Gradual Switching Structural Changes of Meat Consumption in Taiwan

Jane Lu Hsu*

ABSTRACT. This paper utilized a linear approximate version of the Almost Ideal Demand System to evaluate structural changes of meat consumption in Taiwan. Time transition paths for each product were identified and first-order autocorrelation was taken into consideration. Structural changes of beef consumption (1979-1984) were completed before structural changes of other products had started. Shifting in consumption patterns of pork (1990-1995) and poultry (1988-1994) took about the same time length. Structural changes of fishery products (1994-1996) occurred toward the end of the time period. With the gradual switching time paths, estimated elasticities show that own-price elasticities for pork, beef, and fishery products became more responsive to their own-price changes.

Key words: Gradual switching structural changes, Meat consumption, LA/AIDS, Time transition paths, Elasticities

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INTRODUCTION

Changes in meat consumption patterns have been widely researched over the last two decades. Several studies attributed these shifts to changes in relative prices and in real income (Chalfant and Alston; Haidacher *et al*.; Moschini and Meilke, 1984; Wohlgenant). Chavas believed that health and nutritional concerns caused structural changes in meat consumption and moved consumers toward poultry products. Other studies concluded that the fundamental structure of meat demand had changed (Dahlgran; Thurman).

Consumption of livestock and fishery products has increased dramatically in Taiwan in the past few decades. In 1951, the average annual consumption of livestock and fishery products were about 29 kilograms per capita. This amount has increased to 112 kilograms per capita in 1996. The structure of livestock and fishery product consumption also has changed. In 1951, pork accounted for 47 percent of livestock and fishery product consumption, beef accounted for only 2 percent, poultry accounted for 5 percent, and fishery products accounted for 46 percent. In 1996, pork consumption had decreased to 36 percent of total livestock and fishery product consumption, beef consumption increased to 3 percent, poultry consumption increased to 27 percent, and fishery product consumption decreased to 34 percent (figure 1).

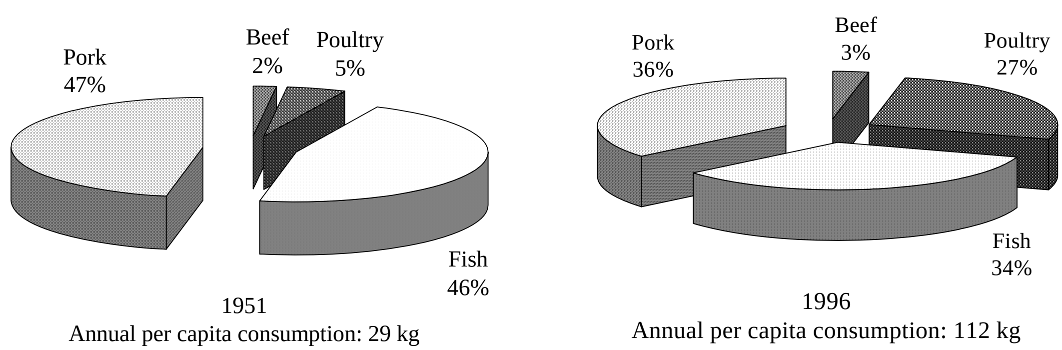

Figure 1. Structure of Livestock and Fishery Product Consumption in Taiwan, 1951 vs. 1996

Consumption patterns of livestock and fishery products have shifted in Taiwan. As shown in figure 2, annual per capita consumption of poultry has an increasing trend while annual per capita consumption of beef has been relatively low. Fishery products have been preferred until the mid-90s. Since then, pork took the lead in the livestock and fishery product consumption.[1]

