An Analysis of Demand for Roots and Tubers in Kenya using the Linear Approximation Almost Ideal Demand System (LA-AIDS)

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Abstract

This article examines Kenya's household demand for major roots and tubers using data obtained from Kenya Integrated Household Survey of 2005-2006. The normalized data is analyzed using the Linear Approximation Almost Ideal Demand System (LA-AIDS) model with symmetry and homogeneity restrictions imposed. Estimated own-price elasticities indicate that the demand for potato, sweet potato, arrow roots, and cooking bananas are elastic while the demand for cassava is price inelastic. Estimated cross-price elasticities suggest that potato and sweet potato, potato and arrow roots, and potato and cooking bananas are substitutes while potato and cassava are compliments. Estimated income elasticities for potatoes and cassava are positive but less than one, thus these are necessity food items in Kenya's roots and tubers demand system. However, estimated income elasticities for sweet potato, arrow roots, and cooking bananas are all positive and greater than one implying that these are luxury food items for the Kenyan households.

Keywords Root and tubers, Linear Approximate Almost Ideal Demand System (LA-AIDS), Marshallian Elasticity, Hickisian Elasticity.

1. Introduction

Root and tuber crops play an important role in food security and nutrition in sub-Saharan Africa including Kenya (Nweke, 2004). They provide an important source of income through value addition and direct sale (Okigbo, 1989). Second to cereals in the importance are root and tubers which are also the source of carbohydrates, minerals, and vitamins (Hahn, 1984). With the growing population in Sub-Saharan Africa, there is increasing demand for root and tuber crops both for food and for feed. Root and tubers provide around 20 percent of the daily per capita calorie intake for the millions of people living in this area in Sub-Saharan Africa. The aggregate value of yam, cassava, potato and sweet potato exceeds all other African staple crops and is much higher than the value of cereal crops (Sanginga, 2005).

Most developing countries in Africa, Asia, and Latin America depend on root and tubers as major staple food crops with Cassava, Yam, Cocoyam, Irish and Sweet potatoes being the major crops. Africa total per capital consumption of root crops is 181 kg/capital with cassava 115kg/capital and yam 39 kg/capital being the most important. In North Central America potatoes form 92 percent of the root and tubers consumed (Sanni *et al*., 2003). Yam, cassava, potato and sweet potato are cheap and rich in nutrients.

Roots and tubers contribute to the energy and nutrition requirements of many people and constitute an important source of income in rural and marginal areas. They are normally food security crops, regular food crops, cash crops and used as livestock feed and raw material for industrial purposes. They have for a long time serve as the source of food and nutrition for many of the world's poor and malnourished households and are generally valued for their stable yields under conditions in which other crops may fail (Scott *et al*, 2000). Cassava and sweet potatoes are two important food and cash crops of Kenya. Cassava is described as a classic food security crop and can grow amidst erratic rainfall and infertile soil. Cassava is a major source of dietary energy for the large population of tropical Africa. It ranks second in importance to Irish potato among other root crops. It can survive drought and poor soil conditions. However, like other crops, it responds well to good crop husbandry. As such it's an ideal resource to farmers in the arid and semiarid land (ASAL) because of its low input requirements. It is able to provide food throughout the year because of its long underground storability.

Cassava is grown in Western, Eastern/Central and Coastal regions in Kenya. According to FAO (2008), an average yield of fresh cassava in Kenya was 10.6 ton/ha in 2007 which was above African average of 9.9 ton/ha. Efforts towards the development of the Cassava industry in Kenya have been focused on the development of high-yielding varieties that are tolerant to pests and diseases. More than 20 cassava varieties have been developed so far. Despite this success, the cassava industry continues to face several challenges. Cassava production has been declining due to shift to other crops that give more returns than cassava, use of poor quality seed and endemic spread of pests and diseases, high cyanogenic content, and a high percentage of post-harvest losses (GOK, 2007).

Sweet potato is one of the high yielding crops with higher food value and total production compared to other crops such as sorghum, maize, and millet. Sweet potato is the world's 7th most important food crop after wheat, rice, maize, barley and cassava (Nungo *et al*., 2007). Sweet potato is an important traditional root crop in Kenya. About 63 percent of the area under sweet potato cultivation is in the Western Kenya and Nyanza Provinces (Shakoor *et al*., 1988). Sweet potatoes, particularly the yellow-fleshed varieties, are good sources of vitamins. At the same time, they yield more calories per acre than many other starchy foods. Sweet potatoes can also be continuously grown throughout the year Kapinga *et al*. (1995). Mutuura *et al*. (1992) suggest that sweet potato is an important food security crop when maize is in short supply or in years of drought. The cultivation of sweet potatoes in most areas in Kenya is enhanced by its ability to adapt to a wide range of climatic conditions including the areas which receive little rains.

