Research Article

Kazi Tamim Rahman, Md. Ruhul Amin, M. Salauddin Palash*

Demand for Selected Animal Sourced Protein Food Items in United States

Abstract: Consumers' preference for food is ever-changing from carbohydrate to protein since protein plays a vital role in the balanced and healthy growth of human being. Among different sources of protein, animal sourced protein foods are getting popularity over time in United States. How demand for animal sourced protein food items are changing, and to be specific which animal food items are preferred by consumers are necessary to know both for producers and suppliers. This study estimates consumer demand for animal sourced food items in U.S. employing linear approximation of AIDS (LA-AIDS) model. Monthly per capita consumption expenditure data on aggregate and disaggregate animal protein items and price indices at national level from 1995 to 2016 have been collected from the Bureau of Economic Analysis of United States. The data consists of monthly per capita consumption expenditure on beef and veal, pork, other meats, poultry, and fish and seafood, and their price indices. The result shows exogenous growth in the budget share of all meat items. Estimated expenditure and cross price elasticities suggest that all goods are normal in nature and substitute to each other. In addition, weak separability test suggests that meat items are separable from non-meat items. The findings of the study would be helpful understanding consumer preferences and behavior for allocating budget among different sources of animal protein.

Keywords: Separability, Structural Change, Animal Protein, Demand

*Corresponding author: M. Salauddin Palash, Department of Agribusiness and Marketing, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh, E-mail: palash@bau.edu.bd
Kazi Tamim Rahman, Department of Agricultural Economics, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh
Md. Ruhul Amin, M. Salauddin Palash, Department of Agribusiness and Marketing, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

1 Introduction

Protein plays a vital role in the balanced and healthy growth of human being. To develop a nation having people sound, healthy and imaginative, it is important to ensure enough per capita protein intake. Searching for high protein enrich food item has been increasing over the decade. Nearly three-quarters of consumers indicated they used high-protein foods (Molyneaux 2015). In the United States, the consumption of beef and veal, pork, poultry, and sheep were 24.7 kg/capita, 22.17 kg/capita, 47.6 kg/capita and 0.4 kg/capita respectively in 2015 (OECD-FAO 2016). The protein consumption is set to grow, with the expansion of animal numbers in 2018 and attractive prices for the consumer.

During the period from 1995 to 2016, consumers in the United States allocated more than 86%, on average, of their total budget for purchasing meat, followed by fish and sea foods (7.86%). A disaggregated model for selected animal protein consists of 5 food items- beef and veal, pork, other meats (includes mutton, lamb, etc), poultry, and fish and seafood. The disaggregated model provides a more elaborate relationship among the food products than the aggregate model. Table 1 indicates that consumers spent the maximum budget (29.06%) on poultry whereas the minimum on fish and sea food (7.68%).

Future protein demand and supply to meet the nutritional requirements of a larger global population needs to be measured, based on current supply volumes (Henchion et al. 2017). A better understanding of demand determinants is essential to identify the reasons for increasing the demand for protein (Schroeder and Mark 2000). Since, the livestock sector around the world is dynamic (Lesser 1993), it is difficult to develop a price strategy for protein food commodities, without understanding consumer demand for protein-trend-commodities. In China over the last 5 years, animal protein product consumption shows a strong positive relationship with consumers' income levels and the expense is increasing like staple food items (Lagrange et al. 2015).

Table 1: Allocation of monthly protein budget among different food item (average 1995-2016)

Model	Food item	Budget (%)
Disaggregated	Beef and veal	23.35
	Pork	17.32
	Other Meats	16.88
	Poultry	34.77
	Fish and seafood	7.68