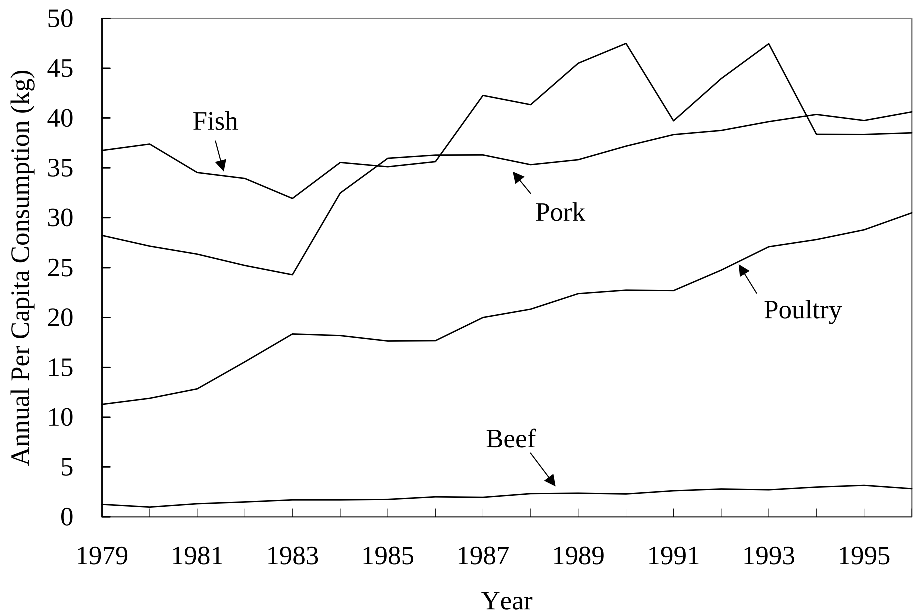

Figure 2. Annual Per Capita Consumption of Livestock and Fishery Products in Taiwan

Real retail prices of beef, pork, poultry, and fish along with real income over the same time period are shown in table 1.[2] Real retail fish prices fluctuated between US$ 3.5 and US$ 6.7 per kilogram. Real retail prices of beef, pork, and poultry were relatively stable. Real beef price of 1996 was only 7 cents per kilogram higher than it of 1979. For pork, it was 10 cents higher. Real poultry price of 1996 was even 31 cents per kilogram lower than it of 1979. The real income for this period was about twofold. Therefore, the variability of consumption patterns of livestock and fishery products may have been caused by changes of consumer preferences and increases in real income.

Changes in consumption patterns occur gradually rather than instantaneously at a certain

[1] Due to reconstruction of consumption data at Council of Agriculture in Taiwan, per capita livestock and fishery consumption data have two different series. The old data set is from 1951 to 1992, and the new reconstructed data set starts from 1984. This research used new reconstructed data set and traced annual per capita consumption data back to 1979 based on the suggestion from the Statistical Sector of the Council of Agriculture in Taiwan.

[2] All the nominal retail prices were divided by consumer price index of food, while income was divided by general consumer price index. Real retail prices and income were converted to U.S. dollars using annual average exchange rates.

point of time (Goodwin and Brester). Different products have different paths of shifting structure of consumption. Standard Chow tests and dummy variable models can not allow

Table 1. Real Retail Prices of Livestock and Fishery Products and Real Income in Taiwan

Year	Pork	Beef	Poultry	Fish	Income
	(US$/kg)				(US$)
1979	2.74	2.99	2.89	4.98	4389
1980	2.65	3.53	2.78	4.10	3814
1981	2.68	3.07	2.56	3.56	3353
1982	2.73	2.94	2.51	4.01	3322
1983	2.66	3.05	2.47	3.87	3484
1984	2.44	3.24	2.59	3.75	3823
1985	2.07	3.27	2.41	3.91	3960
1986	2.45	3.21	2.70	3.67	5000
1987	2.69	3.40	3.09	4.33	6457
1988	2.92	4.01	3.13	5.44	7456
1989	3.35	4.64	3.58	6.54	8283
1990	3.15	4.29	3.24	6.63	8061
1991	2.92	4.22	3.00	5.89	8205
1992	2.85	3.80	2.99	5.13	8886
1993	2.76	3.64	2.73	4.55	8583
1994	2.68	3.36	2.89	4.19	8548
1995	2.72	3.30	2.81	4.89	8503
1996	2.84	3.06	2.58	5.23	8365

Source: Taiwan Agricultural Yearbook

changes of consumption patterns being gradual. Testing differences of demand structure before and after an arbitrary chosen point does not characterize the nature of shifting in consumption over time.

