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The Demand for Fish Products in Malawi: An Almost Ideal Demand System Estimation

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Abstract
The study analyzed the demand for fish products and the factors that affect the consumption of various fish products in Malawi. Considering four fish products, namely dried fish, smoked fish, fresh fish and tinned fish, the study employed a multivariate probit model and an Almost Ideal Demand System (AIDS) model to analyze factors affecting consumption and demand for fish products respectively. Results indicate that consumption of various fish products in Malawi is affected by age, education, gender, marital status, area of residence (Urban versus rural), distance to nearest market, household annual expenditure and occupation of the household head. With regard to demand for fish products, the study found that the demand for dried fish, smoked fish, fresh fish and tinned fish is inelastic and the various fish products were found to be substitutes. It was also noticed that households would increase their expenditure on fish products if their income increases. The results are an important step in designing policies that will increase fish production and ultimately increase fish consumption. The results also show the importance of value chain development by, among others, building the capacity of the fish processors in order to help them better respond to the market and consumer needs.
Keywords: Multivariate probit, Fish, Consumption, AIDS model, Demand

1. Introduction

Fish is an important food for over 400 million Africans, contributing essential proteins, minerals and micronutrients to their diets. Fish is an excellent source of high quality animal protein and essential fatty acids, and micronutrients, which are much greater in fishes than in terrestrial animal-source foods. Fish occupy an important share in the total animal protein supply in most African countries, supplying over 25 percent of animal protein. Leading the list is Ghana, where fish provide 62 percent of animal protein supply (Gordon *et al.*, 2013). Malawi is also one of the countries with the highest dependency on fish as a source of protein in Africa. Fish provides over 30 percent of the animal proteins (Béné and Heck, 2005). The fisheries sector provides 4 percent of Malawi's Gross Domestic Product (GDP) and employs close to half a million people (Malawi Government, 2011).

Fish is one of the cheapest sources of animal protein and its consumption and demand is on the increase particularly in Africa, because of the high level of poverty (Kamangira *et al.*, 2014). Recent figures shows that the average per capita consumption in Africa stands at 8.3 kilogram (Mwina, 2012). This is lower than the recommended World Health Organization/Food and Agriculture Organization of the United Nations level of 17 kilogram and the World average of 18.9kg (Mapfumo, 2015). There is, however, wider variation among African countries. For instance, the consumption in Angola stands at 16.3kgs, 13.6kgs in Uganda, 6.1kgs in Tanzania, and as low as 1.9kgs in Rwanda (Rothuis *et al*., 2014). The per capita fish consumption in Malawi has subsequently fallen by more than 60 per cent, from 14 kg per person per year in the 1970s, to about 8 kg in 2015 due to decrease in fish supply and rapid population growth over the years (Malawi Government, 2016).

An estimated 90% of the fish caught in Malawi is processed into various products and various fish processing methods are being employed by fish processors (Mkoko, 1988). The high perishability of fish necessitates the need for fish processing in order to maintain its quality and taste. Several methods of fish processing such as sun-drying, smoking, para-boiling and pan-roasting are used in Malawi (Malawi Government, 2012). Small-size fish are traditionally sun-dried while large fish are mostly smoked (Kapute, 2008). Fresh-iced fish is also common, especially in the supermarkets. Lately, quality of processed fish has been seen as one of the factors affecting demand for fish among consumers. There is growing interest in improving fish processing in Malawi in order to address the challenge of high post-harvest losses. Post-harvest fish losses are a major concern and occur in most fish distribution chains throughout the world including Malawi, resulting in revenue losses for producers along the value chain and potential for reduced economic growth of the country (Russell, 2008).

Fish remains a key food item in the diet of most Malawians. The demand for fish in Malawi is high such that almost all fish caught is locally consumed. This has made fish one of the expensive food items on the market (Singini *et al.*, 2012). Despite the growth in demand for fish in Malawi, fish supply remains the lowest (Banda *et al.*, 2012). It is therefore envisaged that with a low fish supply, the consumption of fish is usually associated with

high incomes (Malawi Government, 2012). Much as this may be true, the various fish products attract different prices. For instance, Matiya *et al.* (2005) noted that despite fresh fish being the most preferred to the rest, smoked fish was found to constitute a large proportion of the total fish bought on the market in both urban and rural areas in Malawi. He further noted that fish processing also affects the pricing of fish. However, there is hardly any documented evidence on the consumption and demand for the various fish products consumed in Malawi. This study therefore seeks to assess the consumption patterns and demand for various fish products in Malawi.

