Estimation of Meat and Fish Demand System in Vietnam: An Application of the Almost Ideal Demand System Analysis

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ABSTRACT

This study reports the results of Vietnam's meat and fish consumption demand analysis using AIDS models. It uses cross-sectional data (VHLSS2008) collected by General Statistics Office of Vietnam in 2008. The censored regression method for the system of equations was used to analyze meat and fish consumption patterns. The two-step demand system was estimated. In the first stage, Inverse Mill Ratio (IMR) was estimated by using the probit regression model. In the second stage, the IMR calculated previously was included in the AIDS model to estimate demand elasticities for meat and fish, based on a system approach. Meanwhile, with the estimation results, some suggestions about food policy are made. The homogeneity and symmetry restrictions were imposed on the estimated models. Coefficients of the estimated model were used to calculate expenditure and price elasticities. The results revealed that the demand for pork, chicken and fish is elastic while that for beef is inelastic. The cross-price elasticities show that beef, chicken and fish substitute for pork. The elasticities confirm that pork is necessity commodity while beef, chicken and fish are luxury goods.

Keywords: meat and fish demand, elasticities, censored regression, LA/AIDS, Vietnam.

1. INTRODUCTION

Consumption demand analysis is one of the most common topics in applied economics. Previous researches often used single equation model to estimate consumers' goods demand. Besides, characteristics of the mentioned single equation model are mainly for estimating elasticities and little attention is paid to consumption theory (Deaton and Muellbauer 1980b). For the latest decades, consumption demand analysis has taken new and systematically expanded approaches. The approaches ensure the demand system is consistent with consumption theory as demand functions are established on the basis of the theory of consumers' choice. One of the most well-known models applied by researchers is AIDS (Almost Ideal Demand System) of Deaton and Muellbauer (1980a).

Analysis for food demand structure has been common in the world, especially in developed countries, but there are still few researches on the issue in Vietnam. Some recent researches using cross-sectional data in Vietnam food demand analysis include: Linh Vu Hoang (2009), Canh Quang Le (2008), Haughton et al. (2004), Thang & Popkin (2004), Benjamin & Brandt (2002), and Minot & Goletti (2000), etc. However, most of these studies only use single equation estimations and mainly focus on rice item. On the other hand, the reliable estimation of price and expenditure elasticities for meat and fish items is important parameters in building the models used to analyze and design relevant foodstuff policies. Nevertheless, in Vietnam there are only a few empirical studies to estimate the demand elasticities for foodstuff in general and meat and fish in particular in order to serve the above-mentioned policies. Therefore, model builders and policy analysts must rely on their subjective assessments or unpublished estimation of elasticities with the result that their policy analysis partly does not reflect the reality exactly and reliably. These are the major reasons whythis research was conducted. By using AIDS model, this research aims to estimate the different types of demand elasticities for beef, pork, chicken and fish to provide empirical evidences for policy makers to design relevant policies in Vietnam.

2. THEORY AND RESEARCH METHODOLOGY

a. Theoretical Background:

According to Theil & Clements (1987), there are two utility-based approaches to generate demand systems. One approach applies classical economic optimization by

specifying a utility function, an indirect utility function, or a cost function. Examples in this class of models include classical demand systems with quantity dependent equations, linear expenditure systems, budget share demand systems from translog indirect utility functions, and AIDS. Another approach is more mathematical and flexible. It generates demand equations by defining the total differential equation for each food product and, as opposed to the first approach, it does not require the algebraic specification of utility or cost functions. Examples of demand systems generated from this approach include the Rotterdam model and Workings model.

There are various functions for demand systems. However, the choice of suitable functions depends on the empirical research (Nguyen Tien Thong, 2012). The present study uses the AIDS - Almost Ideal Demand System derived by Deaton and Muellbauer (1980a). They used the first approach by specifying the form of the cost function and then applied the Shephard's lemma to generate the popular AIDS model. AIDS is one the most common models for the estimation of demand system. This is probably because it provides a first–order approximation to any demand system, satisfies the axioms of consumer choice exactly, aggregates perfectly over consumers under certain conditions, and is easily estimated (Deaton and Muellbauer, 1980a; Alston and Chalfant, 1993 and Eales and Unnevehr, 1994). The estimated coefficients in a linear approximate almost ideal demand system (LA/AIDS) model are easy to interpret (Fulponi, 1989). Each demand equation in the AIDS is given as:

$$w_i = \alpha_i + \sum_j^n \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{x}{P}\right) + U_i \qquad (1)$$

