is to show that policy options to influence consumer demand over types of oils may be limited due to low substitution by households between imported and domestic edible oils. As far as we know, we are the first paper to produce such a study. We also contribute to the body of work that studies demand for edible oils, notably (Nyange, Weliwita, and Tsujii 2003; Fang and Beghin 2002; Hsu, Chern, and Gale 2001; see Table 8). There is a larger body of work that studies food demand Africa, without focusing on edible oils. This includes work on grains and other staples (Me-Nsope et al. 2016; Mabiso et al. 2008), as well as fish and other proteins (Liverpool-Tasie, Sanou, and Reardon 2017).

We also find large geographic differences in the pattern of edible oil consumption, with palm oil being prevalent in large urban areas, especially Dar es Salaam and other coastal cities. Sunflower oil has its highest share of household budgets in areas near Tanzania's sunflower-belt, six regions in the center of the country that produce 70% of the sunflower seed output, and host the majority of the country's sunflower seed processing operations (Government of Tanzania 2016). We use the results to identify potential policy outcomes and priority areas for further research.

2. DATA AND METHODS

2.1. Data

We use the Tanzania 2011-12 Household Budget Survey (HBS) to model consumer demand, and a recent consumer survey in sunflower production areas to characterize consumer attitudes and buying practices (Alphonce forthcoming). HBS records day-to-day spending of 10,168 households in 692 categories of products and service over twelve months—October 2011 to September 2012. Households were selected from 21 of Tanzania's 31 regions in a stratified, nationally representative random sample. Each household was followed by a National Bureau of Statistics (NBS) enumerator for about a month, to record all purchase transactions. The data captures quantities and values on 1.89 million household spending transactions. [4]

Food items represent 67% of the data . One hundred ninety-nine unique product (COICOP) codes between 111011 and 213107 identify food items, while non-food items are captured by 493 unique COICOP codes between 221100 and 1271105. Several COICOP codes are supplemented with product descriptions to identify the product brand and other meaningful detail. Of the food COICOP codes, six represent edible oils: 115401 (Sunflower), 115402 (Cottonseed), 115403 (Groundnuts), 115404 (Sesame), 115405 (Coconut) and 115406 (Other cooking oils). We identify palm oil as transactions with the 115406 COICOP code and item descriptions exclusive to palm oil, i.e., *Mafuta ya Mawese*, the Swahili expression for palm oil, and *Mafuta ya Korie*, a brand that is exclusively palm oil.

The HBS data included total expenditure at the household level, along with socio-demographic variables that allow calculation of household size, the number of adult-equivalents, as well as the education level and gender of the household head. We use the reported total expenditure measure in this data as a proxy for total household income, and unit values as a proxy for prices in calculating price elasticities.

The data contain a large share of rural households: Tanzania still has more than 60% of its population in rural areas, and the stratified sample contains 40% of households from locations outside urban areas. A few of the urban areas outside Dar-es-Salaam fall within Tanzania's sunflower belt, and 24% of all sampled households (rural and urban) are in this region. The sunflower belt is a considerable distance from the port of Dar-es-Salaam, where most palm oil imports enter the country. We expect this geographic pattern to be reflected in the local prices of edible oil options.

We dropped the 45 edible oil entries with units not defined in liters (L) or milliliters (ml), and converted the units, so that quantities for edible oils are reported uniformly in ml. We drop transactions marked as purchases for resale, and to avoid omitted transactions or errors by enumerators we drop households that purchased fewer than four different items in the month, or with purchase transactions recorded on fewer than 12 days or greater than 31 days. These steps removed 139 of the 8,992 possible households. Enumerators were instructed to record purchase transaction every day for households with illiterate members, and every other day for households with a literate household head.

Alphonce et. al. (forthcoming) collected data during 2017 in a stacked survey approach focusing on milled grain products and sunflower oil in Morogoro and Dodoma cities, and smaller towns outside them. This area is the core of Tanzania's sunflower belt. In randomly selected retail outlets across the survey sites, exiting consumers were interviewed about their current- and last purchase. This

[4] More about the HBS survey can be found on the website of Tanzania's National Bureau of Statistics: http://www.nbs.go.tz/nbstz/index.php/english/statistics-by-subject/household-budget-survey-hbs

effort provides a much smaller sample than the HBS, but far more detail on the particular types and brands of edible oil purchased, about where the purchases are made, and about consumer attitudes towards different attributes of edible oils. We use these data, together with our own observations in markets located in the sunflower belt, to provide important context for interpreting our econometric results from the HBS.

2.2. Methods: Quadratic Almost Ideal Demand System

A utility-based structural model of household responses to prices is necessary for this study, given our goal of estimating the potential impacts of policy on how households demand and substitute between edible oils. We adopt the quadratic extension (QUAIDS) of the Almost Ideal Demand System model (AIDS); Deaton and Muellbauer 1980), introduced by Banks, Blundell, and Lewbel (1997). QUAIDS estimates of the income-expenditure (Engel) curves are more flexible. For each budget item i, with a household budget share w_i, we estimate:

$$w_i = \alpha_i + \sum_{k \epsilon K} \rho_k z_k + \sum_{j \epsilon I} \gamma_{ij} \ln(p_j) + \beta_i \left(\ln\left(\frac{m}{\alpha(p)}\right)\right) + \frac{\lambda_i}{b(p)}\left(\ln\left(\frac{m}{\alpha(p)}\right)\right)^2 + \mu_i \qquad (1)$$

With non-linear price aggregators:

$$\ln(\alpha(p)) = \alpha_0 + \sum_{j \epsilon I} \alpha_j \ln(p_j) + \frac{1}{2}\sum_{l \epsilon I}\sum_{j \epsilon I} \gamma_{lj} \ln(p_l) \ln(p_j)$$

$$b(p) = \prod_{j \epsilon I} p_j^{\beta_j}$$

p_i and m are the price of product group i, and total spending per household, respectively. z_k is a set of demographic variables introduced as controls, while I represents the set of all product-groups in the consumption basket. In line with previous works, (e.g., Deaton and Muellbauer 1980), we impose constraints of homogeneity of degree zero on prices and income. That is, we assume demand is unaffected if prices and income change in the same ratio. The approach also assumes symmetry in the γ_{ij} parameter that determines substitution between product groups i and j.

To control for potential endogeneity of prices and expenditure we adopt the *aidsills* estimation approach (Lecocq et al. 2015), which like Poi et al. (2012)'s model is based on the the almost-ideal demand system (AIDS) of Deaton and Muellbauer (1980) and the quadratic almost-ideal demand system (QUAIDS) of Banks et al. (1997).There may exist unobserved endogeneity not accounted for in the Poi et al. (2012) model. The *aidsills* approach considers potential correlation between the error term and log prices, and also between the error term and total budgets.

Aidsills exploits the conditional linearity of the budget share equation presented in the QUAIDS model, and through an iterative process, where parameters are estimated using given values of price aggregators, then used to update the value of the price aggregators. This helps to address potential bias from the endogeneity of prices. Each iteration consists of seemingly unrelated (SUR) or ordinary least squares (OLS) regressions, with the initial values for the price aggregators given by the Stone price index and the unit vector, respectively. Iterations continue until convergence occurs, and consistent and asymptotically normal estimators are achieved. Once convergence occurs, symmetry is imposed on the last estimation. We use price indexes at the ward-level to control for price endogeneity. The *aidsills* approach also allows for endogenous regressors—endogenous total budgets in particular, a concern of many research papers on demand-system estimations. The approach allows us to identify expenditure using instrumental variables—in our case, the level of education of the household head, and the equivalent number of adults in the household. This is in addition to using demographic variables as *shifters* for the estimation process.

Household spending for some food items or food groups can be zero for several reasons: the items may be unavailable, unaffordable, purchased infrequently, or otherwise unsuited to the household. These zero observations may introduce bias into our estimates, as discussed in Denton and Mountain (2016). We address this concern with robustness checks that use the Shonkwiler and Yen (1999) two-step estimation. In a first step, a probit model is estimated to predict the cumulative distribution (Φ) and probability density functions (ϕ) of making purchases in category i for each household. The second step uses the estimated distributions to modify Eq. (1), creating a predicted budget share w_i^*, to use in equation 1 in place of the observed budget shares.

We simulate budget shares for each edible oil group for some policy scenarios, using the parameters from the QUAIDS estimation to compute price-elasticities for the product(-group)s of interest. The scenarios are: (1) raising the tariffs by 10% on all imported crude (refined) edible oils to 25% (35%); and (2) providing an 18% price tax subsidy to sunflower oils. The 10% tariff and 18% subsidy scenarios reflect the tariff and VAT options facing the government, as described in Section 4.

3. TANZANIA'S EDIBLE OIL MARKET: RECENT GROWTH, AND CONSUMER ATTITUDES

In 2016, Tanzania's edible oil consumption was estimated at 570,000 MT, of which 64% is palm oil, 30% sunflower and 6% cottonseed, with a projected growth rate of 7% per annum in overall oil consumption (Dalberg 2018; TPSF 2017). Domestic production of edible oil is estimated at 270,000 MT in 2016, of which sunflower production accounts for 83%, cottonseed 5%, and palm 2%. Though oils and fats account for only 3.8% of total expenditure on food, this category is important because it is a staple that most households do not produce, but rather purchase from markets. Edible oil plays an important role in household nutrition in Tanzania as it is used as a medium for micro-nutrient (Vitamin A) food fortification and provides a critical source of fat for many consumers.