Given the nutritive, social and economic importance of fish, an analysis of fish products demand and consumption patterns is essential for any policy measure in the fisheries and aquaculture sector. According to Dey *et al.* (2008), responses of fish demand to changes in prices and incomes are important in analyzing the effects of any technological change, infrastructure development or economic policy on future production, consumption and trade of various fisheries products. This study conducts a fish product consumption and demand analysis and proposes interventions that may be carried out to reduce post-harvest losses through prioritization of processing methods and technologies in the fisheries sector as well as increasing fish consumption among various consumers. Analyzing the demand for different fish products is crucial for prioritization of fish processing technologies for the benefit of both the consumer and the producer. This will also help food policy analysts understand how changes in income affect demand for different fish products and how such responses can help in better food policy formulation for improved food and nutrition security of all people.

The main objective of this study is to assess if different fish products affect the demand for fish in Malawi. Specifically, the study will; analyze the socio-economic factors that affect consumption of different fish products: and analyze the own-price, cross-price and income elasticity of demand for the different fish products in Malawi. The structure of the paper is as follows: Section two presents the methodology which outlines the data sources, model specification and description of variables. Section three presents empirical findings and discussion of results. Section four presents conclusion and policy implications.

2. Methodology

2.1 Theoretical framework

A two-stage AIDS model with censoring was opted. In the first stage, a multivariate probit model was used to assess the factors affecting consumption of various fish products. The multivariate probit model was also used to estimate the normal Probability Density Function (PDF) and the normal Cumulative Density Function (CDF). This was done to escape the sample selection problem that arise due to zero expenditure on some food items. In the second stage, the PDF and CDF were incorporated into the budget share equations of the AIDS model.

2.1.1. Determinants of consumption: Multivariate Probit Regression

The IHS3 data reports household expenditure on different food items for a period of seven days preceding the survey. This means that for a household that did not consume a given food item within the specified time period will record a food expenditure of zero on the food item. This is common in most cross sectional household consumption studies. The estimation of demand with zero expenditure on some food items usually results in biased estimates. To overcome such a problem, a number of techniques are proposed in literature. One such technique is the estimation of probit models to find the probability that a household consumes a given a given fish product. This selection model corrects for selection bias resulting from zero expenditure on some fish products.

The probit model estimates, however, suffers from endogeneity (Freedman and Sekhon, 2010). This is because of correlations in the error terms of the different consumption equations. The study, therefore, used a multivariate probit regression to overcome the endogeneity problem. The multivariate probit model has a structure similar to that of a seemingly unrelated regression (SUR) model, except that the dependent variables are binary indicators.

Following (Cappellari and Jenkins, 2003), the multiple regressions analog to the SUR model for M binary variables can be formulated as

$$y_{im} * = \beta_m{}' X_{im} * + \epsilon_{im}, m = 1, \dots, M \quad (1)$$

The relationship between $y_{im} *$ and y_{im} in a multivariate regression model is given by

$$y_{im} = \begin{cases} 1 \; if \; y_{im} * > 0 \\ 0 \; otherwise \end{cases} \quad (2)$$

$\epsilon_{im}, m = 1, \dots, M$ are error terms distributed as multivariate normal, each with a mean of zero, and variance–covariance matrix V, where V has values of 1 on the leading diagonal and correlations $p_{kj} = p_{jk}$ as off-diagonal elements.

The log-likelihood function for a sample of N independent observations is given by;

$$L = \sum_{i=1}^{N} w_i \log \emptyset_h (\mu_i; \cap) \quad (3)$$

where w_i is an optional weight for observation $i = 1, \ldots, N$, and $\emptyset_h$ (.) is the multivariate standard normal distribution with arguments μ_i and $\cap$, where

$$\mu_i = (K_{i1}\beta_{i1}'X_{i1}, K_{i2}\beta_{i2}'X_{i2}, \ldots., K_{ih}\beta_{ih}'X_{ih} \quad (4)$$

with $K_{ik} = 2y_{ik} - 1$, for each *i, k = 1,….j.* Matrix $\cap$ has constituent elements $\cap_{jk}$ where

