Structural Break in the U.S. Meat Demand: Evidence from LA/AIDS Model

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Abstract

The main objective of this paper is to test the suggested structural break in meat demand in the U.S. As an identification step of the structural break and its location, the Chow test is performed in LA/AIDS model. In the understanding step, it is found that the meat expenditure is the most significant source of the structural break. Marshallian, Hicksian, and Morishima elasticities as well as the differences in elasticities are estimated in first differenced LA/AIDS model. The results show that the suggested structural break in meat demand in the U.S. did occur in the late 1970s.

JEL Classification Codes:
Keywords: Structural Break, Meat Demand, LA/AIDS, Chow Test, Elasticity, U.S.

1. Introduction

Modeling and analyzing shocks in market demand and supply is one of the most popular subjects in applied economics (Holt and Balagtas, 2009). Market participants such as policy makers, consumers, and producers want to know the response of the market to particular events which change the structure of the market. The underlying reason of that is the response of the market is very informative to the market participants, and it is inevitable to give a wrong decision without considering it. Therefore the shocks in the market demand and supply should be taken into consideration in every empirical analysis.

Haidacher (1983) defines structural change for complete demand systems as a change in the parameters of the representative consumer's unobservable utility function. In the demand side of the market, for instance, consumer preferences for different goods are reflected in the structure of consumer demands for those goods; and likewise, changes in preferences, known as shocks, are reflected as changes in the structure of consumer demands (Dahlgran, 1988). Economists have long thought that shocks in the economy sometimes lead to permanent changes in behavioral relationships. A serious challenge in empirical demand analysis is the identification and understanding of these permanent changes known as structural change (Choi and Sosin, 1990).

As a first step, identification of a structural change is crucial in empirical analysis due to the fact that assuming a stable utility function in the presence of a structural break might lead to false inference and by extension misguided policy recommendations. Moreover, if a structural break does exist, researcher should also identify the data point or points that the structural break most likely occurs. Understanding the structural break, as a second step, means that the researcher should also examine the possible sources of structural break such as commodity prices or expenditures. In an empirical study on demand systems, for instance, the researcher can statistically test the parameters of these sources, and in accordance with the conclusion he/she can rebuild the empirical model with the correct parameters.

The analysis developed in this paper is applied to structural change in the demand for meat in the U.S. Several studies indicate that the structure of meat preferences shifted in the late 1970s, characterized primarily by a decline in the demand for beef and pork, and increase in poultry and seafood. Some factors, which have been hypothesized in the literature to cause or contribute to changes in the U.S. consumers' preferences for meats, and consequently change the meat demand structure, are: (1) Publication and dissemination of medical evidence linking red meat consumption to high blood cholesterol levels and linking of high blood cholesterol level to heart disease (Dahlgran, 1988); (2) Seafood is found to be particularly healthy because of its Omega-3 fatty acids which is associated with reduced heart disease and neurological disorders; (3) The new popularity of chicken in restaurants, and the introduction of franchise chicken fast food chains and restaurants (Thurman, 1987); (4) Social and economic changes associated with the women's movement, increase in the amount of elderly peoples who eat less than younger people, and more single-person households with a higher consumption of convenience foods (Rickertsen, 1996); (5) The Arab Oil Embargo of 1973 which drastically altered consumer spending habits (Dahlgran, 1988).

The objective of this study is to determine if these possible changes in consumer preferences for different types of meats have caused structural changes in the U.S. meat demands. The structures of demand can be characterized by parameters in demand functions such as elasticities. Structural changes in this study will mean, eventually, changes in parameters. This is in agreement with the literature, as most structural change studies looked at parameter changes implicitly (Moschini and Meilke, 1989; Dahlgran 1988; Chen and Veeman, 1991; Choi and Sosin, 1990; Easles and Unnevehr, 1988; Rickertsen, 1996; Holt and Balagtas, 2009).

The paper proceeds as follows: Section II presents a brief literature review of previous papers relevant to the development of this research; Section III presents the data; Section IV presents the empirical model, LA/AIDS, and then employs Chow test as the identification step of structural break in meat demand system; Section V presents the understanding step of structural break in meat demand by using two different LA/AIDS model structure; Section VI presents the estimation results and discussion; Section VII concludes.

2. Literature Review

In the economics literature, there has been considerable focus on structural change in meat demand. Some examples, especially related to demand of meat in the U.S. and elsewhere, are: Chavas (1983) applies a Kalman filter to handle parameter changes; Braschler (1983) uses a switching regression specification in an inverse demand model; Moshini and Meilke (1989) utilize a Box-Cox transformation to estimate alternative specifications of demand. In general, although the methods and explanations vary, almost all the aforementioned studies conclude that a structural break occurred in U.S meat demand in the late 1970s.

Although, there is a general agreement that structural break did occur in the late 1970s in previous literature, there are also some studies which provide contradictory evidence. Dahlgran (1988) compiles some of the studies on structural break in meat demand, which investigated almost the same time periods: Haidacher et al. (1982); Chavas (1983); Braschler (1983); Moschini and Meilke (1989); Nyankori and Miller (1982); Wohlgenant (1985). In general, some of these works present evidence that structural break in meat demand did occur; however, these studies contain some contradictory results. Table 1 summarizes all of these studies and their associated results. Table 1 is not only useful in comparing the findings of the previous studies but also will be useful for later comparison with the findings of this study. In this table, for instance, it is shown that Haidacher et al. (1983), Moschini and Meilke (1989) and Wohlgenant (1985) find no structural break for beef; however, these results contradict with other studies. Moreover, Braschler (1983) provides evidence for structural break in pork demand; however, other papers results show that this is not the case.