Where: $w_i$is the i^{th} budget share, $p_j$is the price for the i^{th}, x is the total expenditure on all commodities within the system, γ is the price coefficient, β is the expenditure coefficient (income) and P is a price index that is defined in equation 2.

$$\ln P = \alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \qquad (2)$$

To assure theoretically stability for the demand function, Deaton and Muellbauer (1980a, 1980b) carried out relevant studies and indicated restrictions for the AIDS model, specified as followed:

Adding up: $\sum_{i=1}^{n} \alpha_i = 1,\ \sum_{i=1}^{n} \gamma_{ij} = 0,\ \sum_{i=1}^{n} \beta_i = 0$ (3)

Symmetry: $\gamma_{ij} = \gamma_{ji}$ (4)

Homogeneity: $\sum_j \gamma_{ij} = 0$ (5)

b. Research Data:

Data in this research is secondary and of cross-sectional data type, collected from the Vietnamese Household Living Standard Survey (VHLSS2008). The researcher uses "income and expenditure" sample including 9,189 households within the survey to analyze as this sample has enough data for all variables needed in the research. The data are collected twice a year by the General Statistics Office.

To estimate expenditure elasticities of demand, micro-data on household basis is appropriate because this can avoid commodity adding up problem. However, based on using household data for estimation of many commodities separately, a problem can arise when some households have zero consumption. This is because some households do not consume some certain food items during the survey period. Within four items of meat and fish mentioned in this study, zero consumption is serious for beef and chicken when the proportions of households who do not buy beef and chicken are 40.94% and 54.38% respectively (computed by authors of the VHLSS2008).

Because of zero consumption, there are no price data. Households with zero consumption will have no information about expenditure or demand quantities. Therefore, no information about prices to these households is derived. To estimate a complete demand system, prices must be available to any items and households. In this study, dividing expenditure by quantities purchased helps to obtain the price for estimation. Missing price data of four items of meat and fish resulted from households with zero consumption during the survey period using the method of Chern et al. (2003) and Linh Vu Hoang (2009). However, in this study, there is a small change related to the assumption that each household is encountering the mean price of goods relying on income and region. Vietnamese Household Living Standard Survey in 2008 consists of different eight economic regions and five income quintiles. Therefore, we have forty average prices from the sample in total. In this study, there are four commodities with a hundred and sixty average prices from the sample.

c. Model Estimation Techniques:

An AIDS model is estimated in this paper based on the theory described in the previous section. The model is estimated for meat and fish consumption using cross-sectional data abstracted from the Vietnamese Household Living Standard Survey conducted in 2008. The model is estimated for four meat and fish products (beef, pork, chicken and fish).

As mentioned in the research data, the data collected from the household consumption surveys contain many zero values for several goods because some of the households do not consume these food items as a result of non-preference or household inventory. Previous studies show that if we only use positive consumption data to estimate consumption behaviors with OLS method, the results will be biased and inconsistent OLS estimates due to sample selection bias. As a result, predictability of the model is reduced. Dependent variable is the budget share for a particular food item (the i^{th} for instance). This dependent variable values zero if the h^{th} household does not buy the i^{th} and it is positive if it does. The zero-valued share will be censored by an unobservable hidden variable. In this study, the researcher applies the two-step model of Heckman to modify zero consumption problems. The study assumes that zero consumption is due to sample selection. Thus, the Heckman two-step model is appropriate (Chern et al., 2003).

Heckman (1979) suggested an approach to solve the problem of zero consumption. He established a model of consumption decision and used the Probit regression model to identify purchasing probability of a certain item. Estimates from the Probit regression model were used to compute the IMR (Inverse Mill's Ratio), which was the ratio of the estimates of standard density function to the estimates of standard normal accumulative distribution function. The IMR was calculated for each observation of the data set. In terms of mathematics, Heckman procedure can be described as followed:

$$p^* = x\beta + \varepsilon \tag{6}$$

$$q^* = x\beta + \mu \tag{7}$$

$$\text{IMR}_{ih} = \frac{\phi(x\beta)}{\Phi(x\beta)} \tag{8}$$

where equation (6) is for estimating hidden variable p^*; dualistic variable p values 1 if $p^* > 0$ or 0 if $p^* \leq 0$; x is independent variable set; and β is appropriate parameter vector.