At the time of the HBS survey in 2010/11, Tanzania's sunflower sector was on the cusp of a huge three-year boom, during which production would more than triple from 0.8 million tons in 2011 to an estimated 2.6 million tons in 2013 (Food and Agriculture Organisation of the United Nations 2018), the estimated number of small-scale processors would rise to 1,000, and the sector would see investment by two large-scale processors to produce refined sunflower oil. Prior to this time, the sector had seen growth in sunflower seed production of 4% to 8% per annum (Government of Tanzania 2016), with a concomitant rise in small-scale processing located in the sunflower belt. Most of these small processors were located in villages or outside main towns and cities of the sunflower belt. Their distribution capacity was limited, meaning that sunflower oil was available primarily in this region.

The oil produced by these processors is variously referred to as filtered or semi-refined: crushers use cold press technology to extract the oil, allow sediment to settle out, and then force the oil by pressure through a series of dense canvas filters. The resulting product is clear, without any trace of sediment, and is slightly but noticeably darker than fully refined oils (including palm). While Dalberg (2018) estimates that industrially refined sunflower oil is now about 20% of the total sunflower oil market, at the time of the HBS it was likely far lower. This oil was competing primarily with refined palm oil, which was refined by large-scale importer/processors and distributed nationally. Prices for these two oils were at the time, and are today, comparable.

A 2017 consumer survey in the sunflower belt suggests that price is not the most important attribute that consumers look for in choosing their oil (Alphonce et al. forthcoming). Of all 630 respondents, when asked which attribute was most important in their decision, 54% referred to perceived naturalness (22%) or healthiness (32%) of the oil; 22% referred to taste; and only 10% referred to price. A broadly similar pattern obtained among the 380 buying branded oils, with 25% referring to health or naturalness, 37% to taste, and 17% to price. Among the 101 respondents buying loose unbranded oil, 80% wanted oil from a trusted local processor, while 19% said low price was most important.

4. POLICY CHOICES FOR THE EDIBLE OIL SECTOR

The Government of Tanzania (GoT) is interested in the growth of the sunflower sector for at least three reasons. First, as a means to reduce the country's food import bill. Though production of sunflower—and the share sunflower oil in total edible oil consumption—have grown rapidly over the past decade, the country remains currently spends $120 million annually on edible oil imports. These imports account for about 20% of the country's total food import bill (Food and Agriculture Organisation of the United Nations 2018). Rising incomes mean that, unless local production continues to rise strongly, this import gap will not be closed.

Second, the GoT wishes to promote industrialization, and sees oilseed processing as one important contributor to that goal. Promoting the competitiveness of the local processing industry is thus a key goal, as reflected in the country's Sunflower Sector Development Strategy (Government of Tanzania 2016).

Finally, the government remains committed to eliminating poverty. Since sunflower is produced almost entirely by smallholder farmers, increasing farm productivity and linking farmers to industrial demand is seen as an important avenue towards reaching that poverty reduction goal.

To promote domestic edible oil production, policy options for the GoT include domestic tax rebates, as well as trade policy in the form of tariffs. Waiving the Value-Added Tax (VAT) on sunflower oils or otherwise granting a rebate on this consumption tax could boost its domestic consumption.[5] In addition, waiving or reducing taxes on imported processing machinery might enhance local competitiveness. Another alternative is raising tariffs on imported edible oils. The main challenge in selecting a policy option is how to manage imports to meet short-term demands without undermining long-term domestic production.

Stakeholder objectives are not uniform. Small-to-medium scale oil processors prefer protection through raised tariffs on imported palm oil, while large-scale refiners of imported crude palm oil (and now some sunflower, as well) prefer policies that keep costs low. Past changes to tariffs in response to lobbying by stakeholders have not always been helpful, as frequent tariff changes could suggest an unpredictable policy environment.

Tariff changes are also constrained by regional economic cooperation treaties. Under the East Africa Community (EAC) common market, Tanzania has a three-band Common External Tariff (CET) of 0%, 10% and 25%. The CET is complimented by Rules of Origin granting preferential tariff treatment to goods originating in EAC countries. For edible oils, the CET applies a 25% tariff to imported refined oil and 10% and 0%, respectively, on imported semi-refined and unrefined/crude edible oils (East African Community 2018). Tariffs on crude palm oil (CPO) were waived in 2009 but reintroduced in 2016. Currently EAC has initiated the process to review CET and the GoT is evaluating policy options to maintain the growth in local edible oil production.

[5] The Tanzanian government provides more information about VAT at: http://www.tra.go.tz/index.php/value-added-tax-vat

5. RESULTS

5.1. Descriptive Statistics

Table 1 summarizes the socio-demographic variables used as shifters in our estimations, while highlighting rural-urban differences. The data represent 2,845 households from Dar-es-Salaam, 2907 households from other urban areas and 4,081 households from rural areas. The columns show weighted averages for each of the area groups.

Rural households on average have lower income, more children and larger household sizes. Urban households tend to have younger household heads. Households headed by females were more common in urban areas outside Dar-es-Salaam, and represent about a quarter of households in rural areas. Household incomes and expenditures, including food expenditures are also noticeably higher in urban areas.

Table 2 shows that most households purchase edible oils, the category is used by more than 90% of households, almost as much as the broad categories of starches (97%), and proteins (96%)[6]. The mean expenditure share for edible oils is reasonably close to the median, much like the spending shares for non-foods and other broad food categories that account for a larger share of the budget. Nevertheless, the mean spending on bread, cornmeal and others starches was 48,260, much higher than the median of 38,500, while the means spending on eggs, milk, fish, meat, and other proteins was 25,859, clearly above the median of 18,250. The pattern suggests that for the broad consumption categories, either the consumption portfolio is fairly similar for a large share of the population, or it changes in ways that are roughly symmetric around the typical household. In sum, the summary statistics provide some confidence towards estimating parameters that are representative for the population for the broad food categories.

For specific types of edible oil, we see large differences in household consumption patterns. The last two columns show that the median household purchased palm oil, and no other type of edible oil. Sunflower represents only 0.6% of total spending for the average household, while palm oil's average share is more than twice as much. The large differences between households in choosing edible oils is reflected in the low median household spending share of palm oil (0.2%, compared to the 1.6% average share).

Table 1. Summary Characteristics of Households in HBS Survey, 2010/11

Variable (N=9833)	Dar-es-Salam	Other Urban	Rural
Age of household head	40.66	43.71	46.52
Gender of household head (Female=1)	0.22	0.28	0.24
Children under 14	1.30	1.85	2.50
Children under 5	0.58	0.79	1.15
Household size	4.07	4.74	5.33
Adult equivalent size	3.47	3.94	4.23
Per capita food expenditure (Tsh/year)	209,699	155,158	137,064
Per capita total expenditure (Tsh/year)	539,810	347,049	234,296

Source: Government of Tanzania Household Budget Survey (HBS).

[6] All descriptive results use household sample weights.

Table 2. Expenditure and Budget Share Summary

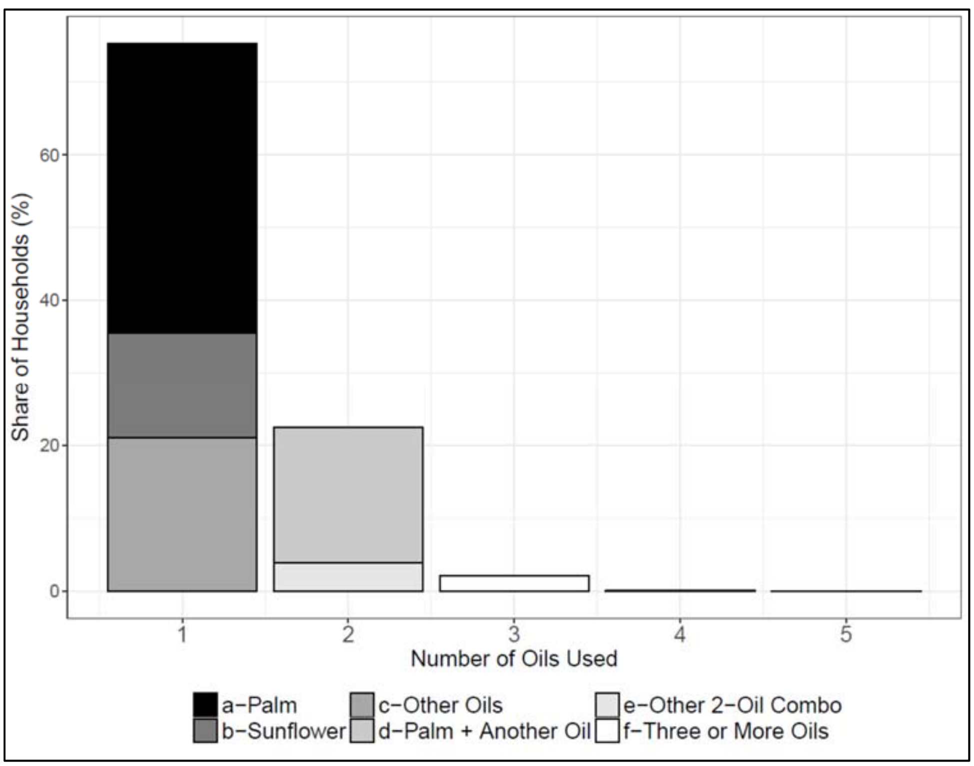
	Share of HHs (Spending>0)	Mean Spending	Mean Share	Median Spending	Median Share
Edible oils	0.91	5,860	0.03	4,350	0.03
Sunflower oil	0.21	1,197	0.006	0	0
Palm oil	0.55	3,047	0.016	400	0.002
All other oils	0.38	1,616	0.009	0	0
Starches	0.97	49,910	0.27	37,500	0.26
Proteins	0.96	24,593	0.13	16,600	0.12
Other food	0.99	41,775	0.22	32,250	0.23
Non-food	1.00	65,628	0.35	37,800	0.29

Source: Authors' calculations from HBS.