Table 1. A Summary of Previous Studies on Structural Break in Meat Demand

Research	*Data*	*Meat Types*	*Result*
Haidacher et al. (1983)	1950-1977	Beef, veal, pork and chicken	No Structural Break for any of the meats
Nyankori and Miller (1982)	1965-1979	Beef and chicken	Structural Break
		Turkey and pork	No Structural Break
Chavas (1983)	1950-1979	Poultry and Beef	Structural Break
		Pork	No Structural Break
Braschler (1983)	1950-1982	Beef and Pork	Structural Break
Moschini and Meilke (1989)	1966-1981	Beef	No Structural Break
Wohlgenant (1985)	1947-1983	Beef	No Structural Break

*Source: Dahlgran (1988).

Another study which points out the fact that inference in econometric studies of structural change in meat demand contains a variety of results, with many contradictions, is Alston and Chalfant (1991). By using a synthetic data, they provide evidence that these varieties of results are attributable largely to differences in model specifications such as different functional forms for demand equations, single equation or systems estimations, and choices about imposing parametric restrictions—homotheticity and separability.

This paper follows the previous studies and utilizes the most used empirical model in the literature, LA/AIDS, along with some specific assumptions which are discussed in the following sections.

3. Data

The data used in this study is consisted of per capita retail quantity in pounds, consumer price index, and per capita expenditure in dollars for beef, veal, pork, poultry, and fish for the 1970-2010 periods in the U.S. The years 1982-1984 are used as the base year for all the consumer price indices. Data for beef and veal categories are aggregated into a single "beef and veal"[1] category to identify the aggregated red meat other than pork.

Consumption patterns for meat products have changed considerably over the periods 1970-2010 in the U.S. This process is illustrated in Figure 1 which presents the per capita retail quantity demanded for beef, pork, poultry, and fish from 1970 to 2010. The most striking feature in Figure 1 is the conspicuous increase in per capita consumption of poultry and fish, both of which are categorized as white meat, while the per capita consumption of red meats—beef and pork—declines. In particular, per capita beef and pork consumption has decreased by 32% and 15% respectively, while the per capita poultry and fish consumption have increased by 106% and 35% respectively from 1970 to 2010.

[1] After this point, "beef" indicates the aggregate of "beef and veal".

Figure 1.