Additionally, not only is demand changing, but also significant separability exists in protein demand among mass population over the world. An analysis provides estimates of structural demand parameters that help to explain current expenditure patterns for animal protein (Lusk and Tonsor 2016). Regarding structural change, in a study in Canada, a time-varying parameterization of the AIDS model provided evidence of a structural change in Canadian demand for protein obtained from meat (beef, pork, chicken). With the exclusion of fish, a comparison between the results obtained for Canada and the US is feasible and the structural change of protein demand (obtained from meat) was more rapid in the US than in Canada, in late 1975 (Reynolds and Goddards 1991). Beside this, Gao and Spreen (1994) estimated the price and expenditure elasticities of demand for six animal protein rich commodities: beef steak, beef roast, ground beef, pork, poultry and fish across the four regions of the United States. In another study, Cao and Li (2013) revealed, demand for animal protein is increasing in most of the Asian countries and it leads to a steady increase in demand for commodities that are enriched in animal protein. They predicted, that in the next 5 to 10 years, greater challenges will be encountered in meeting an ever-increasing demand for animal protein products in developing countries. Huang and Haidacher (1983), Park et al. (1996) estimated demand for all major food commodities whereas Eales and Unnevher (1988 & 1993), Moschini and Meilke (1989), Moschini et al. (1994), Brester and Wohlgennant (1991), Chavas (1983), Yadavalli and Jones (2014) estimated demand for meat products in the United States. So far, no study has yet been done in the United States to identify demand elasticity of individual animal protein food items for understanding consumer preferences for these commodities (beef, pork, poultry, fish and seafood, other meats etc.).

The main objective of the study is to estimate demand elasticities of different selected animal protein food items to understand the consumers' preferences as well as influences of price and income on demand. This study also examines structural change in the demand for animal protein and weak separability among different food items to know how consumers allocate their expenditures on purchasing animal protein items. These will help policy makers, development organizations and industries to formulate effective policies and strategies for the improvement of consumers', as well producers', welfare since it is based on recent data.

2 Materials and Methods

2.1 Data

Monthly per capita consumption expenditure data on aggregate and disaggregate animal protein items and price indices at the national level, from 1995 to 2016, have been collected from the website of the Bureau of Economic Analysis of the United States. The data consists of monthly per capita consumption expenditure on meat, and fish and seafood; and their price indices for the aggregate model and monthly per capita consumption expenditure on beef and veal, pork, other meats, poultry, and fish and seafood, and their price indices for the disaggregate model.

2.2 Empirical model

The demand system estimation is based on Almost Ideal Demand System (AIDS) by Deaton and Muellbauer (1980). The AIDS model has been extensively used in demand estimation for its flexibility. The general form of the AIDS model, with a time trend, is as follows:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln(p_j) + \beta_i \ln\left(\frac{X}{P}\right) + \delta_i t \qquad \forall i \tag{1}$$

Where w_i is the budget share of the ith good.

p_j denote prices and X is total expenditure on all goods.

P is the price index and defined as:

$$\ln P = \alpha_0 + \sum_i \alpha_i \, lnp_i + 1/2 \sum_i \sum_j \gamma_{ij} lnp_i lnp_j \tag{2}$$

The restrictions on this demand function are listed below:
   Adding up restriction:

$$\sum_i \alpha_i = 1 \,, \sum_i \gamma_{ij} = 0 \,, \sum_i \beta_i = 0 \,, \sum_i \delta_i = 0 \tag{3}$$

Homogeneity restriction:

$$\sum_i \gamma_{ij} = 0 \tag{4}$$

Symmetry restriction:

$$\gamma_{ij} = \gamma_{ji} \tag{5}$$

Following Deaton and Muellbauer (1980), the linear approximation to the AIDS model (LA-AIDS) in differences has been used with a time trend:

$$\Delta w_i = \delta_i + \sum_j \gamma_{ij} \, \Delta \ln(p_j) + \beta_i \Delta \ln\left(\frac{x}{P}\right) \tag{6}$$

The stone price index was used to estimate the model. The study estimates the model for both aggregated and disaggregated food items using iterative seemingly unrelated regressions. The intercept in equation (6) indicates the exogenous gradual growth or decline in the budget share of good i.

To test weak separability, 5 disaggregated food items were divided into two groups. All types of meat (beef and veal, pork, other meats, poultry) belong to the first group, and fish and seafood belong to the second group. There are 3 restrictions and a null hypothesis respectively in this model to test weak separability.

2.3 Adjusted Wald Test Statistic

The Wald test (also called the Wald Chi-Squared Test) is a way to find out if explanatory variables in a model are significant. "Significant" means that they add something to the model; variables that add nothing can be deleted without affecting the model in any meaningful way. The test can be used for a multitude of different models including those with binary variables or continuous variables (Agresti 1990).

$$W* = \frac{w/q}{MT/(MT-K)}$$

Where,

　　W: regular Wald statistic
　　q: number of restrictions
　　M: number of equations in the system
　　T: number of observations
　　K: number of free parameters

Ethical approval: The conducted research is not related to either human or animal use.