The area under production of sweet potato has been declining. Mudiope *et al*. (2000) mentioned sweet potato weevils, drought and lack of planting materials as common problems in Uganda. Additionally, labor shortage, lack of machinery and land scarcity were cited by Bashaasha *et al*.(1995) while in neighboring Tanzania, low soil fertility and pests such as moles, rats and pigs were reported (Kapinga *et al*.1995).Potato is the 3rd world most important food crop after rice and wheat with 309 million tons fresh weight tubers. Half of the potatoes production in 2007 was from Asia Latin America and Africa (http://.faostat.fao.org , accessed 01/20/2016).

Table 1: Production and consumption of major root and tuber crops.

Production (1000 tons)	Total Africa	Total world	Consumption	
			Africa	World
Cassava	85,945	158,620	115	27
Sweet potatoes	7,018	129,164	9	22
Potatoes	8,935	295,632	12	50

Sanni *et al*. (2003)

Scott *et al* (2000) argue that, in much of Asia and North Africa, rising incomes and urbanization and a desire by consumers to diversify away from strictly cereal-based diets have increased the use of potato as either fresh food or in processed form. Despite the clear potential of sweet potato in helping to meet Kenya's food requirements, full exploitation of this opportunity is constrained by its bulkiness, perishability, high cost per unit sold, and low consumer acceptability. Consumers perceive it only as a snack and not as a food which can constitute the main part of a family's diet (Gakonyo, 1993). Though root and tubers hold an important position for economic development and food security in Kenya, systematic studies have not been conducted to assess demand for these commodities hence this study intends to fill this knowledge gap. The purpose of this study is to gain a better understanding of consumer demand for root and tuber crops in Kenya.

2. Empirical framework.

Economics analysis of consumer behavior is of great importance. Several studies have model demand functions using different approaches. Most demand models are usually specified in a way that is flexible and simultaneously consistently with economic theory. They assume weak separability of preference for goods. According to Deaton and Muellbauer (1980a), consumer theory requires that demand system must satisfy some general conditions such as adding up restriction, homogeneity of degree zero; symmetry of cross substitution effect. In practice, linear Approximation Almost Ideal Demand system is more frequently estimated because it helps avoid non-linearity and reduce multicollinearity. This paper analyses demand using the Linear Approximation Almost Ideal Demand system model, specified as follows:

(1) $w_{it} = \propto_i + \sum_{j=i}^{n} \gamma_{ij}\, lnp_{jt} + \beta_i \ln\left(\frac{x_t}{P}\right)$

Where, w_{it}= budget share of good i, at time t; i.e ($w_i = P_i Q_i / X_i$);

p_j=Price for good j.

X_t =Total expenditure on the goods in the system, at time t, given by $X = \sum_i^n p_i q_i$

P_t=Price index of the form:

(2) $ln(P) = \sum_{i=1}^n w_{it} \ln(P_{it})$

The form of the price change measurement is based on Green and Alton (1990). The modification allows for the price to change as the units of measurement for prices change. The model in equation 1 is applied to an aggregated demand system consisting of five groups of root tubers: Potatoes (Irish), Sweet potatoes, Arrow roots, Cassava and Cooking bananas. Therefore in this case $i = 1, \dots 5$. The time period (t) consist of weekly observations.

To fulfil theoretic consistency, the estimated model needs to satisfy the standard demand theory restrictions:

(3) $\sum_i \alpha_i = 1,$ $\sum_i \beta_i = 0\,,$ $\sum_i \gamma_{ij} = 0,$ (Adding up restriction)

(4) $\sum_j \gamma_{ij} = 0$ (Homogeneity)

(5) $\gamma_{ij} = \gamma_{ji}\ .$ (Symmetry)

The first 3 restrictions are the adding up requirement for a demand system, where α is the coefficient of for the intercept, β_i are the price index coefficient and γ_{ij} are the price coefficient. The third restriction correspond to the homogeneity condition and the fourth is symmetry which is imposed by the model.

According to Koc and Alpay (2002), expenditure can and price elasticity can be derived easily from parameters estimates obtained in equation 1 thus:

Expenditure elasticities were calculated as:

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

Marshallian elasticities were calculated as:

(7) $\varepsilon_{ii} = \left(\frac{\gamma_{ii}}{w_i}\right) - \beta_i - 1$

(8) $\varepsilon_{ij} = \left(\frac{\gamma_{ii}}{w_i}\right) - \beta_i(w_{ij}/w_i)$

π_i is the expenditure elasticity , w_i is the budget share of good i , ε_{ii} is the own price elasticity and ε_{ij} is the cross price elasticity. Compensated (Hicksian) price elasticity e_{ij} can be derived by using $\pi_i,\ \varepsilon_{ii}, and\ \ \varepsilon_{ij}$ by using the following relation

(9) $e_{ij} = \varepsilon_{ij} + \pi_i * w_i$

LA-AIDS model above describes the relation between budget shares/expenditure proportion of *i* commodity is influenced by variable consisting of j commodity price, the variable of root and tuber.