$$\cap_{jj} = 1 \; for \; j = 1, \ldots, h \quad (5)$$

$$\cap_{21} = \cap_{12} = K_{i1} K_{i2} \rho_{21} \quad (6)$$

$$\cap_{31} = \cap_{13} = K_{i3} K_{i1} \rho_{31} \quad (7)$$

$$\cap_{jk} = \cap_{kj} = K_{ih} K_{ih-1} \rho_{hh-1} \quad (8)$$

As shown, the log-likelihood function depends on the multivariate standard normal distribution function $\emptyset_h$ (.). Estimation of the multivariate probit model requires evaluation of M-order Integrals. The general case is usually handled with the Geweke–Hajivassiliou–Keane (GHK) simulator. The GHK simulator has a number of desirable properties in the context of multivariate normal limited dependent variable models in that the simulated probabilities are unbiased, they are bounded within the (0,1) interval, and the simulator is a continuous and differentiable function of the model's parameters (B¨orsch-Supan and Hajivassiliou 1993). The GHK simulator exploits the fact that a multivariate normal distribution function can be expressed as the product of sequentially conditioned univariate normal distribution functions, which can be easily and accurately evaluated.

After estimation of the multivariate probit model, the Inverse Mills Ratio (IMR) is generated from the multivariate standard normal probability density function. The IMR is given as;

$$IMR_{ij} = \frac{-\emptyset (f_{ij})}{1 - \Phi(f_{ij})} \quad (9)$$

The IMR is used as an instrumental variable. The IMR is added in the model as an exogenous variable in the demand equation to correct the bias problem (Sadoulet and Janvry, 1995).

2.1.2 An Almost Ideal Demand System (AIDS) model

During the last two decades, the AIDS and Rotterdam models have gained prominence in demand analysis of both food and non-food items. The model of Deaton and Meulbauer (1980) has become the model of choice for many applied demand analysts in modelling consumer demand behavior. The AIDS model is frequently used since it can be estimated in a linearized form with theoretical restrictions easily imposed and tested. The AIDS model automatically satisfies the aggregation restriction, and with simple parametric restrictions, homogeneity and symmetry can be imposed (Epstein and Rubinfeld, 2004). The model has been widely used to analyze the demand for food stuffs such as fish (Asche *et al.*, 2005; Debnath *et al*., 2012), meat and dairy products (Akaichi and Revoredo-Giha, 2013; Alboghdady and Alashry, 2010) and other food stuffs as in Maganga *et al.* (2012). In agriculture, it has also been used to estimate the demand for improved legume seeds (Kamkwamba *et al.*, 2012). Demand systems are usually specified with the expenditure share by a given food item as the dependent variable. A household's expenditure share of food for food item *i* is given as

$$\boldsymbol{w_i} = \frac{\boldsymbol{p_i q_i}}{\boldsymbol{m}} \quad (10)$$

Where p_i is the price paid for good i , q_i is the quantity of good i consumed and m is the total expenditure on all goods in the demand system (Poi, 2002). In the AIDS model, expenditure share equations have the form.

$$w_i = \alpha_i + \sum_j y_{ij} \log p_i + \beta_i \log \{x/p\} + u \quad (11)$$

Where w_i is the i^{th} good share, γ_{ij} is the slope coefficient associated with the j^{th} good in the i^{th} share equation, and P_i is the price on the j^{th} good. X is the total expenditure on all the goods, and P is the price index. The price index P is given by

$$\ln p = \alpha_0 + \sum_j a_j \ln p_j + \frac{1}{2} \sum_j \sum_i y_{ij} \ln p_i \ln p_j \quad (12)$$

The use of the general price index complicates the model. Deaton and Meulbauer (1980) suggested the Stone's price index, which can be used instead of the translog price index. The Stone's price index is defined as follows:

$$lnP = \sum_{i=1}^{n} w_i \, ln \, P_i \quad (13)$$

Using the Stone's price index for the translog price index gives rise to the linear approximate of the AIDS model (LA/AIDS) model. The use of the LA/AIDS model is based on the fact that it is comparatively easy to estimate and a reasonably good approximation to the true AIDS. However, the suggestion by Deaton and Meulbauer (1980) led to much debate over the appropriate specification of the LA–AIDS elasticities and the overall properties of the LA–AIDS model. Some studies, using Monte Carlo simulations, have shown that the results from LA/AIDS compare more or less well to the AIDS model. (Alston *et al*., 1994; Buse, 1994; Green and Alston. 1990).