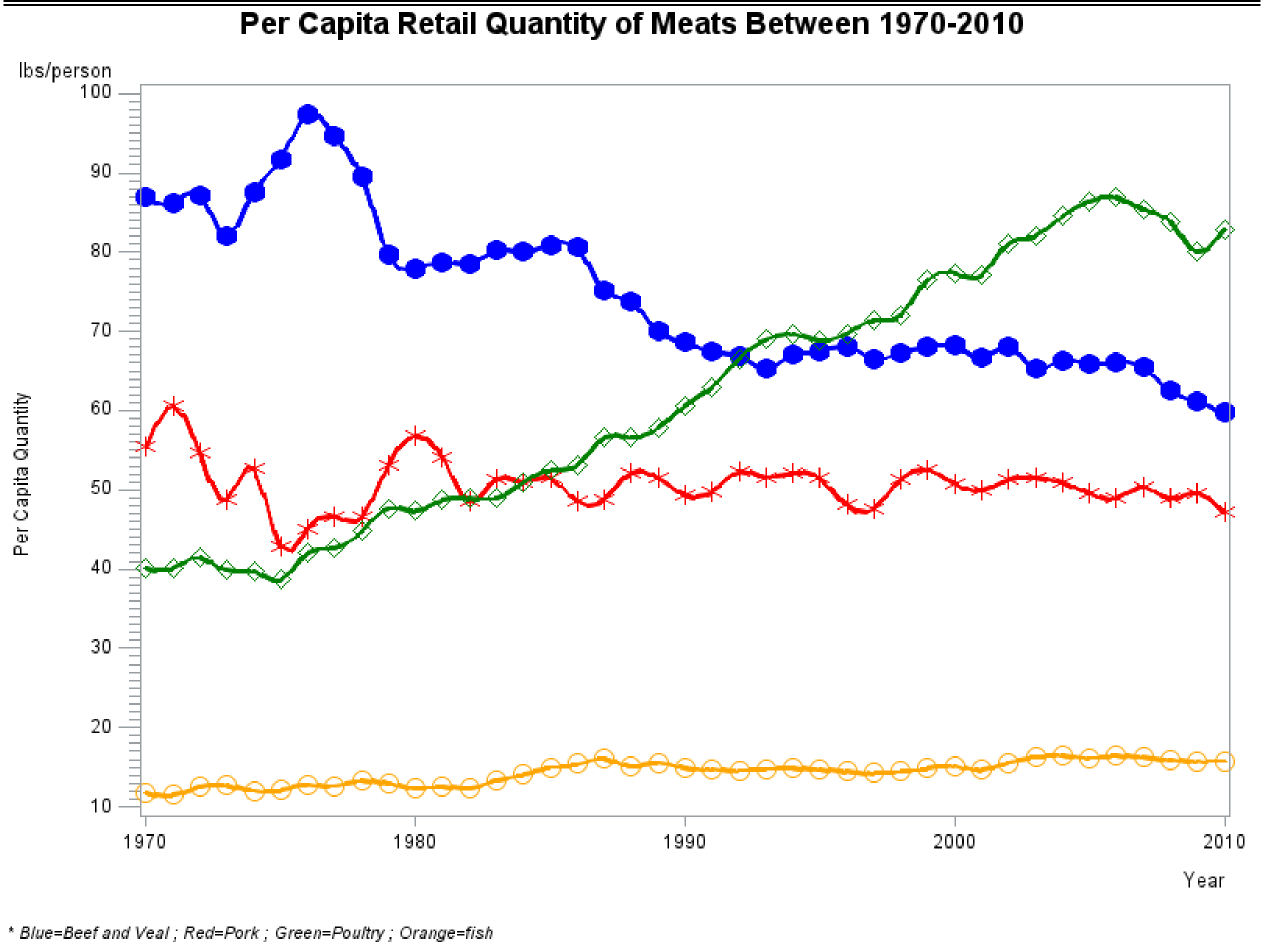
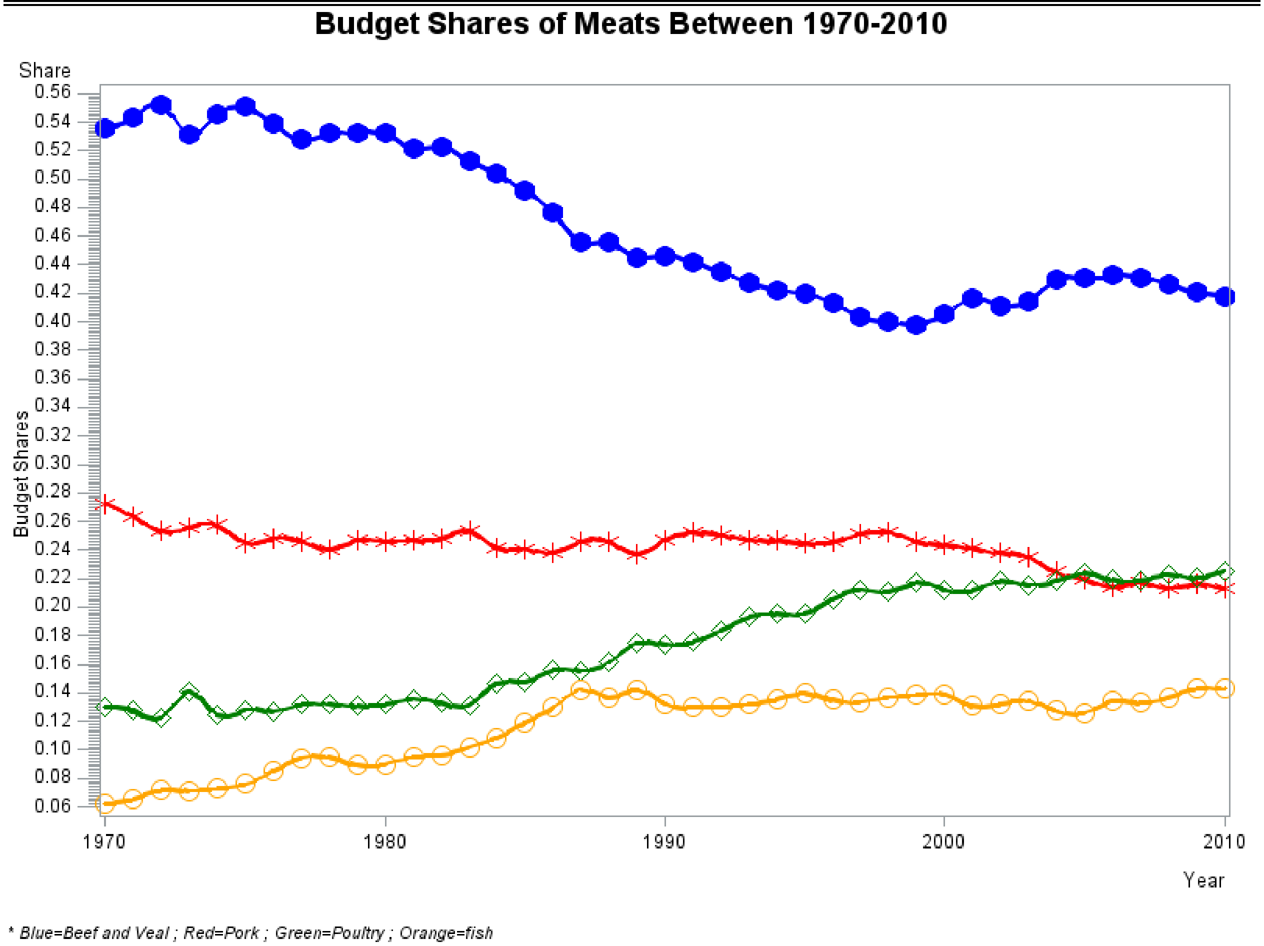


Figure 2 shows the change in consumption patterns for meats in terms of budget shares from 1970 to 2010. Both the budget shares for beef and pork have decreased by 22%, while the budget share of poultry and fish have increased by 74% and 130% respectively. These changes in consumption patterns for meats correspond with the suggestions of previous studies which indicate that the structure of meat preferences shifted in the late 1970s, characterized primarily by a decline in the demand for beef and pork, and increase in poultry and seafood.