3. Data used

The data utilized in this study was from government of Kenya 2005-2006 Kenya integrated household survey conducted by Kenya National Bureau of Statistics. The survey covered a total of 1343 clusters with sample of 13430 households stratified by districts and by urban/rural. Out of 13,340 households sampled data from a total of 329 households were considered for this study.

3.1 **Sampling technique**.

The data utilized in this study was from the government of Kenya 2005-2006 Kenya integrated household survey conducted by Kenya National Bureau of Statistics. The survey covered a total of 1343 clusters with a sample of 13430 households stratified by districts and by urban/rural. Out of 13,340 households, sampled data from a total of 329 households were considered for this study. The rest were discarded due to incomplete information.

3.2 **Method of data analysis.**

Table 2: Summary statistics of main variables of interest.

Variable	N	Mean	Std Dev	Minimum	Maximum
Quantity (Kilograms)					
Potatoes	329	3.485866	4.179471	0.25	42
sweet potatoes	329	2.787082	3.135214	0.25	28
Arrow roots	329	5.175076	38.85197	0.25	500
Cassava	329	4.940061	11.76479	0.5	200
cooking bananas	329	5.694225	12.77392	0.25	200

Prices (Kenya shillings)					
Potatoes	329	61.82979	80.91637	6	1008
Sweet potatoes	329	36.43161	31.17294	5	280
Arrow roots	329	40.15198	29.36723	2	200
Cassava	329	56.43769	63.73064	1	400
Cooking bananas	329	55.90881	69.19897	5	1000

On average potatoes were the most expensive item followed by cassava. Regarding quantity purchased, cooking bananas were the most bought commodity followed by arrow roots.

4. RESULTS AND DISCUSSIONS

The LA-AIDS analysis was carried out following Equation (1). Where w_{it} is the budget share of i th food item, X_t is the jth household total expenditure, p_{is} are the prices of i th good item faced by j th household. Expenditure share equations show that the value of R^2 ranged from 28.68 percent to 52.68 percent.

Table 3: Results for aggregated demand system using LA/AIDS.

w-pota	**Intercept**	**g potato**	**g s potato**	**g Arrow r**	**g cassava**	**g cook b**	**β**
Beta	0.205855***	−0.02941***	0.033149***	0.021178***	−0.02246***	0.021913***	−0.02437***
S.E	0.00419	0.00467	0.00665	0.00525	0.00336	0.00408	0.00306
w-sweet potatoes	**Intercept**	**g potato**	**g s potato**	**g Arrow r**	**g cassava**	**g cook b**	**β**
Beta	0.12119***	0.038304***	−0.07144***	0.007165*	0.000421	0.018597***	0.00695***
S.E	0.00341	0.0038	0.00541	0.00428	0.00273	0.00332	0.00249
w-Arrow roots	**Intercept**	**g potato**	**g s potato**	**g Arrow r**	**g cassava**	**g cookb**	**β**
Beta	0.147801***	0.001581	0.047764	−0.06883***	−0.01513***	0.019389***	0.015227***
S.E	0.00379	0.00423	0.00601	0.00475	0.00304	0.00369	0.00276
w-cassava	**Intercept**	**g potato**	**g s potato**	**g Arrow r**	**g cassava**	**g cook b**	**β**
Beta	0.203305***	−0.01553***	0.029234***	0.019556***	−0.01302***	0.016995***	−0.03723***
S.E	0.00496	0.00553	0.00786	0.00621	0.00397	0.00482	0.00361
w-cook bananas	**Intercept**	**g potato**	**g s potato**	**g Arrow r**	**g cassava**	**g cook b**	**β**
Beta	0.322247***	0.005042	−0.03871***	0.020911**	0.050172***	−0.07692***	0.03938***
S.E	0.00644	0.00718	0.0102	0.00807	0.00516	0.00626	0.00469

*significant at 10% level, **significant at 5% level, ***significant at 1% level

The LA-AIDS model was applied to the system of aggregated demand equations. The dependent variables are the budget shares for each aggregated good. The independent variables are the log of prices for commodities and the log of specified price index using normalization. The estimated parameters of the LA-AIDS equation do not have a straight forward economic interpretation but forms the basis of elasticities that is compensated and uncompensated elasticities. Concerning theoretical restrictions test, homogeneity test was satisfied. Not all price parameters (denoted by g) are significant. Price of potatoes was significant in all equations except Arrow roots and cooking bananas. Price of Arrow roots, cassava and cooking bananas were significant in all equations.