Chen and Hsiao analyzed meat demand in Taiwan and evaluated policy effects of trade liberalization. They suggested that accuracy of estimation could be improved by specifying structural and preference changes. The objective of this study is to identify the changing patterns of livestock and fishery product consumption in Taiwan. A system of demand equations for beef, pork, poultry, and fish is estimated. These meat products are assumed to be weakly separable from other consumption items. This paper presents estimates of price and expenditure elasticities obtained from a model which allows for differential gradual switching structural changes in the demand for each commodity. These estimates are compared to estimates obtained from a demand system which assumes no structural changes.

RELATED RESEARCH

Research had found several reasons for changes in consumption patterns. Chalfant and Alston used a nonparametric method to test whether shifts in meat demands had been caused by changes in tastes and preferences. Both strong and weak axioms of revealed preferences were used to test stability of preferences in meat consumption in the United States and in Australia. Annual per capita disappearance of beef and veal, fish, pork, and poultry in the United States from 1947 to 1978 and from 1947 to 1983, and quarterly disappearance of beef, chicken, lamb, mutton, and pork from 1962 to 1984 in Australia were examined. In both countries, per capita consumption of chicken had increased over time, while per capita consumption of red meats had decreased. Results from their study showed only minor violations of revealed preference. Thus, these data were consistent with a stable utility function. Without evidence of changes in tastes and preferences, they concluded that changes in relative prices accounted for shifts in meat consumption patterns.

Haidacher *et al*. studied demand for beef and veal, pork, other red meats, chicken, turkey, and fish products in the United States from 1950 to 1977 using per capita disappearance data. They found that increased incomes were largely allocated to nonfood items rather than meat products and that all meat products were price inelastic. They concluded that changes in meat consumption patterns were the result of price and income changes rather than from changes in tastes and preferences.

Moschini and Meilke (1984) proposed that structural changes in meat consumption should be examined by general functional forms instead of constant parameter models, which may indicate consumption changes caused by omitted variables, incorrect functional forms, or structural changes. A log-likelihood function based on the Box-Cox transformation was utilized on U.S. quarterly data from the first quarter of 1966 to the last quarter of 1981. Per capita consumption of beef was specified as a function of retail beef price, retail pork price, a price index of other goods, and income. Alternative functional forms (linear, log-log, and linear-log) were also examined. Evidence of structural changes using recursive residual analyses, Chow test, and Farley-Hinich test was weak. Thus, changes in relative prices appeared to cause decreased beef consumption.

Wohlgenant also found that changes in relative prices of competing meats and per capita real income accounted for shifts in meat consumption. Decreases in real poultry prices were larger than decreases in real beef or pork prices from 1973 to 1983. A Fourier flexible functional form using a Fourier series expansion in prices was applied to U.S. annual data from 1947 to 1983. Results showed that beef demand became more sensitive to poultry prices since the mid-1970s. Cross-price elasticities of beef with respect to pork prices and income elasticities remained constant over the period. Thus, this model indicated no structural changes in meat consumption.

Brester and Schroeder examined the impacts of advertising on beef, pork, and poultry demand while considering cross advertising effects. U.S. quarterly data from 1970 through 1993 were used. A nonlinear, log differential form of the absolute price version of Rotterdam model was utilized and advertising expenditures were incorporated. Advertising was considered to indirectly adjust prices and total personal consumption expenditures. Beef and pork advertising were separated into generic and branded product advertising, while poultry advertising was all branded. A nonparametric test was applied to the data. Minor violations were found in real total meat expenditures. Changing tastes and preferences were not supported from the nonparametric test results. Estimated elasticities showed that branded beef, branded pork, and poultry advertising had significantly increased beef, pork, and poultry consumption, respectively.

Conversely, other studies concluded that the fundamental structure of meat demand had changed (Dahlgran; Thurman). Health and nutritional concerns were cited as sources of structural changes in meat consumption. Consumers had tended to consume more poultry products and less red meats, especially beef (Chavas; Eales and Unnevehr; Goodwin; Hahn; Moschini and Meilke, 1989).