3 Result and discussions

With demand system estimation by using the Almost Ideal Demand System (AIDS) by Deaton and Muellbauer (1980), Table 3 and 4 shows the result for the coefficient estimates for the aggregate and the disaggregate models. The result in the aggregate model shows that all coefficients are significant and seem to be reasonable in sign and magnitude. In the disaggregate model, most of the coefficients are significant. However, the disaggregated model provides a better understanding among the food products than the aggregate model. Under consideration of specific restrictions, the intercepts in each equation can be used as evidence regarding structural change in the aggregated and disaggregated models. The intercept shows the exogenous growth or decline in the budget share of each food item, captures the effects of changes in relative prices and income and also is equivalent to a time trend in the static model (Eales and Unnevher 1988). In the aggregate model, the intercepts are significant for all food items. The intercept is positive for meat, and fish and seafood. This indicates that the budget share for meat, and fish and seafood have significantly increased.

The intercept indicates the share of budget allocated by US consumers for different food commodities i.e. meat, and fish and seafood over the period. A positive intercept value of 1.388 for meat indicates that US consumers are now allocating a higher share of their income to meat consumption compared with fish and seafood, whereas fish and seafood also have a positive intercept of 0.466,

Table 2: Null hypothesis with respective restrictions for testing separability

Restrictions	Null hypothesis
Good 1 and 2 are weakly separable from Good 5	H01: $g15(b2+w2)-g25(b1+w1)+(w1b2-w2b1)(w5-b5\ln(x/p))=0$
Good 1 and 3 are weakly separable from Good 5	H02: $g15(b3+w3)-g35(b1+w1)+(w1b3-w3b1)(w5-b5\ln(x/p))=0$
Good 1 and 4 are weakly separable from Good 5	H03: $g15(b4+w4)-g45(b1+w1)+(w1b4-w4b1)(w5-b5\ln(x/p))=0$

Table 3: Coefficient estimates for aggregate model[1]

	Meat	Fish and seafood	Expenditure	Intercept
Meat	-0.010*	0.021*	-0.072*	1.388*
	(0.002)	(0.002)	(0.002)	(0.017)
Fish and seafood	0.021*	-0.008*	-0.054*	0.466*
	(0.002)	(0.002)	(0.002)	(0.016)

1 Standard errors in parentheses. * indicates significance at 5% level

meaning that consumption, as well as allocated budget, have increased too. The results in the aggregated model are also supported by the disaggregate model. In the disaggregated model, the intercept is positive for all types of meat categories except for other meat. This indicates that where the budget share of beef and veal, pork and poultry have significantly increased, the share of other meat has significantly declined during the time period from 1995 to 2016.

Tables 5 and 6 represent the expenditure elasticities and compensated own and cross price elasticities for the aggregated and disaggregated models, respectively. The expenditure elasticity of demand can be interpreted as the percentage change in the quantity demanded when expenditure (income) changes by 1% while other factors are constant. A commodity can be classified as normal, inferior or luxury goods based on expenditure elasticity. All expenditure elasticities are positive and significant in the aggregate model, indicating normal goods. Expenditure elasticities obtained for different food items indicates that, if the household income increases, demand for these food items also increases. Given that the supply

of food items is fixed, the upward shift of demand curves implies that the equilibrium market price will increase. All expenditure elasticities in the disaggregated model are also positive and significant. The result indicates that all the food items are necessity except other meats. Other meats indicate that mutton and lamb are less preferable to the US consumers as a protein source.

The own price elasticity of a product is expected to have a negative sign, according to economic theory, indicating the negative slope of the demand curve. The own price elasticities for meat, and fish and seafood are negative and significant in the aggregate model. The result indicates that the demand for meat is inelastic but the demand for fish and seafood are elastic. In the disaggregated model, own price elasticities for all foods are also

Table 5: Compensated elasticities for aggregate model

	Meat	Fish and seafood	Expenditure
Meat	-0.217*	0.094*	.917*
Fish and seafood	0.530*	-1.075*	.302*

* indicates significance at 5% level

Table 4: Coefficient estimates for disaggregate model[1]