In equation (7), q^* stores information of observations with dualistic variables valued 1. After computing the IMR, the final estimation equation is developed to supplement with the IMR in order to eliminate the sample selection bias in demand equation, which is described in the following equation:

$$\mathrm{w} = f(x\beta) + \lambda \mathrm{IMR} \tag{9}$$

where $f(x\beta)$ is estimation equation and IMR is considered as instrumental variable. In the final estimation, only unlimited valued observations are used. The IMR becomes a variable linking the participation decision (consuming or not) with the equation representing for demand. According to Heckman (1979), sample selection bias occurs if the parameter λ is statistically significant.

Heine and Wessells (1990) generalized the Heckman two-step procedure to associate the IMR with zero valued observations in dependent variables, then using all observations in the second step. The IMR was calculated for each household (h) and food item (i), using maximum likelihood method from Probit regression model and consequently, the IMR equaled to the ratio of standard normal density function (ϕ) to standard normal cumulative distribution function (Φ):

$$\mathrm{IMR}_{ih} = \frac{\phi(x\beta)}{\Phi(x\beta)} \text{ if } \mathrm{y_{ih}} = 1. \tag{10}$$

$$\text{And } \mathrm{IMR}_{ih} = \frac{\phi(x\beta)}{1-\Phi(x\beta)} \text{ if } \mathrm{y_{ih}} = 0. \tag{11}$$

where x represents explanatory variables including demographic variables, log price; β is appropriate parameter vector; and y_{ih} is fake variable valuing 1 if the h^{th} household consumes the i^{th} commodity and valuing 0 if the h^{th} does not consume. In this study, the researcher uses the Heine and Wessells (1990) version generalized from the Heckman procedure (1979) because it comprises all observations in regression equation of the second stage. As a result, Vietnam's meat and fish demand equations will be developed to connect with sample selection bias modified term (IMR):

$$w_i = \alpha_i + \sum_j^4 \gamma_{\mathrm{ij}} \ln p_j + \beta_i Ln(\frac{x}{P}) + \pi_i \mathrm{IMR}_i + U_i \tag{12}$$

The AIDS demand function is linear except the translog form of price index lnP. In most of applied researches, in order to avoid nonlinearity and reduce the influence of multi-collinearity in models, researchers often use the Stone price index ($\ln P = \sum_i w_i \ln p_i$), which creates a linear system (this was suggested by Deaton and Muellbauer, 1980a, 1980b). The AIDS model with the price index $\ln P = \sum_i w_i \ln p_i$ is called the Linear Approximate Almost Ideal Demand System (LA/AIDS). However, the Stone price index does not satisfy the fundamental property of index numbers because the Stone price index is varied according to changes in price measurement units. One solution to adjust measurement unit errors is to standardize price by dividing price to its sample mean value. Moschini (1995) suggested using the Laspeyres price index to solve the problem. The Laspeyres price index can be defined as:

$$\ln(P^L) = \sum_i \overline{w}_i \ln(p_i) \tag{13}$$

where: $\overline{w}_i$ is the average expenditure of the i^{th} goods. In this research, the Laspeyres price index is used to substitute for the Stone price index in the LA/AIDS model. Hence, the specified AIDS model estimated in this paper is shown in equation 14.

$$w_i = \alpha_i + \sum_j^4 \gamma_{ij} \ln p_j + \beta_i \left(\ln x - \sum_{i=1}^4 \overline{w}_i \ln p_i \right) + \pi_i \mathrm{IMR}_i + U_i \tag{14}$$

The procedure of the SUR (Seemingly Unrelated Regression) is used in this study as an estimation method to obtain effectiveness and include the possibility of simultaneous correlation among random errors in the demand system. Because the adding up condition creates a singular covariance matrix, one equation must be excluded from the demand system before estimation (in this study, the fish demand equation is excluded). Parameters in the omitted fish equations can be recovered from the adding up restrictions in the equation (3).The homogeneity and symmetry restrictions were imposed on the estimated models to ensure theoretical consistency. With the above-mentioned specification, price and expenditure elasticities of demand are computed by equation (15), (16) and (17). In this study, elasticities are calculated at sample means.