Economic theory imposes the following restrictions on the AIDS model; Homogeneity, Slutsky symmetry and the adding-up condition (Poi, 2002)

Homogeneity in the model is satisfied if and only if

$$\sum_{i=1}^{n} y_{ij} = 0 \quad (14)$$

In AIDS model, the condition for Slutsky symmetry for any two goods i and j is given by

$$y_{ij} = y_{ji} \quad (15)$$

Adding up is given by

$$\sum_{i=1}^{n} \alpha_i = 1, \sum_{i=1}^{n} \beta_i = 0, y_{ij} = 0 \ \sum_{1}^{n} w \ 1w \quad (16)$$

2.1.2.1 Marshallian price and expenditure elasticities

The expenditure elasticities and the Marshallian price elasticities are calculated as follows (Alboghdady and Alashry, 2010).

Expenditure elasticity:

$$\eta_i = 1 + \frac{\beta_i}{\omega_i} \quad (17)$$

Marshallian own-price and cross-price elasticities are given below.

$$\varepsilon_{ii} = -1 + \frac{\gamma_{ii}}{\omega_i} - \beta_i \quad (18)$$

$$\varepsilon_{ij} = -1 + \frac{\gamma_{ij}}{\omega_i} - \beta_i \ \frac{\omega_j}{\omega_i} \quad (19)$$

2.2 Data sources

The study uses data from Integrated Household Survey 3 (IHS3) which was conducted by the National Statistical Office (NSO) between March 2010 and March 2011. The survey collected information on various aspects of household welfare in Malawi. A total of 12, 271 households were interviewed at the end of the survey. The survey collected data on food items the household consumed seven days before the survey. One such food item is fish. The data comprise of fish under five methods of fish preservation method namely; dried fish, fresh fish, smoked fish, tinned fish and soup fish. Analysis was done using Stata Version 13.

2.3. Description of the independent variables

Table 1 gives a brief description of the independent variables which were used to analyze the determinants of consumption of various fish products. A Multivariate Probit regression model has been employed to achieve such objective.

Table 1: description of independent variables

Variable	Definition	Observations	Mean	Std. Dev	Expected sign
Household size	Number of people in the household	12271	4.5634	2.2075	+
Age	Age of the household head in years	12271	42.148	16.225	+
Education	Number of years spent in school	12271	5.8363	4.5041	+/-
Marital status	1 = Married; 0 = otherwise	12271	0.7327	0.4425	+/-
Gender	1 = male; 0 = female	12271	0.7594	0.4274	+/-
Residence	1 = urban; 0 = rural	12271	0.1819	0.3858	+/-
Distance	Distance to the nearest main market (Km)	12271	12.637	44.730	+/-
Household expenditure	Total annual household consumption expenditure (Mk)	12271	255953 .	339801	+
Occupation	1 = Formally employed; 0 = otherwise	12271	0.2183	0.4131	+

3. Empirical Findings

3.1 Expenditure share of different fish products.

The expenditure shares for dried fish, fresh fish, smoked fish and tinned fish are all shown in Table 2. Fresh fish has the highest expenditure share of 0.475 followed by dried fish which has an expenditure share of 0.458. Tinned fish has the lowest expenditure share of 0.025. The lowest expenditure share of tinned fish is due to the fact that most tinned fish in Malawi are imported from elsewhere which makes them unaffordable for the majority of the poor households.

Table 2. Expenditure share of different fish products.

Variable	Observations	Mean	Std. Deviation	Expenditure share
Dried Fish	12271	0.2244988	0.1376104	0.4577385
Fresh fish	12271	0.2437045	0.1541186	0.4752389
Smoked fish	12271	0.0226749	0.0161657	0.0500981
Tinned fish	12271	0.0131172	0.0081097	0.025468

3.2 Factors affecting consumption of different fish products.

A Multivariate Probit model was used to analyze the factors affecting household consumption of different fish products and the results are shown in Table 3. The study found that age, education, gender, marital status, area of residence (Urban versus rural), distance to nearest market, household annual expenditure and occupation of the household head are some of the significant factors affecting consumption of various fish products. Household size was found not to significantly affect consumption of any fish product.