Dahlgran used a Rotterdam demand system to account for income and price effects on changes in meat consumption and to determine whether a structural change of meat demand occurred. The Rotterdam model contained price-dependent equations for beef, pork, and chicken, and quantity-dependent equations for other foods and nonfood items. Dahlgran assumed that quantities of meats were predetermined, as well as prices of other foods and nonfood items. The model was estimated using U.S. annual data from 1950 to 1985 with gradual structural change factors added to capture timing, rate, and magnitude of the changes. Stepwise likelihood maximization was utilized to search for the most significant specification over all possible structural change combinations in logit and exponential forms. The significant specification of structural change was then added to the Rotterdam model. Results showed a significant structural change occurred in meat consumption in the 1970s. Substitutability between beef and chicken increased, and price and income elasticities restabilized after the structural change. Own-price elasticities tended to be less elastic after the structural change.

Thurman examined poultry demand by using price-dependent and quantity-dependent versions of double log functional forms. U.S. annual data of poultry consumption and prices, beef prices, pork prices, and real per capita income from 1955 to 1981 were used. Results indicated that the demand relationship between poultry and pork changed from substitution to independence in the early 1970s, when poultry demand increased considerably. Using exogeneity tests, poultry prices were found to be predetermined by production costs and consistent with a competitive industry operating under constant returns to scale.

Chavas used a linear model based on Kalman filtering techniques to estimate demand and structural changes for beef, pork, and poultry from 1950 to 1979. He proposed that modifications in beef grading in the mid-1970s induced consumers' concerns regarding beef's fat and cholesterol content.[3] Results showed that beef demand became less elastic with respect to own prices and income for the latter part of the 1970s. Conversely, poultry became more responsive to income but less responsive to pork and beef prices over the same time period. He concluded that structural change, driven from health and nutritional concerns, occurred for beef and poultry, but not for pork.

Goodwin utilized Bayesian inferential procedures in a multivariate gradual switching Almost Ideal Demand System (AIDS) to identify the time and speed adjustment of structural changes in meat demand from 1946 to 1986 in United States. A significant gradual structural change was initiated in 1961 and was 99 percent complete in 1983. The adjustment of consumers' changes in meat consumption was slow. Results showed that demand for beef became more sensitive to changes in own price and prices of pork and poultry. Demand for pork became more responsive to changes in own price while demand for poultry became less responsive to changes in own price. Poultry and fish switched from inferior to superior (luxury) goods after the structural change. However, Goodwin indicated that the results for fish may not be reliable due to small expenditure shares of fish. He concluded that structural change may have been caused by increased consumption of processed, convenience-type poultry products and nutritional concerns of consumers.

Moschini and Meilke (1989) stated that improvement in poultry production, lower real retail poultry prices, higher income, demographic factors, demand for convenience foods, and changes in consumers' preferences because of health concerns may jointly account for shifts in meat consumption patterns. However, structural changes in meat consumption should not be solely determined based on changes in estimated elasticities over time. Structural changes are actually defined as changes in demand which occur even if prices and expenditure levels are held constant. They incorporated a set of time path variables into a conditional linear version of the AIDS model using U.S. quarterly disappearance and retail

[3]Major changes in beef grading in the mid-1970s were: (1) reducing marbling requirements for the Prime and Choice grades; (2) increasing marbling requirements of the Good grade for young cattle, but decreasing requirements for older cattle; (3) removing conformation as a factor in quality grades; and (4) initiating yield grading on all quality graded carcasses. Yield grades are based on external fat thickness, proportion of internal fat, and carcass weight and size. Good grade was renamed Select in 1987. (Purcell and Nelson; McCoy and Sarhan; Lesser)

price data of beef, pork, chicken, and fish from 1967 to 1987. The time path, which simulated the transition path of gradual structural changes in the demand system, had 3,246 possible combinations. The demand system was estimated with each time path and confidence intervals were formed using a maximum likelihood approach. A variety of significant structural change paths were found, and a rapid transition in meat consumption in the mid-1970s was implied. They concluded that structural changes in meat demand were consistent with the advent of dietary concerns.