The mean and median share of palm oil is larger than the sum of all other types of edible oils (coconut, cottonseed, sesame, groundnut, and other generic oil blends). The fraction of households that use any of these other oils, as seen in the first column of the table, is also less than the fraction using palm oil. That first column also confirms our expectations that most, if not all households, record purchases in each of the broad product groups .

Few households used more than one type of oil in the month that they were surveyed. This result is suggestive, given our interest in substitution across oil types. Figure 1 documents the pattern of exclusive oil consumption, combinations across types.

Figure 1. Patterns of Oil Use by Household



Source of Data: Government of Tanzania 2012 Household Budget Survey (HBS).

The horizontal axis shows how many kinds of oil a household purchased in the survey month, and the vertical axis shows the number of households with the given number of oils purchased. Thus, a household that purchased only one type of oil falls in the first column, and within that column, it falls in the color segment that represents their choice of edible oil. Each bar—representing the number of oils used—also shows the combination of oils used by households that used more than one kind of oil. Of the households that used edible oils, 43% used palm oil exclusively, while 12% used sunflower oil exclusively.

In sum, about three-quarters of households are exclusive users of one type of edible oil. This estimate is a lower bound, as we count the generic other oil category as one kind. About 99% purchased no more than two types. The prevalence of use is also reflected in budget shares. Palm oil purchases represented 52% of the value of edible oil purchase. The balance of households that use more than one type of oil represent about a third of the sample. The multi-oil households used many oil combinations, with palm oil being the most common, and with only a few households combining purchases of sunflower and palm oil. The pattern of exclusive use, or zero spending on certain edible oils motivated steps to address selection, or controls for thresholds when we estimate elasticities later in this section.[7]

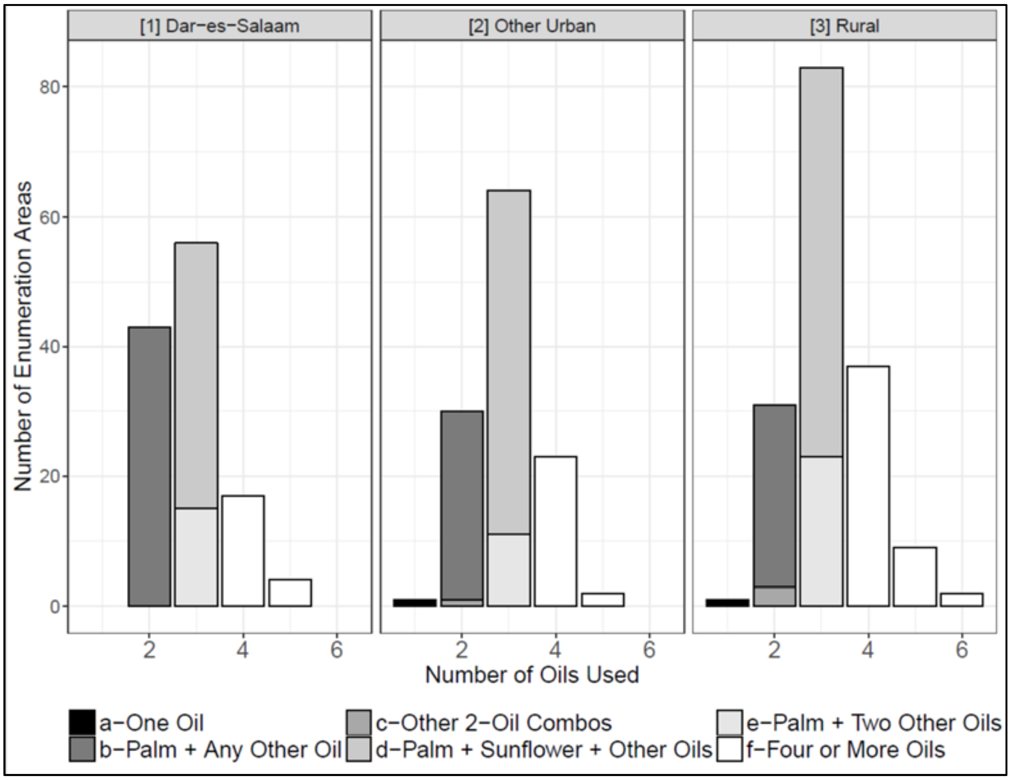
Figure 2 suggests that the pattern of using only one type of edible oil is not because only one is available for purchase. Within each enumeration area, we usually observe three or more different types of oil purchased in each cluster; this is without considering specific brands for each kind of oil. Notably, the data show no obvious disadvantage for rural areas. The fraction of rural enumeration areas with fewer than two types of oil purchased, as a share of all rural enumeration areas is smaller than the corresponding ratio for urban areas. Even without showing the aggregate shares of edible oil purchases, the data establishes that the country's retail network offers most households a choice between several types of edible oils, with palm oil having the greatest geographic reach. Availability does not appear to fully explain the pattern of exclusive oil use by households.

This pattern may reflect consumer preferences, income or price effects. If the pattern were due to consumer choice or revealed preferences, it would be consistent with the literature on habit formation (e.g., Dynan 2000; Pollak 1970) and habit persistence (e.g., Ravina 2005; Brown 1952). It is reasonable to expect that dietary preferences, with the habitual uses of specific oil types for meal preparation, is responsible in part for the observed pattern.

Substitution between edible oils would be less responsive to policy stimuli or small price changes if consumers tend to consume only one type of oil. First, such consumers may not be aware of the prices of other oils. Second, even if they were aware, habitual patterns of consumption, or the suitability of different oils for different meals creates *switching costs* that limit the demand response to price or supply changes for products outside households' current consumption portfolio.

[7] We include Table A1 with a more detailed breakdown of oil use patterns by households in Appendix Section A.

Figure 2. Patterns of Oil Use by Enumeration Area



Source of Data: Government of Tanzania 2012 Household Budget Survey (HBS).

5.2. Price Elasticities

To provide a robust answer to our first main question (*can tariffs on imported edible oils be used to stimulate demand for homegrown oil varieties?*), we use the QUAIDS model to estimate cross-price elasticities of demand for narrow edible oil and food groups, with a focus on (largely imported) palm oil, and (largely domestically produced) sunflower oil. The cross-price (and own-price) elasticities are estimated from a system of equations with the budget shares of each edible oil and food group as the dependent variable. The demand system includes a total expenditure as well as instrumental variables for total expenditure—a feature of *aidsills* that corrects for endogeneity in spending. For our instruments, we use the education level of the household head, household size in adult equivalents, and the household's area designation—rural, urban or around Dar-es-Salaam. Each household represents an observation in the demand system. As intercepts we use gender and age of the household head, number of children, as given in the data (under 14, as well as under 5), and region. The price indexes for food and edible oils are the predictors in the estimation process, which iteratively adjusts the price indexes to correct for endogenous prices. The resulting cross-price elasticities can indicate whether a tariff policy that increases the price of the imported oil is expected to stimulate demand for the domestically produced alternative.

5.2.1. Narrow Edible Oil Categories

Table 3 presents model estimates. Product groups include three edible oils: sunflower, palm, and an aggregate of other edible oils. The other two product groups are all other food or beverage, and non-food. To interpret the first row, we see that own-price elasticity of sunflower oils is 0.79 (inelastic), while the cross price elasticity with palm oil is 0.31 (column 2). This suggests that a 1% increase in palm oil prices should come with about a 0.3% increase in demand for sunflower oil. The second row captures expected changes in the demand for palm oil with a percentage change in price for the product in the column header.

Results are consistent with the pattern of exclusive use in the previous table: sunflower oil and palm oil are substitutes, but the relationship is *not statistically significant.* The other edible oils group shows a statistically significant cross-price elasticity, suggesting that a 1% price increase for all other edible oils should correspond with a 0.23% increase in demand for sunflower oil. The basket of other edible oils and palm oil appear to be complements, such that an increase in the price of one decreases the demand for the other, but this relationship is not statistically significant. Two possible reasons for the unexpected sign may be income effects and data issues. Some palm oil transactions may be recorded as other oils, so that price behavior for the group always mimics that for palm oil; it is also possible that demand for the oils responds in similar fashion to common shocks to income, so that the products appear to behave as complements, when in fact they are substitutes. To address the concern that the estimates reflect more of the *income effect* than the *price effect*, Appendix Section B includes tables with compensated price elasticities. The estimates suggest that palm oil behaves as a substitute with other food items other than edible oils, as well as with non-food items. To address other concerns that availability explains the pattern of substitution observed in our results, Table A5 shows that our estimates remain largely unchanged, even if the sample was limited to only households that use both palm and sunflower oil.

Few statistically significant cross-price elasticities appear in Table 4, suggesting that consumption for many households involves little substitution. The own-price estimates appear reasonable, or consistent with other literature, and statistically significant across groups. These low cross-price elasticities are also consistent with the findings of Alphonce et al. (forthcoming) who show that price is a minor attribute in consumers' minds as they choose which oil to buy.