Figure 2.



The following sections of this paper statistically test these suggested changes—structural break—in meat demand: (1) the Chow test is employed to test structural break in the late 1970s which is widely suggested in the literature; and (2) if the results of Chow test indicates a structural break for meat demand, LA/AIDS model incorporated with structural break will be assessed in terms of before and after the structural break elasticities.

4. Empirical Model – LA/AIDS and Chow Test

During the last three decades, consumer demand analysis has moved toward system-wide approaches. Although there exist numerous algebraic specifications of demand systems, two of them, the Almost Ideal Demand System (AIDS) and the Rotterdam model, have gained prominence in demand system analysis, especially in the field of agricultural economics.

Since the introduction of the AIDS by Deaton and Muellbauer (1980), many applications of this model have been made to analyze consumer demand for food (e.g., Moshini and Meilke, 1989; and Rickertsen, 1995). Most of these studies have applied the linear approximation of AIDS model (LA/AIDS) derived by Deaton and Muellbauer (1980).

According to Deaton and Muellbauer (1980) and Alston and Chalfant (1993) the popularity of the AIDS can be attributed to several reasons: (1) it is not only as flexible as the other locally flexible functional forms but also it has the added advantage of being compatible with aggregation over consumers; (2) it is derived from a specific cost function and therefore corresponds with a well-defined preference structure, which is convenient for welfare analysis; (3) the linear approximation of AIDS (LA/AIDS) is relatively easy to estimate and interpret; (4) the AIDS also provides an arbitrary first-order approximation to any demand system; and (5) it aggregates perfectly across consumers without invoking parallel linear Engel curves and it has a functional form which is consistent with known household budget data.

Detailed derivations of the AIDS and LA/AIDS models are available in Deaton and Muellbauer (1980a,b). However, it is worth to mention that the main difference between the AIDS and the LA/AIDS lies in the specification of the price index. Instead of using a non-linear Stone price index as in AIDS, LA/AIDS uses the approximated Stone price index which makes the model linear; and hence simpler to estimate. Also, the LA/AIDS eludes a serious problem of multicollinearity which is peculiar to use of the Stone price index. Moreover, Deaton and Muellbauer (1980), in testing the general restrictions with AIDS, find that when they first-difference their equations and include intercepts in the equations, the incidence of serial correlation and rejection of homogeneity descends. Therefore, considering the several advantages mentioned above, this paper follows Deaton and Muellbauer (1980) and employs the first differenced linear version of the almost ideal demand system, first differenced LA/AIDS.

The LA/AIDS model in first differenced form is formulated as follows:

$$\Delta w_{it} = \theta_i + \beta_i \left[\Delta \log x_t - \sum_j w_{jt} \Delta \log p_{jt} \right] + \sum_k \gamma_{ik} \Delta \log p_{kt} + \varepsilon_{it} \quad (1)$$

where Δ is the first difference operator, (i, k) = 1,…,4 index the goods, t = 1,…,T indexes time, p_i denotes the consumer price index for *i*th meat, x denotes the total expenditure on the four meats, w_i represents the budget share of *i*th meat, ε is the error term, and θ, β, γ are the parameters.

In his paper, Moschini et al. (1994) show that the Stone index is not invariant to price scaling. His suggested solution for this problem is to use price indexes instead of actual prices for price variables in the model. Following Moschini et al. (1994), consumer price indexes for meats are employed into the model.

To be consistent with the fundamental assumptions of the demand theory, the following restrictions must hold in terms of the model's parameters on (1):

$\sum_i \theta_i = 1$, $\sum_i \beta_i = 0$, $\sum_i \gamma_{ik} = 0$ ➔ the adding-up restrictions; (2.1)

$\sum_k \gamma_{ik} = 0$, ➔ the zero homogeneity of the share equations; (2.2)

$\gamma_{ik} = \gamma_{ki}$, ➔ the slutsky symmetry condition; (2.3)

In the literature, there is a controversy in calculating elasticities in the LA/AIDS model. The question is that should the elasticities be derived from the LA/AIDS model or should they be based on the full AIDS model? However, in an important paper, Asche and Wessells (1997) provide evidence that at the point of approximation where all prices and income are normalized at unity; both the AIDS and the LA/AIDS have the same formulas for price and income elasticities. Therefore, this study employs the elasticity formulas of the full AIDS model.

In the literature, most of the studies examine price and income elasticities of meats to analyze the structure of the meat demand market; however, only a few of them investigate the degree of substitutability between two goods—how easy it is to substitute one good for the other. The degree of substitutability between goods is measured by elasticity of substitution. The most commonly used measurement for elasticity of substitution is the Allen elasticity. However, when the number of goods exceeds two, there are intuitive and natural properties of the Allen measure that fail to hold. Blackorby and Russell (1989) summarize these properties and propose a different measure for elasticity of substitution called Morishima elasticity which has attractive properties not possessed by the Allen elasticity. Following Blackorby and Russell (1989), the Morishima elasticity is calculated to investigate the ease of substitutability between goods in the meat demand market.