	Beef and veal	Pork	Other meats	Poultry	Fish and seafood	Expenditure	Intercept
Beef and veal	-0.012*	-0.023*	0.032*	-0.001	-0.001	-0.133*	1.197*
	(0.004)	(0.003)	(0.002)	(0.004)	(0.001)	(0.009)	(0.067)
Pork	-0.023*	-0.026*	-0.003	0.033*	0.01*	-0.049*	0.532*
	(0.003)	(0.006)	(0.003)	(0.005)	(0.002)	(0.006)	(0.046)
Other meats	0.032*	-0.003	0.007	-0.038*	-0.001	0.141*	-0.857*
	(0.002)	(0.003)	(0.004)	(0.003)	(0.002)	(0.005)	(0.035)
Poultry	-0.001	0.033*	-0.038*	0.028*	0.0002	-0.037*	0.5593*
	(0.004)	(0.005)	(0.003)	(0.006)	(0.002)	(0.008)	(0.059)
Fish and seafood	-0.001	0.010*	-0.0010	0.0002	-0.003*	-0.047*	0.416*
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)	(0.024)

1 Standard errors in parentheses. * indicates significance at 5% level

negative and significant. The demand for beef, other meat, and poultry is inelastic but the demand for pork and fish is elastic.

Cross price elasticities measure the responsiveness of demand for one commodity to a change in the price of another. It indicates the relationship between two products, whether the products are complimentary or substitutes. A negative cross price elasticity means that the two products are complementary and positive cross elasticity indicates that the two products are substitutes. The aggregate model shows that all the goods are substitutes. In the disaggregated model, most of the goods are substitutes, except beef and veal, and pork, which are complementary in the disaggregated model, but the result is not significant. It is supposed to be a substitute as per economic sense. The similar explanation is valid for poultry and other meats where these two products are substitutes but not showing significance in statistical outcomes.

Table 7 presents the comparison of own price and expenditure elasticities among different studies. The results of this study are almost like previous studies.

The study fails to reject the null hypothesis of weak separability at the 5% level of significant. The result indicates that the food categories are weakly separable from each other. It can be concluded from the findings of previous and the present study that consumers firstly allocate their total expenditure between food and non-food items.

Then they allocate food expenditure between meat and non-meat items.

4 Conclusion

The present study analyzes the consumers' demand for animal protein using aggregated and disaggregated food models. The aggregated per capita monthly consumption data on different aggregated and disaggregated protein food items from 1995 to 2016 is used to estimate elasticities using the AIDS model. The result shows exogenous growth in the budget share of all meat items, except other meats. Estimated expenditure elasticities suggest that all goods are normal. The results for own price elasticities support the theory that demand for goods decrease with increase of price, with other things remaining the same. The cross-price elasticities indicate that most of the food items are substitutes for each other. The weak separability test suggests that meat items are separable from non-meat items. The findings of the study would clarify consumer preferences and behavior for allocating budget among different sources of animal protein. The policy maker and industry stakeholder can formulate effective policies and strategies for the expansion of different animal sourced protein industries in the US market.

Table 6: Compensated elasticities for disaggregated model

	Beef and veal	Pork	Other meats	Poultry	Fish and seafood	Expenditure
Beef and veal	-0.950*	-0.023	0.211*	0.120*	0.030*	0.432*
Pork	0.035*	-1.029*	0.106*	0.396*	0.112*	0.716*
Other meats	0.620*	0.302*	-0.651*	0.312*	0.136*	1.837*
Poultry	0.199*	0.263*	0.018	-0.649*	0.068*	0.872*
Fish and seafood	0.080*	0.196*	0.053*	0.116*	-1.006*	0.390*

* indicates significance at 5% level

Table 7: Comparison of estimated own price and expenditure elasticities among different studies

	Beef and veal		Pork		Other meats		Poultry		Fish and seafood	
	price	Exp	price	Exp	price	Exp	price	Exp	price	Exp
Park et al. (1996)	-.438	.621	-.448	.610			-.346	.604	-.585	.741
Moschini and Meilke (1989)	-.983	1.220	-1.01	1.041			-.090	.238	-.138	.432
Eales and Unnevehr (1988)	-.570	.344	-.762	.278			-.276	.527		
This study	-.950	0.432	-1.03	0.716	-0.651	1.84	-.649	0.872	-1.01	0.390

Conflict of interest: Authors declare no conflict of interest.

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