Eales and Unnevehr postulated that a major cause of structural changes in meat consumption was by the introduction of new, convenient chicken products. They used chicken, beef, and pork disappearance and price data, other foods and all other goods categories in estimating a linear approximate version of Almost Ideal Demand System. The U.S. data spanned the years 1965 to 1985. In a model which aggregated chicken products into a single good, they found a preference shift (structural change) away from beef and toward chicken after 1974. They also estimated a disaggregated model in which chicken was disaggregated into whole birds, cut up parts (including processed chicken products), and beef was disaggregated into table cuts and hamburger. Results showed that chicken parts/processed chicken products and beef table cuts were normal goods, but hamburger and whole birds were inferior goods. In addition, hamburger was found to be a substitute for whole birds.

Hahn presumed tastes were determined by factors other than prices and expenditures and should be used to explain changes in consumers' meat consumption patterns. To incorporate taste changes, a random coefficient demand system was utilized to estimate demands for beef, pork, chicken, and turkey using U.S. monthly disappearance data from 1980 to 1992. Results showed that meat demand elasticities fluctuated over the sampling period because of changes in consumers' tastes. Beef demand declined, while poultry demand increased. Beef and pork had higher substitutability than any other pair of meats. Consumers tended to favor poultry over beef while pork demand appeared to be stable.

Brester and Wohlgenant stated that demand for ground beef may be distinct from the demand for table cut beef. However, ground and table cut beef were not strictly produced by nonfed beef (i.e., bulls, cull cows, grass-fattened steers and heifers) and fed beef (i.e., grain-fatted cattle), respectively, although many other studies had made such an assumption (see Arzac and Wilkinson; Brester and Marsh). A new measure of ground and table cut beef was constructed based on a procedure of Western Livestock Marketing Information Project in the United States. The absolute price version of the Rotterdam model was utilized. Annual disappearance data for ground beef, table cut beef, pork, and poultry from 1962 to 1989 were used. A nonparametric test was applied to the data. No violations of the general axioms of revealed preferences were found, indicating consumers' preferences were stable during the sampling period. Results showed an increasing trend for poultry consumption. Ground beef was a substitute for poultry. Income elasticities for both ground and table cut beef were inelastic with ground beef being an inferior good.

MODEL SPECIFICATION

The Almost Ideal Demand System (Deaton and Muellbauer) is chosen for the demand analysis. The linear approximate version (LA/AIDS) of the model is linear in parameters and is a first order local approximation to any system of demand equations (Blanciforti and Green). The LA/AIDS system of share equations can be written as

$$w_{it} = \alpha_i + \sum_k \gamma_{ik} \log P_{kt} + \beta_i \log\left(\frac{X_t}{P^*}\right) + e_{it} \tag{1}$$

where t represents time, i and k denote commodities, w_i represents the expenditure budget shares of the i^{th} good, P denotes nominal prices for each commodity, X represents total expenditures on the i^{th} goods, P^* denotes a price index, and e is a time-wise independent error term which is contemporaneously correlated across the system. P^* is approximated by the Stone's share weighted price index:

$$\log P^* = \sum_i w_i \log P_i \tag{2}$$

For each equation of the LA/AIDS model, a time transition path, λ_{kt} , is introduced and represents gradual structural changes in the system. The transition path is approximated by a linear function of time t (Ohtani and Katayama):

$$\begin{aligned} \lambda_{kt} &= 0 && \textit{for } t = 1, 2, \dots, t_1^*, \\ \lambda_{kt} &= \frac{(t - t_1^*)}{(t_2^* - t_1^*)} && \textit{for } t = t_1^*+1, \dots, t_2^*-1, \\ \lambda_{kt} &= 1 && \textit{for } t = t_2^*, t_2^*+1, \dots, T. \end{aligned} \tag{3}$$

The parameter t_1^* represents an end-point of the first regime and t_2^* indicates the start-point of the second regime. Incorporating the time transition paths into the LA/AIDS model yields:

$$w_{it} = \alpha_i + \gamma_i \lambda_{it} + \sum_k (\gamma_{ik} + \delta_{ik}\lambda_{kt}) \log P_{kt} + (\beta_i + \phi_i \lambda_{it}) \log \frac{X_t}{P^*} + e_{it} \tag{4}$$