The following equations present the marshallian price elasticites, and income elasticites of meats as well as the morishima elasticity between meats for the LA/AIDS model. Hicksian price elasticities of meats can be easily derived by using slutsky equation.

$$\eta_i = \frac{\beta_i}{w_i} + 1, \qquad \rightarrow \text{Income elasticity of } i\text{th meat;} \qquad (3.1)$$

$$\varepsilon_{ik} = \frac{[\gamma_{ik} - \beta_i * w_k]}{w_i}, \quad \rightarrow \text{Cross-price elasticity between } i\text{th and } k\text{th meat;} \tag{3.2}$$

$$\varepsilon_{ii} = \frac{\gamma_{ii}}{w_i} - \beta_i - 1, \quad \rightarrow \text{Own price elasticity of } i\text{th meat;} \tag{3.3}$$

$$\sigma_{ik} = \varepsilon^*_{ki} - \varepsilon^*_{ii}, \quad \rightarrow \text{Morishima elasticity between } i\text{th and } k\text{th meat;} \tag{3.4}$$

where ε* denotes the Hicksian price elasticities and w_i indicates the mean budget share of the *i*th meat.

In the literature, Chow (1960) test has been widely used in testing for parameter shifts or structural breaks in demand systems when there is one known break point. The Chow testing procedure splits the sample into two sub-periods, estimates the parameters for each subperiod, and then tests the equality of the two sets of parameters using a classic F statistics (Hansen, 2001). However, an important limitation of the Chow test is that the break date must be known a priori. When the number of possible break points is unknown, the problem becomes even more complicated. Bai and Perron (1998) solve this problem with a testing strategy that searches for the number and location of the breaks simultaneously. The test statistics proposed by Bai and Perron (1998) are sup-F tests, i.e., the relevant test statistic is the maximum F-statistic over all possible break points. In other words, it is the maximum value of the familiar Chow test.

Although Bai and Perron (1998) provide a test procedure for unknown break date and improve the Chow (1960) test, this study uses Chow test to detect the presence and location of structural break in the meat demand. The reasons for using the Chow test instead of Bai and Perron (1998) are; the previous studies suggest and provide evidence that there is a structural break in the late 1970s, so the break date is not fully unknown. Moreover, the data set used in this study has 41 data points, which is relatively low. Thus, Chow test can be easily performed for each data point.

Before performing Chow test in first differenced LA/AIDS model as presented in equation (1), homogeneity and symmetry restrictions are tested.[2] The likelihood-ratio test statistic is 4.60 and the associated p-value for this statistic is 0.05964. Hence, the null hypothesis which jointly holds homogeneity and symmetry restrictions cannot be rejected. Then, the Chow test is performed by jointly imposing homogeneity and symmetry conditions. The results of Chow test confirm the suggestion of the literature which says there is a structural break in meat demand in the late 1970s. In the 41 data points, the null hypothesis—no structural break—is rejected in 10% significance level only for the years 1975, 1976 and 1977 (the associated p-values are 0.0585, 0.0465 and 0.0801 respectively). Since the year 1976 has the highest F-value and is significant in 5% level, it is chosen as the structural break date. Therefore, the presence and location of the structural break in meat demand in the U.S. is detected. The next step is to understand the source of the structural break and to analyze the effects of the structural break by examining the elasticities.

5. LA/AIDS with Pure and Partial Structural Breaks

Although the Chow test detects the presence and location of the structural break, it does not provide any information about the source. Therefore, structural break parameters should be incorporated into model and their significance should be tested. In the literature, tests are considered for the case of "pure" structural break, in which the entire parameter vector is

[2] Deaton and Muellbauer (1980b) state that adding-up restriction is not testable since the data add up by construction and automatically satisfies adding-up restriction. Therefore, the only testable restrictions are homogeneity and symmetry restrictions.

subjected to change under the alternative, and for case of “partial” structural change, in which only a component of the parameter vector is subject to change under the alternative (Andrews, 1993).

To identify the correct source of the structural break in meat demand, following Moschini and Meilke (1989), dummy variable approach is employed to incorporate the structural break parameters into first differenced LA/AIDS model by using two different cases of structural break—pure and partial cases.

The Model 1 presents the modified first differenced LA/AIDS model for the case of pure structural break. Since all the parameters in the model are subjected to change, a dummy variable is added for each term in equation (1). The model 1 is as follows:

$$\Delta w_{it} = \theta_i + \delta_i \Delta D_t + \beta_i \left[\Delta \log x_t - \sum_j w_{jt} \Delta \log p_{jt} \right] + \psi_i \Delta \left[D_t \left(\log x_t - \sum_j w_{jt} \Delta \log p_{jt} \right) \right]$$
$$+ \sum_k \gamma_{ik} \Delta \log p_{kt} + \sum_k \phi_{ik} \Delta \left(D_t \log p_{kt} \right) + \varepsilon_{it} \qquad (4)$$

where D is the dummy variable which is 0 for 1970-1975 and 1 for 1976-2010, and $\delta, \psi, and\ \phi$ are the structural break parameters for the intercept, expenditure and price indices respectively.