Table 4: Uncompensated (Marshallian) Price elasticities of root and tubers, LA/AIDS Model.

	Potato	Sweet potato	Arrowroots	Cassava	Cooking bananas
Potato	**-1.28481*** **	0.469352***	0.006393	-0.06924	0.178887**
Sweet potato	0.77327***	**-2.76037*** **	1.185641***	0.651348***	-1.02138***
Arrow roots	0.25506***	0.108335*	**-2.00887*** **	0.197722**	0.221998*
Cassava	-0.09483***	0.000309	-0.09483***	**-0.9842*** **	0.478243***
Cooking bananas	0.01734***	0.028117***	0.031236***	0.001435	**-1.13647*** **

*significant at 10% level, **significant at 5% level, ***significant at 1% level

Table 4 presents the estimated Marshallian price elasticities and cross-price elasticities; In general, the elasticity coefficients obtained in this study seem to conform to economic theory. Positive Marshallian cross-price elasticities imply that two goods are substitutes, while negative cross-price elasticities suggest the goods are complements. Own-price elasticities of the majority of the food items considered were elastic in addition to coming up with a negative sign as expected on a priori ground. This was consistent with the findings by Akinponde (2015) who found that own price elasticities of food were elastic and had a negative sign meaning that every price increase of commodity will lessen the number of requested commodity. However, Basarir (2013) found that own price elasticity of beef was positive. Suroso *et al* (2014) in their study on demand for the main vegetables in Java Island found that most of the cross-price parameter influenced the proportion of vegetable expenditure at the significance level of 99 percent. They also found that all commodities had a negative value of cross price elasticity meaning the commodities were compliments.

Table 5: Compensated (Hicksians) price elasticities of root and tubers, LA/AIDS Model.

	Potato	Sweet potato	Arrowroots	Cassava	Cooking bananas
Potato	**-1.2281*** **	0.434128***	0.29535***	-0.06016	0.85953***
Sweet potato	0.8683***	**-2.71288*** **	0.263352**	0.09893	1.18368***
Arrow roots	0.3544***	0.158011**	**-1.92607*** **	-0.15003***	1.02741***
Cassava	-0.03609	0.029679	-0.07502***	**-0.8863*** **	0.72223***
Cooking bananas	0.1031***	0.07102***	0.102741***	0.144446***	**-0.42141*** **

*significant at 10% level, **significant at 5% level, ***significant at 1% level

Table 5 shows Hicksian price elasticities. The Hicksian (compensated) own-price elasticities came up with negative signs as expected a priori, and are statistically significant at 1 percent level. The compensated elasticities values were generally higher than uncompensated elasticities which agree with findings by Koc and Alpay (2002) and Obayelu *et al*. (2009).The compensated own price elasticity for Sweet potatoes (-2.71288) is the most elastic indicating that Sweet potatoes consumption is sensitive to prices, followed by own price elasticity for Arrowroots (-1.92607), Potatoes (-1.2281), Cassava (-0.8863) and Cooking bananas (-0.42141). Except for price elasticity of Potato demand and vice versa and Arrowroots demand and vice versa, all other cross price elasticity carry positive signs meaning they are substitutes. Similar to own price elasticities cross price elasticities are statistically significant except for potato demand and cassava and vice versa and sweet potato demand and cassava and vice versa. Regarding the cross price elasticities, the consumption of sweet potatoes shows the strongest substitution response for the price of cooking bananas (1.18368).

Table 6: The Expenditure elasticities of demand system equation using LA-AIDS.

	Potatoes	**Sweet potatoes**	**Arrow roots**	**Cassava**	**Cooking bananas**
Expenditure	0.699378***	1.171444***	1.225353***	0.724461***	1.058282***

*significant at 10% level, **significant at 5% level, ***significant at 1% level

The calculated expenditure elasticities are all positive and statistically significant at 1 percent level, indicating that all root and tubers are can be considered as normal to luxury goods, as expected a priori.

5. Conclusion

The estimates in this paper add to the growing literature on root and tuber demand using LA-AIDS framework. LA-AIDS showed that own price elasticities of the five root and tubers are valued to be negative, meaning that every price increase will reduce the demand. The demand of the 5 commodities is elastic shown from the value of the own price which is greater than one. Moreover, cross-price elasticities are a mixture of positive and negative values, meaning commodities are a mixture of substitutes and compliments.

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