Table 3. QUAIDS Model Results: Narrow Product Categories

	Sunflower oil	Palm oil	Other edible oils	All other food	Non-food
	b/se	b/se	b/se	b/se	b/se
Sunflower oil	-0.792**	0.314	-0.990	0.246	0.002
	(0.303)	(0.309)	(1.098)	(1.510)	(1.006)
Palm oil	-0.219	-0.930***	0.021	0.129	0.027
	(0.131)	(0.096)	(0.114)	(0.708)	(0.290)
Other edible oils	0.231**	-0.228	-0.709***	-0.028	-0.021
	(0.083)	(0.133)	(0.165)	(1.205)	(0.518)
All other food	0.055***	0.034*	0.006	-1.039***	-0.137***
	(0.014)	(0.017)	(0.016)	(0.031)	(0.031)
Non-food	-0.094***	-0.062**	-0.001	0.057	-0.761***
	(0.014)	(0.019)	(0.035)	(0.175)	(0.067)

Note: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Table 4. QUAIDS Model Results: Income and Own-Price Elasticities

	Income b/se	u_price b/se	c_price b/se
Sunflower oil	0.473	-0.792**	-0.788**
	(2.405)	(0.303)	(0.284)
Palm oil	1.140	-0.930***	-0.907***
	(0.703)	(0.096)	(0.098)
Other edible oils	0.986	-0.709***	-0.698***
	(1.279)	(0.165)	(0.177)
All other food	1.059***	-1.039***	-0.391***
	(0.031)	(0.031)	(0.021)
Non-food	0.899***	-0.761***	-0.446***
	(0.139)	(0.067)	(0.060)

Note: * p<0.05, ** p<0.01, *** p<0.001.

Income elasticity is positive as expected across all the groups, but insignificant (Table 4). This may reflect limited variation in expenditure (as seen in Table 2). Nevertheless, the estimates suggest that households' demand for palm oil is more than twice as responsive to income changes as is their demand for sunflower oil. This result is surprising, but needs to be interpreted in light of the fact that palm oil is nearly all refined, while sunflower oil at the time of the HBS was nearly all unrefined. Thus, the result may be finding a turn toward refined oil as incomes rise, not to palm *per se*.

The uncompensated own-price elasticities (u_{price}) mirror the items on the diagonal of Table 3, while the compensated price elasticities (c_{price}) correct for the income effect in household response to price changes. All groups show negative uncompensated own-price elasticities. The demand for all the defined groups are inelastic, except for the *all other food* group, which has an own-price elasticity of -1.03. Sunflower oil demand appears to be slightly less responsive to prices than the demand for palm oil, although the difference between the two is not statistically significant. The estimates for uncompensated and compensated own-price elasticities in Table 4 are consistent for the edible oils groups. The signs and statistical significance are the same, and size in absolute terms decreases for all the groups.

As described in Section 2.2, the estimates in Tables 3 and 4 correct for censoring and potential endogeneity in expenditures. We address this concern in the robustness checks section with results that use transformed budget shares, following the two-step procedure proposed in Shonkwiler and Yen (1999).

5.2.2. Policy Simulations

To visualize whether policies that nudge prices, like tariffs, can meaningfully change consumer demand across oils, we estimate the effect of the price changes on household spending on the narrow product groups, in two hypothetical policy scenarios: (1) an 18% price drop for sunflower oil, the most optimistic case for consumers if the Tanzanian government completely phased-out the VAT on sunflower oil and middlemen pass the full benefits to consumers; and (2) a 10% price hike for palm oil, as could happen if government raised the tariffs on imported palm oil by 10 percentage points, and the same percentage was passed through to consumers.

The first panel of Figure 3 shows the current demand profile and the expected change in the profile of sunflower oil and palm oil in the first policy scenario. The lower price does not substantially alter households' budget share for palm oil. For the highest income quartile, the difference is indistinguishable to the unaided eye. Interestingly, this scenario also leads to less spending on sunflower oil. The lower budget share on sunflower oil is not surprising, given that its demand is inelastic, so that the combination of increased demand and lower prices yields lower total spending on sunflower oil. (The predicted budget share of sunflower oil fell in this scenario from 0.0071 to 0.0065, suggesting that purchase quantities will increase by around 11%, but it is not clear that this projected increase is statistically significant, even with the extremely optimistic view that consumers will receive the benefits of the VAT rebate in full).

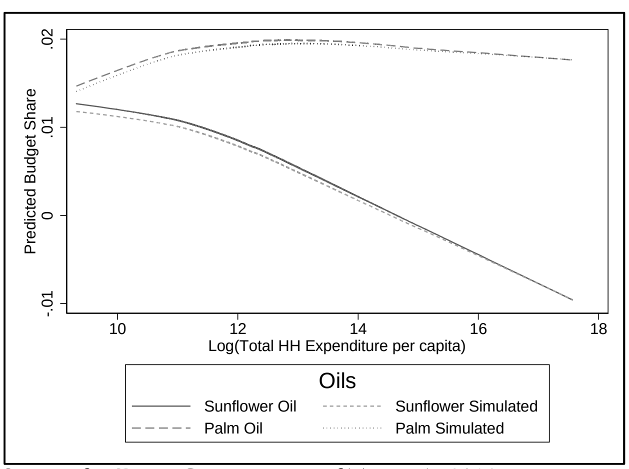
The second panel also shows results after a 10% price hike for palm oil. The price change does not substantially alter households' budget share for either oil. The impact also does not vary perceptibly over income. For households in the last income quartile, the graph shows a small projected increase in the budget share of both oils. The rationale for this result is that higher palm oil prices lead to slightly lower demand for palm oil, and some substitution to sunflower oil. The estimates suggest a rise in the predicted budget share of palm oil from 0.0197 to 0.0201. The higher budget share, with a 10% increase in prices suggests that demand for edible oils would be 7.2% lower, though this estimate is also not statistically significant. In the scenario with a price hike due to a tariff on palm oil, demand for sunflower oil increase by a tiny amount, from a budget share of 0.0071 to 0.0077.

5.2.3. Broad Product Categories

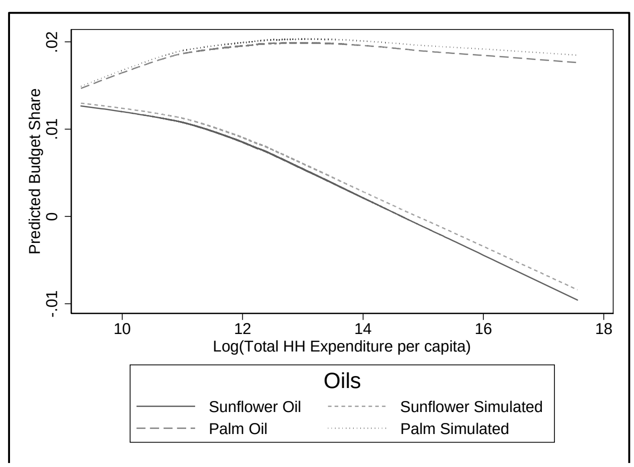
Table 5 helps answer our second research question: *How is demand for edible oil linked to income growth?* All product groups behave as normal goods, with positive and statistically significant income elasticities. Among food groups, edible oils appear the least sensitive to changed income. Nevertheless, the income elasticities are remarkably close—near 0.87 for each of the broad groups defined in the table. In sum, broadly speaking, the estimates suggest that as incomes rise, demand for edible oils is expected to increase, at rates comparable to the increase in demand for other goods.

Figure 3. Predicted Budget Shares for Simulated Scenarios

a. 18% Price Drop for Sunflower Oil



b. 10% Price Hike for Palm Oil



Source for Data: Government of Tanzania 2012 Household Budget Survey (HBS).

Table 5. Broad Product Groups: Income and Own-Price Elasticities

	Income b/se	u_price b/se	c_price b/se
Edible oils	0.970*	-1.050***	-1.014***
	(0.002)	(0.030)	(0.037)
Starches	1.116***	-1.169***	-0.885**
	(0.112)	(0.106)	(0.284)
Proteins	1.139***	-1.106***	-0.957***
	(0.164)	(0.037)	(0.097)
Other food	0.956***	-1.039***	-0.818***
	(0.115)	(0.073)	(0.178)
Non-food	0.895***	-0.832**	-0.521**
	(0.108)	(0.308)	(0.187)

Note: * p<0.05, ** p<0.01, *** p<0.001.

To further examine the income-demand relationship, we derive the income elasticity of demand for each edible oil separately for each income quartile. For sunflower oil, the estimates are: 0.68, 0.55, 0.50, and -0.26. The negative sign on the last coefficient suggests that (unrefined) sunflower oil is considered an inferior good for households at the highest income levels. For (refined) palm oil, the estimates are: 1.20, 1.16, 1.13 and 1.08. That the coefficient on the income variable in Table 5 is not statistically significant at the 1% level may reflect the fact that for a subset of households, one of these edible oils is an inferior good.

Own-price elasticities in Table 5 are consistent with the estimates for the narrow groups in Table 4. They are similar across groups, with edible oils having some of lowest elasticities. The own-price elasticity estimates are also comparable across the last two columns, with the compensated price elasticities having consistently lower absolute values, as expected.

These findings, as well as additional estimates using broad categories (see Table A6 in the appendix), imply that a change in edible oils prices prompt changes to consumer demand, largely in the form of substitution to other food products outside the starchy staples and protein-rich options.