The following restrictions of parameter estimates are imposed on the system:

$$\sum_i \alpha_i = 1, \ \sum_i \gamma_i = 0, \ \sum_i \gamma_{ik} = 0, \ \sum_i \delta_{ik} = 0, \ \sum_i \beta_i = 0, \ \sum_i \phi_i = 0; \tag{5}$$

$$\sum_k \gamma_{ik} = 0, \ \sum_k \delta_{ik} = 0; \tag{6}$$

$$\gamma_{ik} = \gamma_{ki}\,, \quad \delta_{ik} = \delta_{ki} \tag{7}$$

These restrictions impose adding-up, homogeneity, and symmetry, respectively.

Equation (4) is estimated to obtain the time path parameters. Upon estimation, autocorrelation commonly exists in the system. Therefore, the following model is estimated to account for first-order autocorrelation:

$$w_{it} - \rho w_{it-1} = \theta + \gamma_i\left(\lambda_{it} - \rho\lambda_{it-1}\right) + \sum\nolimits_k \left[\gamma_{ik} + \delta_{ik}\left(\lambda_{kt} - \rho\lambda_{kt-1}\right)\right]\left(\log P_{kt} - \rho \log P_{kt-1}\right)$$

$$+\left[\beta_i + \phi_i\left(\lambda_{it} - \rho\lambda_{it-1}\right)\right]\left(\log\frac{X_t}{P^*} - \rho\log\frac{X_{t-1}}{P^*}\right) + e_{it} - \rho e_{it-1} \tag{8}$$

where -1 ≤ ρ ≤ 1, represents the first-order autocorrelation coefficient, and θ is the new intercept. Denoting $\varepsilon_i = e_{it} - \rho e_{it-1}$, the maximum likelihood estimate of σ_i^2 is giving by $\varepsilon'\varepsilon/T$. The concentrated log-likelihood ratio is given by:

$$L_{(i)\max}\left(t_1^*, t_2^*, \rho\right) = -\frac{T}{2}\left(\log 2\pi + 1\right) - \frac{T}{2}\log\hat{\sigma}_i^2 \tag{9}$$

The maximum likelihood estimates of t_1^*, t_2^* and ρ, say $\hat{t}_1^*$, $\hat{t}_2^*$ and $\hat{\rho}$, can be obtained by searching over all combinations of t_1^*, t_2^* and ρ. The rejection region of the likelihood ratio test at the 5 percent level for the null hypothesis, H_0: $\rho = 0$, is:

$$L_{(i)\max}\left(\hat{t}_1^*, \hat{t}_2^*, \hat{\rho}\right) - L_{(i)\max}\left(\hat{t}_1^*, \hat{t}_2^*, \hat{\rho} = 0\right) > \frac{\chi^2}{2} \tag{10}$$

where χ^2 is the upper 5 percent critical value of the chi-square distribution with one degree of freedom.

After $\hat{t}_1^*$ and $\hat{t}_2^*$ are chosen for each product, the transition paths of λ_{kt} are then included in each equation of the demand system. Given the initial results of estimating Eq. (4), the differencial form of the LA/AIDS is estimated to obtain the price and expenditure elasticities. The dynamic gradual switching regression model becomes

$$dw_{it} = \gamma_i d\lambda_{it} + \sum\nolimits_k \left[\gamma_{ik} d\log P_k + \delta_{ik}(d\lambda_{kt})(d\log P_{kt})\right]$$

$$+ \beta_i d\log\frac{X_t}{P^*} + \phi_i(d\lambda_{it})(d\log\frac{X_t}{P^*}) + u_{it} \tag{11}$$

where d denotes that the variables are in different form, and u_{it} is a time-wise independent, contemporaneously correlated error term.