Expenditure (income) elasticity

$$A_i = 1 + \beta_i / \mathrm{w}_i \quad (15)$$

Own-price elasticity

$$E_{ii} = -1 + \gamma_{ii} / \mathrm{w}_i - \beta_i \quad (16)$$

Cross-price elasticity

$$E_{\mathrm{ij}} = (\gamma_{\mathrm{ij}} - \mathrm{w}_j \beta_i) / \mathrm{w}_i \quad (17)$$

3. RESULTS AND DISCUSSIONS

The LA/AIDS model is estimated by using Seemingly Unrelated Regression (SUR), with the theoretical restrictions of adding-up, homogeneity, and symmetry imposed during estimation. Table 1 presents the estimated coefficients for the LA/AIDS model.

Table 1: Parameter Estimates of LA/AIDS

Variables	Pork	Beef	Chicken	Fish
Intercept	1.1080 (22.7079)***	-0.3636 (-13.0236)***	-0.2609 (-10.4183)***	0.5165 (-)
Ln(pork price)	-0.0772 (-6.0440)***	0.0011 (0.2295)	0.0136 (2.8555)**	0.0625 (-)
Ln(beef price)	0.0011 (0.2295)	0.0167 (2.7384)**	0.0600 (16.7694)***	-0.0778 (-)
Ln(chicken price)	0.0136 (2.8555)**	0.0600 (16.7694)***	-0.0362 (-8.1033)***	-0.0374 (-)
Ln(fish price)	-0.0041 (-0.7831)	0.0214 (10.3707)***	0.0236 (11.1236)***	-0.0409 (-)
Expenditure (Lnx/P)	-0.0746 (-26.5820)***	0.0156 (14.5228)***	0.0135 (12.3499)***	0.0455 (-)
IMR	-0.2535 (-25.7920)***	-0.0361 (-15.5440)***	0.0340 (14.0091)***	0.2556 (-)
Mean budget share $(\overline{\mathrm{W}})$	0.5353	0.0641	0.0596	0.3409

Notes: The ratio t is in brackets; *** and ** denote 1% and 5% significance levels respectively.

Table 1 shows estimated regression coefficients of meat and fish by price and expenditure (income) in the LA/AIDS model, using cross-sectional data obtained from the VHLSS2008. The model was estimated with homogeneity and symmetry imposed. Estimated coefficients of fish were obtained by using adding-up restrictions. The results show that regression coefficients of the IMR variable are statistically significant in all meat and fish demand equations. This implies that if the zero consumption problem is ignored, there will be a strong sample selection bias. In addition, most of estimated regression coefficients are statistically significant. Parameter estimates gained from the LA/AIDS are used to calculate price elasticities of Marshallian and Hicksian demand systems and expenditure elasticities, which are presented in Table 2 and 3.

Table 2: Marshallian Price and Expenditure Elasticities of Demand for Meat and Fish in the LA/AIDS Model for Vietnamese Consumers, 2008

Food items	**Pork price**	**Beef price**	**Chicken price**	**Fish price**	***Expenditure (Lnx/P)***
Pork	-1.0697	0.0111	0.0337	0.0398	0.8607
Beef	-0.1124	-0.7558	0.9218	0.2810	1.2432
Chicken	0.1065	0.9925	-1.6206	0.3192	1.2269
Fish	0.1120	-0.2368	-0.1177	-1.1654	1.1334

Table 2 presents Marshallian price and expenditure elasticities calculated from parameter estimates of the LA/AIDS. The result shows that own-price elasticities for pork, beef, chicken, and fish are negative (-1.0697; -0.7558; -1.6206; and -1.1654 respectively), which indicates that demand functions have negative angular coefficients (downward-sloping demand curves). This suggests that beef demand is price inelastic (irresponsive to changes in price), while pork, chicken and fish consumption is very responsive to changes in price (the highest is for chicken, at -1.6202). Expenditure (income) elasticities are 0.8607 for pork; 1.2432 for beef; 1.2269 for chicken and 1.1334 for fish. It implies that beef demand responds the most to changes in total expenditure, next is chicken, fish and pork. This implies that beef will be consumed the most or the least compared with the rest three competitive items when consumers increase or decrease expenditure on meat and fish. It also implies that pork is a necessity commodity while the remaining three - beef, chicken and fish - are luxury

goods. All own-price elasticities and expenditure elasticities have correct signs in consistence with theory. Cross-price elasticities for pork are positive, which indicates a gross substitution relationship between chicken and fish.