5.3. Rural-Urban Differences

To address our third question: *Is urbanization driving the demand for edible oils?*, Figure 4 shows the dramatic rural-urban difference in palm oil's share of spending on edible oils, as well as contrasting patterns of consumption change with income. We are interested in how the transition to urban environments contributes to the pattern of demand for edible oils.[8]

The stark rural-urban differences in edible oil consumption persist across high- and low-income households. The poorest rural households on average allocate about 30% of their spending on edible oils to palm oil, while the poorest in Dar-es-Salaam generally allocate more than 90% to palm oil. For the poorest households in Dar-es-Salaam, the major seaport and entryway for palm oil imports, we observe little to no purchases of sunflower oil, while rural and urban households outside

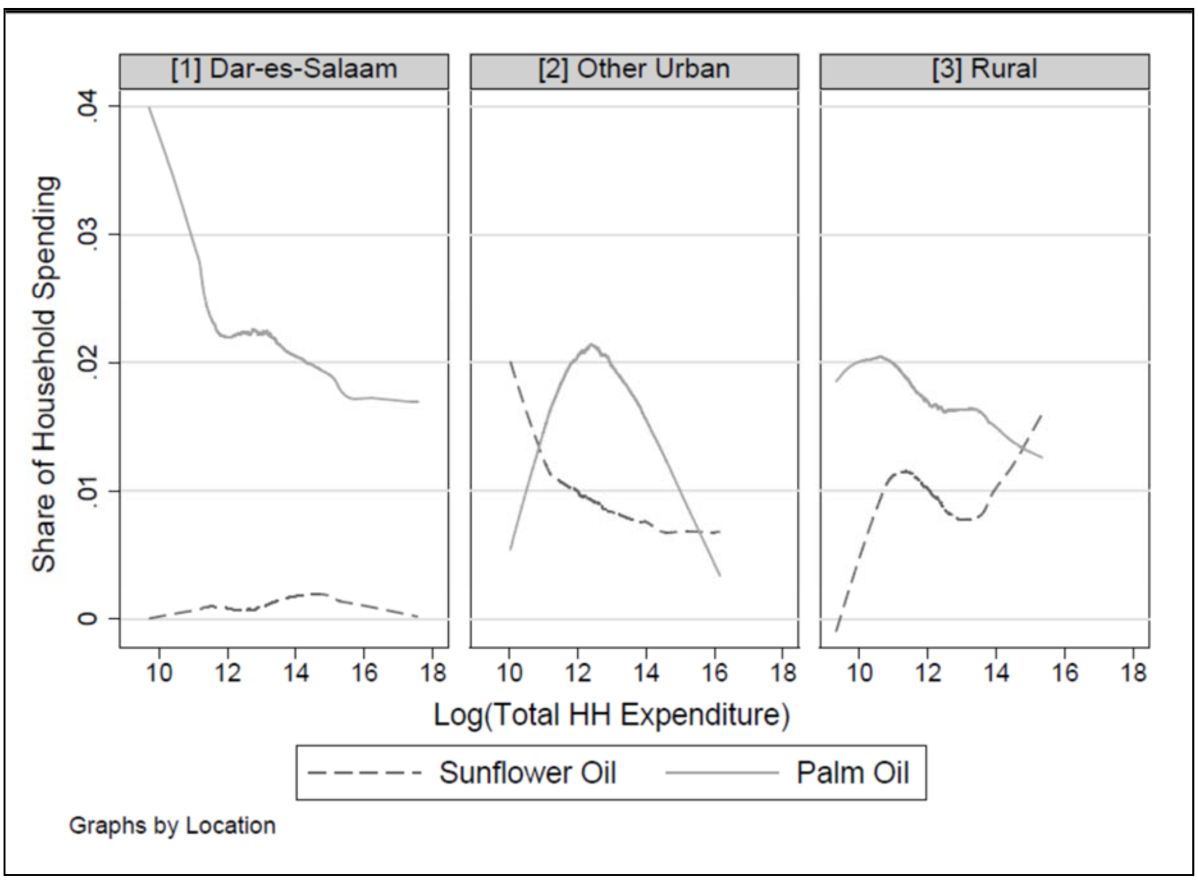
[8] Tanzania is one of the few countries expected to contribute more than 50 million to the increment in global urban population between 2014 and 2050 (United Nations 2014).

the port city use more sunflower oil, even if at lower rates than palm oil. As is expected, sunflower use is common among households in the sunflower belt.

These large differences may be more linked to accessibility, habit and taste than price, as sunflower oil's share is high in urban areas near or in the sunflower belt, just as palm oil's share is highest in areas nearest the port. Proximity to source should translate to lower prices, and lower prices should stimulate demand. However, it is not clear that prices for palm oil are lower than sunflower oil near the port, or that sunflower is less costly than palm oil in the farming regions. Table A2 in the Appendix shows a general pattern of higher prices in rural areas. Within this pattern, the evidence suggests that sunflower is the less expensive oil for the small quantities typically purchased for daily use. However, for packaged edible oil in the standard one-liter (1L) quantities more suited to weekly purchases, palm oil prices are on average 22% lower than sunflower oil prices in the Dar-es-Salaam area. The price difference is only 7% in other urban areas and 16% in rural areas. Thus, we can conclude that while lower unit values may attract consumers making weekly purchases to palm oil, consumption habits or other factors still ensure that many households buy palm oil at higher prices than sunflower oil in small quantities.

The pattern of differences with income in Figure 4 also echo previous questions about whether all the oil types behave as normal goods. Palm and sunflower oil both are normal goods for rural residents—according to the income elasticity estimates in Table 4, whereas the largest urban area in

Figure 4. LOWESS Estimates for Share of Total Household Expenditure on Palm and Sunflower Oil



Source of Data: Government of Tanzania 2012 Household Budget Survey (HBS).

Tanzania sees the highest-income residents substituting away from palm oil. (Much of the reduction in budget share is due to increases in total household spending, and the low prices for palm oil, rather than substitution from palm to sunflower oil). Another possible reason for the decline in average oil budget share of palm oil may be health concerns, although the literature is not definitive on the health effects of palm oil, (e.g., Fattore et al. 2014). The pattern is also relevant to previous studies that find mixed results in the response of household spending on edible oils to rising income. Fang and Beghin (2002) find that the share of animal fat in total fat and oil consumption decreases with rising income, while the broad category of edible oils behaves as a normal good.

5.4. Robustness Checks

We include results that predict budget shares with a multivariate probit model as a first step (Table 6). This reduces the bias that may be introduced by the many observations for which households spend zero on a given product group. The predictors for this first stage are the price indices for the product groups, and demographic variables.

Estimates closely mirror results in Table 4, with slightly higher absolute values for the elasticity estimates and more estimates that are statistically significant. As in the previous table, these results suggest that demand for edible oils is not very elastic, with absolute values near unity, so that quantities purchased by households are not very responsive to price changes. They also imply low substitution between palm and sunflower oil in response to price changes. While the cross-price elasticity estimates are statistically significant, the absolute values are smaller, roughly half the previous estimated response.

Compared with Table 3, the approach in Table 6 offers advantages and weaknesses. It reduces the bias in coefficients when many households have zero purchases of an item, but it inflates the predicted budget share of edible oils and other items with zero budget shares.

For this reason, it could not be used for reasonable simulations like Figure 3. In sum, using an approach that uses adjusted budget shares to avoid bias from zero-budget-share observations strengthens the implications of our findings.

Table 6. QUAIDS Estimates with Corrections for Zeros

	Sunflower oil	Palm oil	Other edible oils	All other food	Non-food
	b/se	b/se	b/se	b/se	b/se
Sunflower oil	-0.985***	0.158***	-0.289***	-0.016	-0.054***
	(0.006)	(0.008)	(0.007)	(0.014)	(0.005)
Palm oil	0.024***	-1.001***	0.032***	0.055***	0.030***
	(0.003)	(0.004)	(0.005)	(0.011)	(0.009)
Other edible oils	0.012**	-0.067***	-0.895***	-0.010	-0.022***
	(0.004)	(0.004)	(0.008)	(0.011)	(0.002)
All other food	0.033***	0.019	0.032**	-1.021***	-0.089***
	(0.008)	(0.012)	(0.010)	(0.012)	(0.007)
Non-food	-0.112***	-0.081**	0.009	-0.003	-0.805***
	(0.017)	(0.026)	(0.027)	(0.049)	(0.030)

Note: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

To address concerns that some purchases coded as other edible oils were in fact palm oil, we run two set of estimates. The first assumes that all other oils without palm oil-specific descriptions are sunflower oil. The second assumes that the entire class of other oils is palm oil. The goal is to see: 1) whether the two worst-case scenarios for data misclassification change our main conclusion, and 2) whether estimates in the extreme setups fit the expectations raised by previous estimates.

Table 7 replicates the previous tables for these two scenarios, with two key results. First, the results are largely consistent with Table 4, and the two panels of the table are remarkably similar. Compared to Table 4, own price elasticities in Table 7 are larger in absolute terms, but keep their signs and statistical significance in most cases. The all other foods and non-food categories report almost identical responses to the previous table, while the other edible oils category keeps its sign but loses statistical significance. (The change in statistical significance is not surprising, given that less than 9% of households use this category, which represents less than 1.5% of the average food budget). The cross-price elasticities for palm and sunflower oil change in the new estimates. The sign changes from positive to negative, implying that sunflower and palm oils are complements, not substitutes. If this were true, policy initiatives to decrease the price of sunflower oil, or to increase the price of palm oil would be plainly counterproductive.