Again, to be consistent with the fundamental assumptions of the demand theory, the following restrictions must hold in terms of the model’s parameters on (4): (5.1), (5.2), and (5.3) presents the adding-up, homogeneity and symmetry conditions respectively.

$$\sum_i \theta_i = 1, \quad \sum_i \beta_i = 0, \quad \sum_i \gamma_{ik} = 0, \quad \sum_i \delta_i = 0, \quad \sum_i \psi_i = 0, \quad \sum_i \phi_{ik} = 0; \qquad (5.1)$$

$$\sum_k \gamma_{ik} = 0, \qquad \sum_k \phi_{ik} = 0; \tag{5.2}$$

$$\gamma_{ik} = \gamma_{ki}, \qquad \phi_{ik} = \phi_{ki}; \tag{5.3}$$

As a starting point, the testable restrictions—homogeneity and symmetry—are tested. The likelihood-ratio test statistic is 28.71 and the associated p-value for this statistic is <0.0001. Hence, the null hypothesis which holds homogeneity and symmetry restrictions jointly is rejected significantly. As indicated in Deaton and Muellbauer (1980b), the homogeneity and, in some cases, the symmetry restrictions are consistently rejected in the economics literature. The one possible conclusion from these tests is that in the presence of pure structural break, our model does not satisfy the utility maximization theory and the structural break makes the restrictions incompatible with the data. However, Wohlgenant (1983) suggests that the possible reason of rejecting the homogeneity and symmetry conditions is the model misspecification; and hence, the researcher should re-specify and re-estimate the model.

Following the suggestion of Wohlgenant (1983), the model 1 is re-specified by employing partial structural break parameters vector. In other meaning, some of the dummy parameters for the structural break are dropped, and the model is re-estimated with several versions of partial structural break case—different combinations of dummy variables for intercept, expenditure and price index terms—until the homogeneity and symmetry conditions are not rejected jointly by the specified model. The results show that the combination of dummy parameters for intercept and expenditure terms is the only specification which holds homogeneity and symmetry conditions jointly. Therefore, model 1 is modified and redefined as model 2. The model 2 presents the modified first differenced LA/AIDS for the case of partial structural break. The model 2 is as follows:

$$\Delta w_{it} = \theta_i + \delta_i \Delta D_t + \beta_i \left[\Delta \log x_t - \sum_j w_{jt} \Delta \log p_{jt} \right] + \psi_i \Delta \left[D_t \left(\log x_t - \sum_j w_{jt} \Delta \log p_{jt} \right) \right]$$

$$+ \sum_k \gamma_{ik} \Delta \log p_{kt} + \varepsilon_{it} \tag{6}$$

where D is the dummy variable which is 0 for 1970-1975 and 1 for 1976-2010, and δ *and* ψ are the structural break parameters for the intercept and expenditure respectively.

The modified versions of the restrictions as follows: (6.1), (6.2) and (6.3) presents the adding-up, homogeneity and symmetry conditions respectively.

$$\sum_i \theta_i = 1, \qquad \sum_i \beta_i = 0, \qquad \sum_i \gamma_{ik} = 0, \qquad \sum_i \delta_i = 0, \qquad \sum_i \psi_i = 0; \tag{7.1}$$

$$\sum_k \gamma_{ik} = 0; \tag{7.2}$$

$$\gamma_{ik} = \gamma_{ki}; \tag{7.3}$$

As a starting point in estimation of model 2, the testable restrictions—homogeneity and symmetry—are tested. The likelihood-ratio test statistic is 1.60 and the associated p-value for this statistic is 0.9523. The re-specified model satisfies the utility maximization theory since the null hypothesis which jointly holds the homogeneity and the symmetry restrictions is not rejected.

As a second step in estimation of model 2, to gain some insight into the nature of structural break, the dummy parameters for intercept and expenditure terms are tested jointly and separately while the homogeneity and symmetry conditions are imposed. In the joint test, the hypothesis of no structural break in the dummy parameters for intercept and expenditure is not rejected at the 5% significance level. In the separate tests, the hypothesis of no structural break for expenditure is rejected in 10% significance level, whereas the same hypothesis cannot be rejected for intercept. Table 2 presents the test statistics and p-values of these tests. From Table 2 it is apparent that the main source of the structural break, which is consistent with utility maximization theory, is the meat expenditures. The possible explanation of this result is that the consumer behavior in the meat market has changed not through the meat prices but through the meat expenditures.