Table 3: Hicksian Price Elasticities of Demand for Meat and Fish in the LA/AIDS Model for Vietnamese Consumers, 2008

Food items	Pork price	Beef price	Chicken price	Fish price
Pork	-0.6090	0.0662	0.0850	0.3332
Beef	0.5531	-0.6761	0.9959	0.7048
Chicken	0.7633	1.0711	-1.5475	0.7375
Fish	0.7187	-0.1641	-0.0502	-0.7790

Table 3 contains Hicksian own-price and cross-price elasticities of demand for meat and fish. Own-price elasticities for meat and fish are negative (downward-sloping demand curves), which is also consistent with theoretical expectation. Cross-price elasticities are positive for pork. This implies that pork has a net substitution relationship with beef, chicken and fish. Particularly, for cross-price elasticities between beef and pork items, while Marshallian estimates are negative, Hicksian estimates are positive. This suggests that the income effect in this case outweighs the substitution effect. In general, the cross-price effects had no clear direction and a relatively low degree of substitutability and complementarities among the meat and fish items.

4. CONCLUSION

This paper analyzes meat and fish demand in Vietnam by using VHLSS2008 data. It also provides an empirical study about meat and fish demand analysis in Vietnam. The results of the study can be of interest to researchers in the same area. Expenditure (income) and price elasticities are estimated for four food items of meat and fish. The research results show the demand for beef was empirically less sensitive to price changes while pork, chicken and fish are more elastic. Pork is empirically a necessity commodity while beef, chicken and fish are empirically luxury goods to Vietnamese households. Household consumption demand analysis for different types of commodities is essential, especially for purposes of policy planning such as food supply and food import policies. This also gives policy makers an empirical evidence to design policies relevant to Vietnam meat and fish consumption demand. Based on

an analytical framework and a well-structured theory with a data set of Vietnam household living standard surveys in 2008, this research was conducted in the context of very limited studies on this area in Vietnam. Therefore, the research results are reliable and can be used to make decisions on relevant policies about meat and fish consumption in Vietnam.

Main findings of the study and policy implications drawn from these findings are as follows:

(1) Demand for most meat and fish commodities are quite responsive to the changes in own prices and income. For any meat and fish policy to be effective in alleviating the problems of food insecurity and malnutrition, attention must be paid to these factors.

(2) The results show that pork is a necessity commodity while beef, chicken and fish are luxury ones.

(3) Whereas the fact that beef demand is inelastic to own price but elastic with respect to the expenditure suggests that income-oriented policies have a greater effect on promoting beef consumption than price policies, pork is elastic with respect to own price but inelastic with respect to expenditure. Therefore, a price-oriented policy will have a greater influence on promoting pork consumption than income policies. For the chicken and fish, demand is very responsive to changes in price and income. However, no systematic differences in the absolute magnitudes of the expenditure elasticity and own-price elasticity were found between chicken and fish. This implies that a combination of income and price policies may be more effective in influencing consumption pattern than those based solely on one of the two policies.

(4) Estimated elasticity coefficients can also be used to forecast meat and fish demand in Vietnam, and from here policy makers may have a good strategy to satisfy the demand in terms of domestic production as well as appropriate import plan.

Like any other studies, this study also has several limitations. Firstly, the research data were collected in the time of an economic crisis in 2008, which really had a strong impact on Vietnamese household consumption. Consequently, the results can not be highly generalized. Secondly, the data of fish item was aggregated from shrimps, fresh fish and shrimps, dried fish and processed fish. Future studies can collect data over a stable economic period of time and from separated items regarding fish item.

Moreover, a panel and time series data in these studies could shed some light on changing food consumption patterns ■

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