Table 7. Estimates with Alternative Definitions for Palm and Sunflower

	Sunflower oil	Palm oil	Other edible oils	All other food	Non-food
	b/se	b/se	b/se	b/se	b/se
			All Other Oils=Sunflower		
Sunflower oil	-0.977***	-0.091	-0.151	0.068	-0.011
	(0.082)	(0.088)	(0.184)	(0.562)	(0.312)
Palm oil	-0.113*	-0.938***	0.132	0.183	0.031
	(0.057)	(0.082)	(0.189)	(0.589)	(0.189)
Other edible oils	-0.161	0.008	-1.204	-0.016	-0.124
	(0.811)	(0.458)	(1.550)	(5.418)	(1.728)
All other food	0.031*	0.045**	-0.038***	-1.056***	-0.144***
	(0.015)	(0.016)	(0.011)	(0.027)	(0.030)
Non-food	-0.048*	-0.079***	0.067	0.084	-0.749***
	(0.024)	(0.018)	(0.050)	(0.143)	(0.036)
			All Other Oils=Palm		
Sunflower oil	-0.966***	-0.534	-0.392	0.189	-0.031
	(0.128)	(0.595)	(0.689)	(1.355)	(0.830)
Palm oil	-0.058	-0.919***	0.099	0.109	0.028
	(0.036)	(0.072)	(0.131)	(0.446)	(0.172)
Other edible oils	0.441	-0.516	-1.129	0.010	-0.124
	(0.433)	(0.991)	(1.669)	(6.262)	(2.217)
All other food	0.044**	0.050**	-0.032**	-1.049***	-0.143***
	(0.015)	(0.016)	(0.011)	(0.029)	(0.031)
Non-food	-0.075***	-0.080***	0.056	0.073	-0.751***
	(0.018)	(0.018)	(0.054)	(0.161)	(0.048)

Note: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

This seemingly odd result is not surprising. It in fact fits the expectation that if the data was for the most part correctly classified, but in the approach here we incorrectly lumped palm oil into sunflower oil, demand for our *constructed sunflower* would go down when palm oil prices go up, much as it would for a complementary product, because of the reduced demand for palm that was incorrectly recorded as sunflower. This fits what we find in the first panel, and suggests that the category of *other edible oils* may contain some palm oil transactions that were not clearly described as such. The second panel fits the same narrative, if we incorrectly assumed that all edible oils without a specific description or code were palm oil, then our new estimates should show less substitution between palm and other oils. We find no change in sign and significance between the new estimates and the old, and a slight increase in the size that suggests less substitution. This is just what would be expected if the data classification we used in Table 4 was largely correct. The low and insignificant cross-price elasticities are consistent with the main findings of low expected substitution between palm and sunflower oil.

5.5. Estimates from Related Work

We compare our estimates with the findings of other scholars (Table 8). We selected all the papers we could find that were published in the last 18 years with a focus on estimating the price elasticities of edible palm and sunflower oil. India and China dominate this literature.

Table 8. Own-price Uncompensated Elasticities in Related Papers

Study	Data Description	Palm oil	Sunflower oil	Edible oil
Dewanta, Arfani, and Erfita (2016)	Indian National Data	-1.1381 and -0.8588		
Srinivasan (2012)*	Indian Households (HH)	-1.62	-1.0284	-1.08 to -0.35
Zheng and Henneberry (2012)	3,002 Chinese HH			-1.383 to -1.083
Kumar et al. (2011)	Indian HH			-0.77 to -0.332
Govindaraj (2010)	Indian HH	-0.409	-1.578	
Huq and Arshad (2010)	Bangladeshi HH			-1.39
Mittal (2010)	Indian HH			-0.81 to -0.78
Ghosh (2009)*	Indian HH			-0.5112
Lin, et al. (2008)	Chinese Retail data		-0.849	
Ng, Zhai, and Popkin (2008)	12,269 Chinese HH			-1.1, -1.3, and -0.9
Pan, Mohanty, and Welch (2008)	1,192 Indian HH	-0.75		-0.69
Akbay (2007)	18,278 Turkish HH		-1.25 to -1.071	
Persaud and Landes(2006)*	Indian HH	-1.05	-0.30	
Nyange, Weliwita, and Tsujii (2003)	4,994 Tanzanian HH			-0.885
Fang and Beghin (2002)	Chinese Urban HH			-1.3191 to -0.6041
Hsu, Chern, and Gale (2001)*	Chinese HH			-0.58 to -0.41
Guo, Popkin, Mroz, and Zhai (1999)	3,780 Chinese HH			-1.58 to -0.25

* - Not peer-reviewed

Note: The Dewanta, Arfani, and Erfita (2016) paper includes both the long-run own-price estimate (- 1: 14) and short-run estimate (- 0: 86).

The other countries represented in our review include Bangladesh (Huq et al. 2010), Turkey (Akbay 2007), and Tanzania (Nyange, Weliwita, and Tsujii 2003). The estimates for own-price elasticity for edible oils in Table A6 in the appendix are reasonably close to the estimates from Nyange, Weliwita, and Tsujii (2003), and the slightly higher absolute value for elasticities is consistent with the trend in the table of demand being more elastic as countries achieve higher average incomes over time. Overall, the estimates of own-price elasticities in Tables 4 and 6 are largely consistent with the findings of other papers that study demand for oil in developing economies.

6. CONCLUSION

We analyze demand for edible oils in Africa's sixth most populous country, using a detailed household survey of purchase transactions and the QUAIDS model. Our analysis is largely driven by the question of how policy could be used to stimulate demand for homegrown oil varieties. Related to this main question was the need to understand how rising average incomes and urbanization influence the demand for edible oils. The two products at the center of our study are palm oil, the leading imported edible oil, and sunflower oil, the leading domestic alternative.

We find a surprisingly low cross-price elasticity of demand for palm and sunflower oil. Furthermore, demand is relatively inelastic, with own-price elasticities less than unity in absolute value. The estimates of own- and cross-price elasticities are consistent with descriptive statistics that show a majority of households purchasing only one type of edible oil, even when the typical household is in a residential cluster with three or more edible oils available for purchase. The pattern of use and low propensity for substitution suggests that policies to stimulate demand for one product by altering the price of the other may be ineffective. Simulations of reducing the price of sunflower oil with a tax rebate, or increasing the price of imported palm oil with a tariff hike, yielded no significant changes to the pattern of consumption. The two policy simulations further support the conclusion that price-based policy interventions would lead to little change in the budget shares for the respective edible oils.

We also find increasing edible oil consumption with growing incomes. We note, however, that the average income is very low, and that rising incomes still leave most of the population well below the median of high-income economies. The QUAIDS estimates show that edible oil behaves like a normal good for rural and urban and urban households. Spending on palm oil as a share of total household expenditure generally decreases with rising income, given its low per-unit cost, but the income elasticity of demand is slightly greater one, and higher than the 0.47 for sunflower even if the difference is not statistically significant. The income elasticity of demand for edible oils as a group is positive and statistically significant, (at 0.87), consistent with expectations that edible oils are normal goods.

Finally, we observe rural-urban differences in the pattern of demand for edible oils. These differences are consistent with our expectations that sunflower oil consumption will be more prevalent in Tanzania's sunflower belt—rural and urban areas far from the coastal sources of palm oil, and close to the largest growers and processors of sunflower oil.

Extensions and areas for future research include understanding differences in demand for refined vs crude edible oils. We also plan to relate our findings to a study with production value chain analysis, and structured estimates of how markups change prices from producers, through processors and other intermediaries, to retailers and consumers.

APPENDICES

A. Additional Results

Figure A1 provides baseline evidence that demand for food in Tanzania is consistent with the predictions of the literature (e.g., Aitchison and Brown 1954; Prais 1952). The Engel curve (panels 1 and 2) of the graph show that spending on food generally increases with income, while the share of total household budget spent on food decreases.

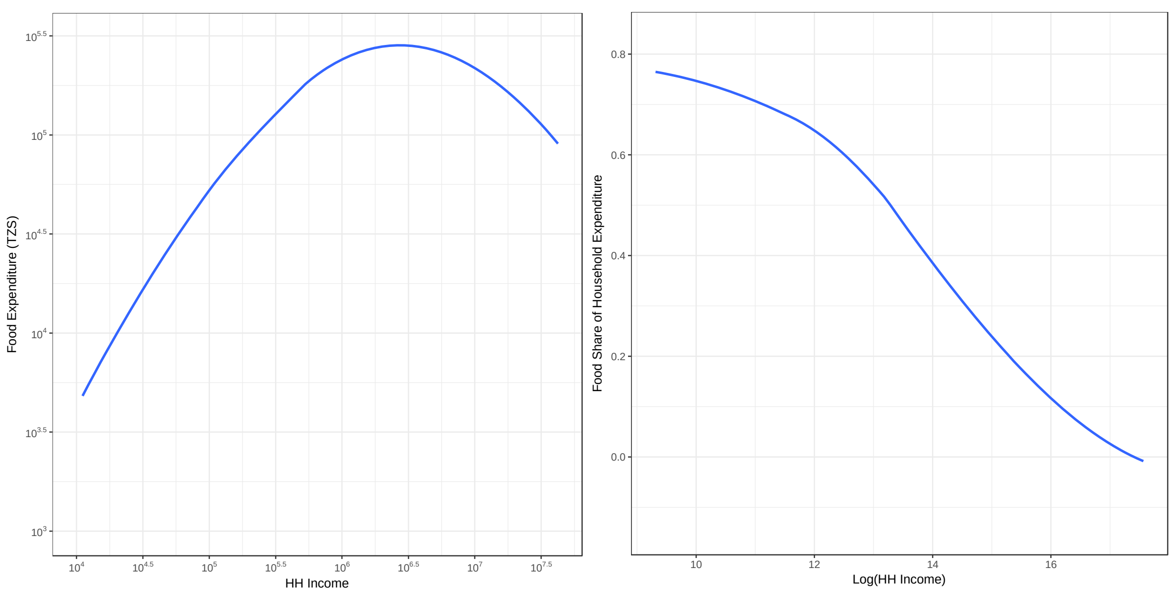
The Lowess plot of food expenditure and food's share of total household spending against household income establishes that consumer behavior in the data is consistent with other studies.