Table 2. Likelihood Ratios for Structural Break Tests

Hypothesis	***Likelihood-Ratio***	***P-value***
No Structural Break in:		
Intercept and Expenditure	9.49	0.1479
Intercept	2.91	0.4054
Expenditure	7.25	0.0644

Although, the intercept term is found to exhibit no structural break—dummy parameters for intercept equal to zero, it does not alter any of the elasticity calculations. However, the suggested structural break in the meat expenditure term differentiates the elasticities in terms of before and after the structural break period, which are 1970-1975 (period 1) and 1976-2010 (period 2) respectively. The following equations present the modified versions of elasticities related to Model 2 for the after structural break period.

$$\eta_i^a = \frac{\beta_i + \psi_i}{w_i^a} + 1, \quad \text{➔Income elasticity of } i\text{th meat;} \qquad (8.1)$$

$$\varepsilon_{ik}^a = \frac{\left[\gamma_{ik} - (\beta_i + \psi_i) * w_k^a\right]}{w_i^a}, \quad \text{➔Cross-price elasticity between } i\text{th and } k\text{th meat;} \qquad (8.2)$$

$$\varepsilon_{ii}^{a} = \frac{\gamma_{ii}}{w_i^a} - (\beta_i + \psi_i) - 1, \qquad \text{➔Own price elasticity of } i\text{th meat;} \qquad (8.3)$$

$$\sigma_{ik}^{a} = \varepsilon_{ki}^{*a} - \varepsilon_{ii}^{*a}, \qquad \text{➔Morishima elasticity between } i\text{th and } k\text{th meat;} \qquad (8.4)$$

where ε* denotes the Hicksian price elasticities, w_i^a indicates the mean budget share of the *i*th meat in after the structural break period (period 2) and superscript "a" denotes the after structural break period.

The elasticities that reflect demand response before structural change are obtained by setting the ψ parameters to zero and substituting w_i^b for w_i^a. The w_i^b indicates the mean budget share of the *i*th meat in before the structural break period (period 1).

6. Estimation Results and Discussion

With the two sets of demand restrictions—homogeneity and symmetry—satisfied as well as the structural break in meat expenditures accounted for, the first differenced LA/AIDS model is estimated by using Iterated Seemingly Unrelated Regression (ITSUR). Marhallian, hicksian, and Morishima elasticities for period 1 and 1 are estimated by using the ITSUR parameter estimates. Table 3, 4, and 5 present the estimated elasticites and their corresponding p-values for period 1 and 2.

Table 3. Estimated Marshallian Elasticities at the Sample Mean

	Beef	*Pork*	*Poultry*	*Fish*	*Expenditure*
			Before Structural Break		
Beef	-1.10485***	-0.07306*	-0.1118***	-0.10849***	1.3982***
	(<.0001)	(0.0831)	(0.0002)	(0.0003)	(<.0001)
Pork	0.040366	-0.95637***	-0.08633*	-0.03821	1.040541***
	(0.8205)	(<.0001)	(0.0753)	(0.4505)	(0.0006)
Poultry	-0.01438	-0.04813	-0.2265**	-0.26887**	0.557882
	(0.9600)	(0.6818)	(0.0234)	(0.0165)	(0.2060)
Fish	0.691805	0.495164**	-0.23978	0.478692*	-1.42589*
	(0.1833)	(0.0194)	(0.1192)	(0.0625)	(0.0969)
			After Structural Break		
Beef	-0.90178***	0.016902	-0.08636*	-0.10605***	1.077296***
	(<.0001)	(0.7447)	(0.0664)	(0.0083)	(<.0001)
Pork	0.079982	-0.93503***	-0.08211	-0.03454	0.971689***
	(0.5282)	(<.0001)	(0.2171)	(0.5513)	(0.0004)
Poultry	-0.06724	-0.05519	-0.44672***	-0.18154**	0.750687***
	(0.5568)	(0.4295)	(<.0001)	(0.0158)	(0.0027)
Fish	-0.41458**	-0.10623	-0.33602***	-0.2803**	1.137121***
	(0.0217)	(0.3265)	(0.0082)	(0.0451)	(0.0028)

***, **, ** denotes significance at 1%, 5%, and 10% level respectively.

The most striking result from the Table 3 is that the fish is not only an inferior but also a giffen good before the structural break since the income and own price elasticities of fish are negative and positive respectively. However, after the structural break fish turns out to be a normal good. The second important result is that the cross-price elasticities show more significant complementarity relationships than expected. Thirdly, the income elasticities of beef and pork have decreased while the income elasticities of poultry and fish have increased after the break. In other meaning, the necessities of the beef and pork as a protein source have increased whereas fish has become to be a more luxury good than before, and poultry remains to be a necessity for consumers even though the income elasticity of it has increased. One possible interpretation of this result is that the some of the suggested advantages of white meat pertaining to health issues has increased the value of fish and poultry from consumer's perspective.

Table 4. Estimated Hicksian Elasticities at the Sample Mean

	Beef	*Pork*	*Poultry*	*Fish*
		Before Structural Break		
Beef	-0.34535***	0.287462***	0.068541***	-0.01066
	(<.0001)	(<.0001)	(0.0063)	(0.6527)
Pork	0.605593***	-0.68807***	0.047881	0.034598
	(<.0001)	(<.0001)	(0.2084)	(0.3993)
Poultry	0.288661***	0.09572	-0.15455	-0.22983**
	(0.0063)	(0.2084)	(0.1737)	(0.0137)
Fish	-0.08274	0.127503	-0.42369**	0.378927*
	(0.6527)	(0.3993)	(0.0137)	(0.0827)
		After Structural Break		
Beef	-0.41258***	0.275076***	0.109643***	0.027863***
	(<.0001)	(<.0001)	(0.0004)	(0.3280)
Pork	0.521225***	-0.70216***	0.094685**	0.086253*
	(<.0001)	(<.0001)	(0.0243)	(0.0561)
Poultry	0.27365***	0.124717**	-0.31014***	-0.08822
	(0.0004)	(0.0243)	(0.0004)	(0.1683)
Fish	0.101784	0.166285*	-0.12913	-0.13894
	(0.3280)	(0.0561)	(0.1683)	(0.2523)