Table 3. Multivariate Probit Model estimates

Variable	Dried fish			Fresh fish			Smoked fish			Tinned fish		
	dy/dx	Std. error	T-score	dy/dx	Std. error	T-score	dy/dx	Std. error	T-score	dy/dx	Std. error	T-score
Household size	0.0104	0.0058	1.78	0.0054	0.0064	0.85	0.0005	0.0081	0.06	-0.0516	0.0286	-1.8
Age	-0.0024***	0.0008	-3.05	-0.0044***	0.00089	-4.9	-0.0029**	0.0011	-2.59	-0.0147***	0.0048	-3.08
Education	0.0030	0.0033	0.9	0.0056	0.0036	1.54	-0.0106**	0.0046	-2.31	0.0207	0.0133	1.56
Marital status (Married)	0.0114	0.0432	0.26	-0.0208	0.04691	-0.44	0.1205	0.0612	1.97	-0.3825**	0.1410	-2.71
Gender	0.1090**	0.0429	2.54	0.0423	0.0471	0.9	-0.0281	0.0608	-0.46	0.2003	0.1531	1.31
Residence	0.0566	0.0355	1.6	0.399***	0.0357	11.17	0.1749***	0.0453	3.86	0.6527***	0.1158	5.64
Distance to nearest market	-0.0004	0.0003	-1.5	-0.0007**	0.0003	-2.19	0.0003	0.0003	1.01	-0.0001	0.0009	-0.07
Household expenditure	0.0002	0.0003	0.5	7.61E-07***	5.17E-08	14.73	2.75E-07***	4.59E-08	6	4.74E-07***	6.61E-08	7.17
Occupation	0.0734**	0.0324	2.26	0.0238	0.0340	0.7	0.0627	0.0431	1.46	0.0978	0.1109	0.88
Number of obs.	12271											
Wald chi2(44)	1151											
Prob > chi2	0											
Log likelihood	-18079.46											

****Significant at 1%. **Significant at 5%*

Results show that an additional unit of age decreased the consumption of all the four fish products. The result on the influence of age on consumption of various fish products contradicts findings by Erdoğan *et al*. (2011) and Moses *et al*. (2015) who found a positive relationship between seafood consumption and age. It is generally argued that older people are more health conscious than younger people and would choose food such as fish for a healthier life. However, Malawi is predominantly a youthful population, with 48% of the population aged below 15 years as of 2011 (Malawi Government, 2012). The negative sign implies that the youthful population in Malawi is less mindful of their diets such that they would not opt for fish and fish products for a healthier living. Education was found to significantly affect consumption of smoked fish. An additional year spent in school reduced the consumption of smoked fish 1.06 percent. This is expected in Malawi, where the more educated earns more income and fresh fish is more preferred. This is in line with findings by Herath and Radampola (2016) who observed that university students' consumption of smoked fish in Sri Lanka was very low as compared to dried and tinned fish.

There was no significant difference between marital status and the consumption of dried, fresh and tinned fish. However, the study found that married couples consumed less tinned fish unlike the unmarried. This could be due to the nature of tinned fish which are already prepared food. Such products are preferred by single bachelors and spinsters who do not have dedicated cooking time. The study also found no significant gender differences in the consumption of fresh, smoked and tinned fish. This is similar to the findings of Erdoğan *et al*. (2011) who noted that gender does not affect fish consumption levels. For dried fish, however, the study found that male individuals consumed more dried fish by 10.9 percent than their female counterparts. These male individuals could possibly be casual laborers who usually have their lunch locally known as 'Mmemo' with the dried small pelagics due to their affordability and easy to prepare. Households whose household head was employed were also found to consume more dried fish.

The study also found a positive and significant relationship between residing in urban areas and consumption of fresh fish, smoked fish and tinned fish. Being an urban dweller increased consumption of fresh fish by 39.9 percent, smoked fish by 17.49 percent and tinned fish by 65.27 percent. The increased consumption of fish by the urban dwellers can be attributed to higher income earnings of such people. This is especially true for tinned fish, whose coefficient is much larger than that of fresh and smoked fish, and is usually highly priced. Most tinned fish found on the markets in Malawi are imported from South Africa and constitutes of the Sardines species. This makes them unaffordable to most rural based Malawians. For fresh fish, distance to market was found to reduce the consumption of fresh fish. Distance is an important factor households have to consider when it comes to making purchase decisions of fresh fish due to its fast perishability. It is therefore not surprising that the consumption of fresh fish decreases with an increase in distance to the nearest market.