Most households purchased only one type of oil. 8,988 of the 10,168 households surveyed purchased edible oil (88.4%). Of these households that purchased edible oil, 98% purchased no more than two types of oil. The pattern of consumption is linked to geography, as expected. Palm oil is largely imported, thus it is prevalent in the port city of Dar-es-Salaam. On the other hand, sunflower oil is prevalent in markets within the sunflower belt—the farming regions in Tanzania's hinterland that produce most of its oilseeds.

Palm oil is the most purchased oil-type, followed by generic oils (62.8% and 33.4% of households that purchased edible oils, respectively). The data suggest combinations of edible oil purchases within the scope of the survey account for a small portion (21.61%) of households that purchase edible oils. The most common combination of oil purchases is palm oil and generic oils, with 1,052 households.

Price differences do not explain all of the rural-urban differences in the consumption of edible oils.

Figure A1. Engel Curves for Tanzanian Households



Data: Government of Tanzania 2012 Household Budget Survey (HBS).

Table A1. Patterns of Oil Use by Households

	Households that used each oil-type	(%)	
Sunflower oil	1,829	20.35%	(out of 8,988)
Palm oil	5,648	62.84%	(out of 8,988)
ccgs oils*	783	8.71%	(out of 8,988)
Generic oils**	3,001	33.39%	(out of 8,988)
Total***	8,988	88.39%	(out 10,168)
	Households that used only 1 oil-type		
Sunflower oil	1,114	16.20%	(out of 6,878)
Palm oil	3,848	55.95%	(out of 6,878)
ccgs oils*	364	5.29%	(out of 6,878)
Generic oil**	1,552	22.56%	(out of 6,878)
Total (#1)	6,878	76.52%	(out of 8,988)
	Households that used only 2 oil-types		
Sunflower and palm	380	19.57%	(out of 1,942)
Sunflower and ccgs*	35	1.80%	(out of 1,942)
Sunflower and generic**	174	8.96%	(out of 1,942)
Palm and ccgs*	213	10.97%	(out of 1,942)
Palm and generic**	1052	54.17%	(out of 1,942)
ccgs* and generic **	85	4.38%	(out of 1,942)
Total (#2)	1,942	21.61%	(out of 8,988)
Total (#1+#2)	8,820	98.13%	(out of 8,988)
	Households that used 3 or more oil-types		
Sunflower plus other oils	126	75.00%	(out of 168)
Palm plus other oils	155	92.26%	(out of 168)
ccgs plus other oils*	83	49.40%	(out of 168)
Generic plus other oils**	138	82.14%	(out of 168)
Total***	168	1.87%	(out of 8,988)

Data: Government of Tanzania 2012 Household Budget Survey (HBS).
Note: *ccgs is coconut, cottonseed, groundnut, and sesame oil, **generic oil, contains all other oils not specified, ***there exists some overlap in counting, so the total does not reflect the column sum

Table A2. Mean Price of Purchased Edible (TZS/ml)

	Mean Price (1L)			Mean Price (0.1L)		
Oil Type	Dar-e-S	O. Urban	Rural	Dar-e-S	O. Urban	Rural
Sunflower	2.97	2.84	2.99	3.17	2.57	2.96
Palm	2.34	2.65	2.52	3.62	3.31	2.90
Cottonseed		2.77	2.44	1.83	3.94	2.58
Groundnut	3.00		1.82	2.50	1.00	3.04
Sesame			3.20	3.33	2.00	3.78
Other (generic)	2.91	2.66	2.65	3.88	3.28	3.25

Data: Government of Tanzania 2012 Household Budget Survey (HBS).
Note: Dar-e-S is Dar-es-Salaam and O. Urban represents other urban areas outside Dar-es-Salaam. Prices in Tanzanian shillings per milliliter (TZS/ml) are shown for purchases of standard quantity units (1 litre and 0.1L) to ensure meaningful comparisons.

B. Income and Compensated Price Elasticities

Tables A3 to A5 show the own-price and cross-price elasticities with compensated elasticities.

Table A3. QUAIDS Estimates with Corrections for Zeros

	Sunflower oil	Palm oil	Other edible oils	All other food	Non-food
	b/se	b/se	b/se	b/se	b/se
Sunflower oil	-0.853***	0.359***	-0.099***	0.307***	0.121***
	(0.006)	(0.007)	(0.006)	(0.017)	(0.013)
Palm oil	0.150***	-0.807***	0.215***	0.365***	0.198***
	(0.003)	(0.003)	(0.003)	(0.012)	(0.016)
Other edible oils	0.149***	0.142***	-0.697***	0.326***	0.159***
	(0.005)	(0.003)	(0.004)	(0.014)	(0.010)
All other food	0.162***	0.216***	0.218***	-0.706***	0.081***
	(0.008)	(0.011)	(0.010)	(0.014)	(0.013)
Non-food	0.010	0.106***	0.186***	0.296***	-0.643***
	(0.018)	(0.029)	(0.032)	(0.051)	(0.025)

Note: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Table A4. QUAIDS Estimates without Corrections for Zeros

	Sunflower oil b/se	Palm oil b/se	Other edible oils b/se	All other food b/se	Non-food b/se
Sunflower oil	-0.788**	0.323	-0.985	0.535	0.168
	(0.284)	(0.273)	(1.124)	(2.941)	(1.866)
Palm oil	-0.210	-0.907***	0.033	0.826	0.425
	(0.119)	(0.098)	(0.121)	(1.068)	(0.599)
Other edible oils	0.238**	-0.208	-0.698***	0.575	0.324
	(0.075)	(0.143)	(0.177)	(1.925)	(1.016)
All other food	0.062**	0.055***	0.018	-0.391***	0.233***
	(0.020)	(0.012)	(0.017)	(0.021)	(0.046)
Non-food	-0.088***	-0.044	0.009	0.607	-0.446***
	(0.017)	(0.027)	(0.036)	(0.310)	(0.060)

Note: * p<0.05, ** p<0.01, *** p<0.001.

Table A5. QUAIDS Estimates: Users of Both Palm and Sunflower Oil

	Sunflower oil b/se	Palm oil b/se	Other edible oils b/se	All other food b/se	Non-food b/se
Sunflower oil	-0.792**	0.318	-0.964	0.539	0.166
	(0.264)	(0.252)	(1.035)	(2.872)	(1.805)
Palm oil	-0.206	-0.908***	0.032	0.825	0.420
	(0.117)	(0.097)	(0.119)	(1.049)	(0.585)
Other edible oils	0.242***	-0.210	-0.695***	0.577	0.320
	(0.073)	(0.140)	(0.186)	(1.951)	(1.021)
All other food	0.062**	0.055***	0.017	-0.388***	0.231***
	(0.020)	(0.012)	(0.016)	(0.021)	(0.047)
Non-food	-0.088***	-0.044	0.009	0.610	-0.447***
	(0.017)	(0.027)	(0.036)	(0.313)	(0.059)

Note: * p<0.05, ** p<0.01, *** p<0.001.

C. Estimates Using Broad Product Categories

Table A6 shows clear evidence of substitution between edible oils and other product groups, as well as elastic own-price demand. The rows represent the product for which we estimate the response to a change in price for the product group in the column. To interpret the first row of the table, we see that own-price elasticity of edible oils is a statistically significant -1.05, while the cross price elasticity with starches is 0.197, suggesting that a 1% increase in starches should come with slightly less than a 0.2% increase in the demand edible oils, as consumers substitute away from starches to oils (or other food items).

The pattern in columns 2-6 suggests that most food groups as defined are substitutes, but that the substitution relationships are not statistically significant. The items that stand out are the positive response to the demand for edible oil with a hypothetical price increase for starches, the statistically significant cross-price elasticity of protein with other foods, and the implied finding that edible oils are complements with non-foods, or a subset of the non-food group. The findings imply that a change in edible oils prices prompt changes to consumer demand, largely in the form of substitution to other food products outside the starchy staples and protein-rich options.

Table A6. QUAIDS Model Results: Broad Product Categories

	Edible oils b/se	Starches b/se	Proteins b/se	Other food b/se	Non-food b/se
Edible oils	-1.050***	0.197***	0.080	-0.088	-0.075
	(0.030)	(0.049)	(0.048)	(0.473)	(0.593)
Starches	0.102	-1.169***	-0.065*	0.098	-0.033
	(0.080)	(0.106)	(0.032)	(0.198)	(0.100)
Proteins	0.036	0.214	-1.106***	-0.022	0.018
	(0.049)	(0.142)	(0.037)	(0.143)	(0.099)
Other food	0.036*	0.017	0.062***	-1.039***	-0.214
	(0.015)	(0.019)	(0.019)	(0.073)	(0.135)
Non-food	-0.106**	0.011	0.038	-0.028	-0.832**
	(0.037)	(0.033)	(0.049)	(0.225)	(0.308)

Note: * p<0.05, ** p<0.01, *** p<0.001.

REFERENCES

Aitchison, J. and J.A. Brown. 1954. A Synthesis of Engel Curve Theory. *Review of Economic Studies* 22.1: 35-46.

Akbay, C. 2007. Urban Households Cooking Oil and Fat Consumption Patterns in Turkey: Quality vs. Quantity. *Quality and Quantity* 41.6: 851-867.

Alphonce, R., D. Tschirley, V. Caputo, and T. Reardon. Forthcoming working paper. Consumer Preference for Processed Foods: A Comparison of Rural and Urban Tanzania.