***, **, ** denotes significance at 1%, 5%, and 10% level respectively.

Table 4 presents the estimated Hicksian elasticities and their corresponding p-values for period 1 and 2. The results show that most of the estimated elasticities are significant. One important result is that except fish the own price elasticities of all other meats has increased. When the significant elasticities in the both period are compared, it is seen that the cross price elasticity of pork and beef, and poultry and beef have decreased. Moreover, even after the income effect is discarded the fish own price elasticity is positive before the structural break which suggests that either there is mistake in estimation process or there is still a model misspecification.

Table 5. Estimated Morishima Elasticities at the Sample Mean

	Beef	*Pork*	*Poultry*	*Fish*
		Before Structural Break		
Beef		0.260247***	-0.05669	-0.42809**
		(<.0001)	(0.4700)	(0.0122)
Pork	-0.40061***		-0.59235***	-0.56057***
	(<.0001)		(<.0001)	(0.0002)
Poultry	-0.08601	-0.10667		-0.57823***
	(0.3927)	(0.3273)		(0.0009)
Fish	0.368269*	0.413525**	0.149092	
	(0.0777)	(0.0416)	(0.4600)	
		After Structural Break		
Beef		0.108643*	-0.13893**	-0.3108***
		0.0536)	(0.0136)	(0.0009)
Pork	-0.42709***		-0.57745***	-0.53588***
	(<.0001)		(<.0001)	(<.0001)
Poultry	-0.2005***	-0.21546***		-0.43927***
	(0.0048)	0.0094)		(<.0001)
Fish	-0.11108	0.166285	-0.22717*	
	(0.3176)	(0.6190)	(0.0544)	

***, **, ** denotes significance at 1%, 5% and 10% level respectively.

Table 5 presents the estimated morishima elasticity of substitutons and their corresponding p-values for period 1 and 2. Negative and positive morishima elasticity of substitution indicate complementarity and substitutability of goods respectively. The results show that almost all of the significant elasticity estimates exhibit the complementarity relationship between goods which is an unexpected result but coincides with the results of Table 3. Some of the important results are: the degree of substitutability between beef and pork has decreased in the second period whereas the degree of complementarity between other goods and fish has decreased which indicates an increased substitutability between other goods and fish.

Most of the previous studies have only provided the elasticities before and after the structural break and tried to compare numerical values of elasticities. Only a few of them provide evidence on differences in elasticities. Since the elasticities are basically numerical values, in some cases, the numerical differences might be insignificant even if they are numerically large; and hence, not estimating the differences in elasticities leads to illusive results. Therefore, this paper estimates the differences in marshallian between period 1 and 2. Table 6 presents these estimates and their corresponding p-values.

Table 6. Differences in Marshallian Elasticities Between Period 1 and 2

	Beef	*Pork*	*Poultry*	*Fish*	*Expenditure*
Beef	0.203073*	0.089962	0.025437	0.002432	-0.3209***
	(0.0899)	(0.1483)	(0.5246)	(0.9236)	0.1877)
Pork	0.039615	0.021345	0.004222	0.00367	-0.06885
	(0.8275)	(0.8161)	(0.9410)	(0.9183)	(0.8493)
Poultry	-0.05285	-0.00706	-0.22022***	0.087327	0.192805
	(0.8482)	(0.9553)	(0.0008)	(0.1258)	(0.7015)
Fish	-1.10639**	-0.60139***	-0.09624	-0.75899***	2.563007***
	(0.0314)	(0.0080)	(0.3802)	(<.0001)	(0.0067)

***, **, ** denotes significance at 1%, 5% and 10% level respectively.

The results of table 6 shows that there are five significant differences in marshallian elasticities between period 1 and 2: income elasticity of beef and fish; own price elasticity of fish and poultry; and the cross-price elasticity of fish and pork. Moreover, differences in own price elasticity of beef, and differences in cross price elasticity of fish and beef are significant at 10% and 5% levels respectively. As a result, the suggested structural break has significantly changed the own price elasticity of three type of meats and changed the income elasticity of two types of meats. These results indicate that the suggested structural break is in fact effective and change the meat demand structure in the U.S.

7. Conclusion

In summary, this paper tried to provide evidence on the suggested presence and location of the structural break in meat demand in the U.S. First, Chow test was incorporated to locate the data point of the suggested structural break. Second, in a homogeneity and symmetry restrictions-imposed LA/AIDS model, a test detecting the source of structural break in meat demand is performed. It is found that the meat expenditure exhibited the most significant effect in meat demand in the U.S. Lastly, with the two sets of demand restrictions—homogeneity and symmetry—imposed as well as the structural break in meat expenditures accounted for, the first differenced LA/AIDS model is estimated by using Iterated Seemingly Unrelated Regression (ITSUR). Using the estimated marshallian, hicksian and morishima elasticities indicated that the structure of beef, pork, poultry, and fish demand have changed significantly. Moreover, estimated differences in marshallian elasticities provide evidence in favor of the presence of structural break in meat demand in the U.S.

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