In all the four fish products, it was also noticed that an increase in household expenditure increased fish consumption. Household consumption expenditure is a proxy for income, such that when income rises there is an increase in purchase of fish. Jensen (2006) noted that income is an important determinant of the level and types of foods and services purchased, and when income rises, people purchase more food.

3.3 Demand for fish, the LA/AIDS model

The LA/AIDS model was estimated by means of a Restricted Seemingly Unrelated Regression (RSUR) in Stata version 13. The theoretical restrictions of homogeneity and symmetry were imposed during the estimation. The inclusion of the inverse mills ratio in the model means that the adding-up property does not hold, hence no need to impose the adding up restriction and drop one equation (Akaichi and Revoredo-Giha, 2013). The RSUR parameter estimates and corresponding standard errors for the AIDS demand model are reported in Table 4. The own price coefficients of the model are significant at $p<0.01$.

Table 4. Parameter estimates of the LA/AIDS model.

Variables	Dried fish	Fresh fish	Smoked Fish	Tinned fish
Price of dried fish	0.1140254***			
	(0.000397)			
Price of fresh fish	-0.0651879***	0.106519***		
	(0.000274)	(0.000325)		
Price of smoked fish	-0.0384384***	-0.03113***	0.0796589***	
	(0.000295)	(0.000279)	(0.000378)	
Price of tinned fish	-0.0103991***	-0.010202***	-0.0100907***	0.0306915***
	(0.000174)	(0.000171)	(0.00019)	(0.000359)
Fish expenditure	0.0506776***	0.068813***	0.0458864***	0.0147644***
	(0.000597)	(0.00043)	(0.000404)	(0.000228)
Invmills	0.0492544	0.027603***	-0.0113957	-0.0109048***
	(0.012709)	(0.009194)	(0.007913)	(0.003206)
Constant	0.0090271	0.003362	0.0133582	0.0043423**
	(0.007834)	(0.005669)	(0.004878)	(0.001977)
Chi2	145703.4	137434.6	47587.26	7393.6

- ******, ** Significant at 1% and 5% respectively***
- ***Standard errors in parentheses***
- ***Price of fish in Malawi Kwacha (MK)***

3.3.1 Uncompensated own-price and cross-price elasticities.

Consumer theory suggests that compensated own-price elasticities are negative for normal goods. Moreover, if cross price elasticities are positive, then the two goods are substitutes. If they are negative, then the two goods are complements (Alboghdady and Alashry, 2010; Maganga *et al.*, 2014). The Uncompensated own-price and cross price elasticities are shown in Table 5.

Table 5. Uncompensated price and expenditure elasticities.

	Dried Fish	Fresh fish	Smoked fish	Tinned fish
Dried Fish	**-0.8015716**	0.173653414	1.840756391	4.448159715
Fresh fish	0.18009285	**-0.844674762**	1.690930349	4.153436925
Smoked fish	0.16848058	0.163930942	**-0.544171906**	3.098760469
Tinned fish	0.06423065	0.060893501	0.589301095	**0.190336118**
Expenditure	1.11071299	1.14479749	1.915930943	1.579723575

*The values in **bold** are own price elasticities. The rest are cross price and expenditure elasticities*

The own-price elasticities were found to be negative for fresh fish, dried fish and smoked fish but positive for tinned fish. Fresh fish showed the highest own-price elasticity of 0.84 followed by dried fish and smoked fish with own-price elasticities of 0.8 and 0.54 respectively. Dried fish, fresh fish, smoked fish and tinned fish all have inelastic demand meaning that a 1 percent increase in price will result in less than 1 percent decrease in consumption. This shows the importance of fish as a one of the major sources of animal protein in Malawi. Is also signifies the gap that is there between fish supply and demand. The low fish supply, due to among others the dwindling fish stocks, means that people will still buy fish regardless of increasing fish price as the other alternatives of animal protein such as poultry and beef are not affordable. Banda *et al.* (2012) noted that there is a high demand for fish in Malawi due to, among others, the high population growth. The demand, however, is not met by the current supply of fish. The results are similar to the findings of Dey *et al.* (2008) who observed that in Asia, households are generally less responsive to changes in prices for different fish types due to the relative importance of fish in the Asian diet contributing about 37 per cent to the total animal protein intake in most households. The positive sign of tinned fish implies that tinned fish is a Giffen good in Malawi.