Banks, J., R. Blundell, and A. Lewbel. 1997. Quadratic Engel Curves and Consumer Demand. *Review of Economics and Statistics* 79.4: 527-539.

Brown, T.M. 1952. Habit Persistence and Lags in Consumer Behaviour. *Econometrica: Journal of the Econometric Society* 20.3: 355-371.

Byerlee, D. and S. Haggblade. 2013. *African Food Systems to 2030: Toward Inclusive Business Models.* Stanford, CA: Center on Food Security and the Environment, Stanford University.

Dalberg. 2018. Feasibility Study for the Edible Oil Sector in Tanzania. Dar-es-Salaam, Tanzania: Dalberg.

Deaton, A. and J. Muellbauer. 1980. An Almost Ideal Demand System. *American Economic Review* 70.3: 312-326.

Denton, F.T. and D.C. Mountain. 2016. Biases in Consumer Elasticities Based on Micro and Aggregate Data: An Integrated Framework and Empirical Evaluation. *Empirical Economics* 50.2: 531-560.

Devereux, S. and S. Maxwell. 2001. *Food Security in Sub-Saharan Africa.* London: ITDG Publishing.

Dewanta, A.S., R.N. Arfani, and E. Erfita. 2016. Elasticity and Competitiveness of Indonesias Palm Oil Export in India Market. *Economic Journal of Emerging Markets* 8.2: 148-158.

Dorosh, P.A. and S.C. Babu. 2017. *From Famine to Food Security: Lessons for Building Resilient Food Systems.* IFPIR Policy Brief. Washington, DC: International Food Policy Research Institute

Dynan, K.E. 2000. Habit Formation in Consumer Preferences: Evidence from Panel Data. *American Economic Review* 90.3: 391-406.

East African Community. 2018. Overview of the East African Community Customs Union. URL https://customs.eac.int/index.php?option=com_content&view=article&id=123&Itemid=78

Fang, C. and J.C. Beghin. 2002. Urban Demand for Edible Oils and Fats in China: Evidence from Household Survey Data. *Journal of Comparative Economics* 30.4: 732-753.

Fattore, E., C. Bosetti, F. Brighenti, C. Agostoni, and G. Fattore. 2014. Palm Oil and Blood Lipid-Related Markers of Cardiovascular Disease: A Systematic Review and Meta-Analysis of Dietary Intervention Trials. *American Journal of Clinical Nutrition* 99.6: 1331-1350. https://doi.org/10.3945/ajcn.113.081190.

Food and Agriculture Organization of the United Nations (FAO) 2018. FAOSTAT Database. Retrieved on March 25, 2018. www.fao.org/faostat/en/.

Ghosh, N. 2009. *Effects of Tariff Liberalization on Oilseed and Edible Oil Sector in India: Who Wins and Who Loses?* Working Paper No. 2. Mumbai, India: Takshashila Academia of Economic Research Limited. https://www.researchgate.net/publication/228951063_Effects_of_tariff_liberalization_on_oil seed_and_edible_oil_sector_in_India_Who_wins_and_who_loses

Government of Tanzania. 2016. 2014/15 Annual Agricultural Sample Survey Report. Vol. September. National Bureau of Statistics. Dar es Salaam, Tanzania: Tanzania's National Bureau of Statistics. http://www.nbs.go.tz/nbstz/index.php/english/statistics-by-subject/household-budget-survey-hbs

Govindaraj, G. 2010. Dynamics of Edible Oils in Tamilnadu-An Econometric Analysis. Ph.D. Thesis. University of Agricultural Sciences GKVK, Bangalore.

Guo, X., B.M. Popkin, T.A. Mroz, and F. Zhai. 1999. Food Price Policy Can Favorably Alter Macronutrient Intake in China. *The Journal of Nutrition* 129.5: 994-1001.

Hsu, H.-H., W.S. Chern, and F. Gale. 2001. How Will Rising Income Affect the Structure of Food Demand? In *China's Food and Agriculture: Issues for the 21st Century/AIB-775*. Economic Research Service/USDA. Pages 10-13. https://www.ers.usda.gov/webdocs/publications/42432/15186_aib775_1_.pdf?v=41055#page=16

Huq, A. and F. Arshad. 2010. Demand Elasticities for Different Food Items in Bangladesh. *Journal of Applied Sciences* 10.20: 2369-2378.

Kumar, P., A. Kumar, S. Parappurathu, and S. Raju. 2011. Estimation of Demand Elasticity for Food Commodities in India. *Agricultural Economics Research Review* 24.1: 32

Lecocq, S. and J.-M Robin . 2015. Estimating Almost-Ideal Demand Systems with Endogenous Regressors. *Stata Journal* 15.2: 554-573.

Liverpool-Tasie, S., A. Sanou, and T. Reardon. 2017. *Demand for Imported-Frozen versus Domestic-Traditionally Processed Fish in Africa: Panel Data Evidence from Nigeria.* Feed the Future Innovation Lab for Food Security Policy Research Brief No. 57. East Lansing: Michigan State University.

Mabiso, A. and D. Weatherspoon. 2008. Fuel and Food Tradeoffs: A Preliminary Analysis of South African Food Consumption Patterns. Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, July 27-29. Orlando, Florida.

Maxwell, D. 1999. The Political Economy of Urban Food Security in Sub-Saharan Africa. *World Development* 27.11: 1939-1953.

Me-Nsope, N.M. and J.M. Staatz, 2016. Household-Level Evidence of Cereals Demand and the Welfare Implications of Cereals Price Shocks in Rural and Urban Mali. Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016. Addis Ababa, Ethiopia.

Mittal, S. 2010. Application of the QUAIDS Model to the Food Sector in India. *Journal of Quantitative Economics* 8.1: 42-54.

Ng, S.W., F. Zhai, and B.M. Popkin. 2008. Impacts of China's Edible Oil Pricing Policy on Nutrition. *Social Science and Medicine* 66.2: 414-426.

Nyange, D., A. Weliwita, and H. Tsujii. 2003. Food Demand Patterns in Tanzania, A Censored Regression Analysis of Microdata. *Sri Lankan Journal of Agricultural Economics* 5.1: 9-34.

Pan, S., S. Mohanty, and M. Welch. 2008. India Edible Oil Consumption: A Censored Incomplete Demand Approach. *Journal of Agricultural and Applied Economics* 40.3: 821-835

Persaud, S.C. and M. Landes. 2006. *The Role of Policy and Industry Structure in India's Oilseed Markets*. Economic Research Report No. 17. Washington, DC: US Department of Agriculture, Economic Research Service.

Poi, B.P. 2012. Easy Demand-System Estimation with QUAIDS. *Stata Journal* 12.3: 433-446.

Pollak, R.A. 1970. Habit Formation and Dynamic Demand Functions. *Journal of Political Economy* 78.4, Part 1: 745-763.

Popkin, B.M. 2001. The Nutrition Transition and Obesity in the Developing World. *Journal of Nutrition* 131.3: 871S-873S.

Prais, S.J. 1952. Non-linear Estimates of the Engel Curves. *Review of Economic Studies* 20.2: 87-104.

Ravina, E. 2005. *Habit Persistence and Keeping up with the Joneses: Evidence from Micro Data*. NYU Working Paper No. FIN-05-046. New York, NY: New York University.

Reardon, T., D, Tschirley, B. Minten, S. Haggblade, P. Timmer, and S. Liverpool-Tasie. 2013. The Emerging Quiet Revolution in African Agrifood Systems. Brief presented at the Harnessing Innovation for African Agriculture and Food Systems: Meeting Challenges and Designing for the 21st Century, November 25-26 2013. Addis Ababa, Ethiopia.

Shonkwiler, J.S. and S.T. Yen. 1999. Two-Step Estimation of a Censored System of Equations. *American Journal of Agricultural Economics* 81.4: 972-982.

Srinivasan, P. 2005. Impact of Trade Liberalization on India's Oilseed and Edible Oils Sector. Working Paper. Report prepared for IGIDR-ERS/USDA Project: Indian Agricultural Markets and Policy February 2, 2005. Mumbai and Washington DC: IGIDR-ERS and United States Department of Agriculture, Economic Research Service.

TPSF. 2017. Fiscal Policy Study on Edible Oil Sector in Tanzania. June. Dar-es-Salaam, Tanzania: Tanzania Private Sector Foundation.

Tschirley, D., T. Reardon, M. Dolislager, and J. Snyder. 2015a. The Rise of a Middle Class in East and Southern Africa: Implications for Food System Transformation. *Journal of International Development* 27.5: 628-646.

Tschirley, D., J. Snyder, M. Dolislager, et al. 2015b. Africa's Unfolding Diet Transformation: Implications for Agrifood System Employment. *Journal of Agribusiness in Developing and Emerging Economies* 5.2: 102-136.

UN COMTRADE data. https://comtrade.un.org

United Nations. 2014. World Urbanization Prospects: The 2014 Revision. Vol. 352. New York, NY: United Nations Publications.

Yingchun, Dai, Francis Tuan, William W. Lin, Funing Zhong and Xi Chen. 2006. Does Biotech Labeling Affect Consumers' Purchasing Decisions? A Case Study of Vegetable Oils in Nanjing, China. Selected paper for the American Agricultural Economics Association (AAEA) 2006 Annual meeting, July 23-26. Long Beach, CA.

Zerbe, N. 2004. Feeding the Famine? American Food Aid and the GMO Debate in Southern Africa. *Food Policy* 29.6: 593-608.

Zheng, Z. and S.R. Henneberry. 2012. Estimating the Impacts of Rising Food Prices on Nutrient Intake in Urban China. *China Economic Review* 23.4: 1090-1103.