The cross-price elasticities are reported in Table 5. Negative cross-price elasticities imply that the relevant items tend to be complementary, while positive elasticities imply that they tend to be substitutes (Maganga *et al*., 2014). The cross-price elasticities are all positive implying that dried fish, fresh fish, smoked fish and tinned fish are substitutes. This is indeed true considering that they are all just fish processed differently. Similar results were obtained by Fousekis and Revell (2005) in demand analysis of fish and fish products in Great Britain. The consumption of tinned fish shows the strongest substitution to dried fish (4.45) while the consumption of dried fish is not as responsive to the price of tinned fish (0.06). The second strongest substitute response is the consumption of tinned fish to that of fresh fish (4.1) followed by tinned fish for smoked fish (3.1), smoked fish for dried fish (1.8) and smoked fish for fresh fish (1.7). All the other remaining cross-price elasticities are less than 1.

3.3.2 Expenditure elasticities

The calculated expenditure elasticities are all positive and greater than one (Table 5). A one percent increase in income will increase expenditure on fish by more than one percent. For instance, a 1 percent increase in income will increase expenditure on dried fish by 1.11 percent. Smoked fish has the highest expenditure elasticity of 1.9 followed by tinned fish with an expenditure elasticity of 1.6. Matiya *et al.* (2005) noted that smoked fish was found to constitute a large proportion of the total fish bought on the market in both urban and rural areas in Malawi. Smoked fish is considered to have a longer shelf life hence can be stored for longer periods after being bought. Tinned fish has the second largest expenditure elasticity possibly due to the fact that it is one of the luxurious fish product on the market. It is therefore expected that consumption of luxurious commodities increases with increasing income. The result on expenditure elasticities agrees to the findings of Debnath *et al.* (2012) and Fousekis and Revell (2005). Fousekis and Revell (2005) found that most fish and fish products in Britain are expenditure elastic.

4. Conclusion and policy implications

The main aim of the study was to estimate the demand for fish products in Malawi. Specifically, the study analyzed the socio-economic factors that affect consumption of different fish products and analyzed the own-price, cross-price and income elasticity of demand for fish the different fish products in Malawi. The paper finds compelling evidence that the current fish supply do not satisfy the demand on the market as it has been noticed that the demand for fish products in Malawi is inelastic. It also shows that the consumption of various fish products increases with an increase in household income.

The results of the study indicate that consumption of various fish products is a function of Household income. It was noted that educated people and urban dwellers, who usually earn considerably higher incomes, prefer fresh and tinned fish to dried fish. Tinned fish, on the other hand, is mostly imported from South Africa. This signals a market potential for the fish processors in Malawi to venture into tinned fish processing. The results of this study also shows the importance market information to the producers and other processors. With available market information, the producers and processors can prioritize their processing methods to the need of the different classes of consumers. The study has also revealed that the demand for fish in Malawi is very high. The consumption of the various fish products was found to be less sensitive to price changes. This means that with the current low supply of fish, consumer purchases of fish products do not change much with an increase in price. This shows the importance of fish as an important source of animal protein in Malawi.

These results are an important step in designing policies that will increase fish production and ultimately increase fish consumption by Malawians. Investment into fish farming and re-stocking the major water bodies can help increase fish supply in the country, and in so doing benefiting the vast majority of Malawians whose livelihood, as well as food and nutrition security depend on the fisheries resources. It is important to build the capacity of the fish processors in order to help them better respond to the market and consumer needs in Malawi. This can be achieved by facilitating the transfer and adoption of modern fish processing technologies such as canned/tinned fish processing and production of other fish products such as fish sausages. Lastly, it is important to put in place mechanisms that will enhance value chain development by providing stronger links between the value chain actors in the fisheries and aquaculture sector and the consumers. This can allow the actors to better respond to the needs of the consumers. This can be achieved by, among others, encouraging PPPs.

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