EMPIRICAL APPLICATION AND RESULTS

Average annual retailing price data for pork, beef, poultry, and fishery products from 1979 to 1996 were collected from various issues of the Taiwan Agricultural Yearbook. Annual per capita disappearance data were obtained from the reconstructed Balance Sheets from the Council of Agriculture in Taiwan. Prior to estimating the gradual switching regression model, the proper time transition paths for each meat product was obtained. The system represented by Eq. (4) is estimated over all possible combinations of time paths and the maximum likelihood method was used to search for the transition paths. The equation representing fishery product consumption is deleted from the system for purposes of estimation to avoid a singular covariance matrix of residuals. The parameters of the deleted equation are recovered using the restrictions imposed by Eq. (5)-(7). For pork, the structural change begins in 1990 and ends in 1995. The transition path for beef begins in1979 and ends in 1984. The switching period for poultry begins in 1988 and ends in 1994. Conversely, the structural change for fishery products begins in 1994 and ends in 1996. Results indicate each product has its own shifting patterns of consumption. Structural changes of beef were completed before other shifting paths started. The transition time for fishery products was shorter than livestock products and was toward the end of sampling period, when the annual per capita consumption of fishery products became lower than the annual per capita consumption of pork.

After obtaining the transition time paths for each product, the system represented by Eq. (8) is estimated repeatedly for various values of autocorrelation coefficients between 1 and -1. The maximum likelihood method was used for selecting the coefficients of autocorrelation for each product in the demand system. The values of the likelihood functions at different values of autocorrelation coefficients are shown in figures 3-6. The coefficients of autocorrelation are pork, 0.14, beef, -0.06, poultry, 0.33, and fishery products, -0.39, chosen at the highest values of the likelihood functions in the demand system. The significance of each autocorrelation coefficient was tested using chi-square distribution.

To avoid the loss of the first observation, the Prais-Winsten transformation is applied using the coefficients of autocorrelation for each product. Upon completing the searching of the transition time paths and coefficients of autocorrelation, the system of dynamic gradual switching regression model represented by Eq.(11) is estimated. Elasticity estimates for these four commodities are calculated following Moschini and Meilke's (1989) approach. Budget shares are assumed to shift gradually with the shifts in consumer preferences. Thus, the time transition path in each equation should catch the gradual switching trend.

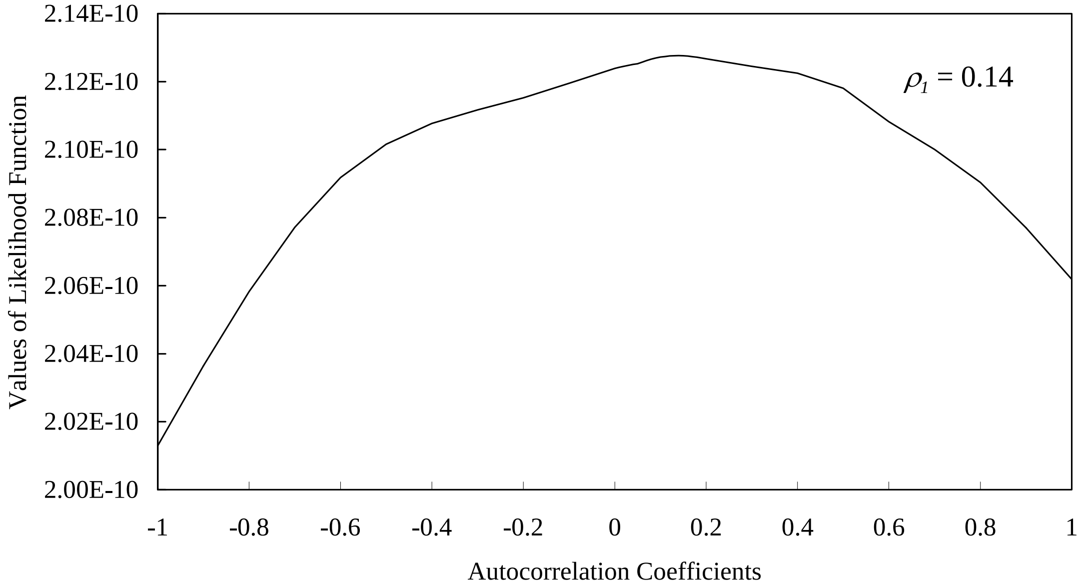

Figure 3. Values of Likelihood Functions at Various Autocorrelation Coefficients for Pork Equation in the Demand System

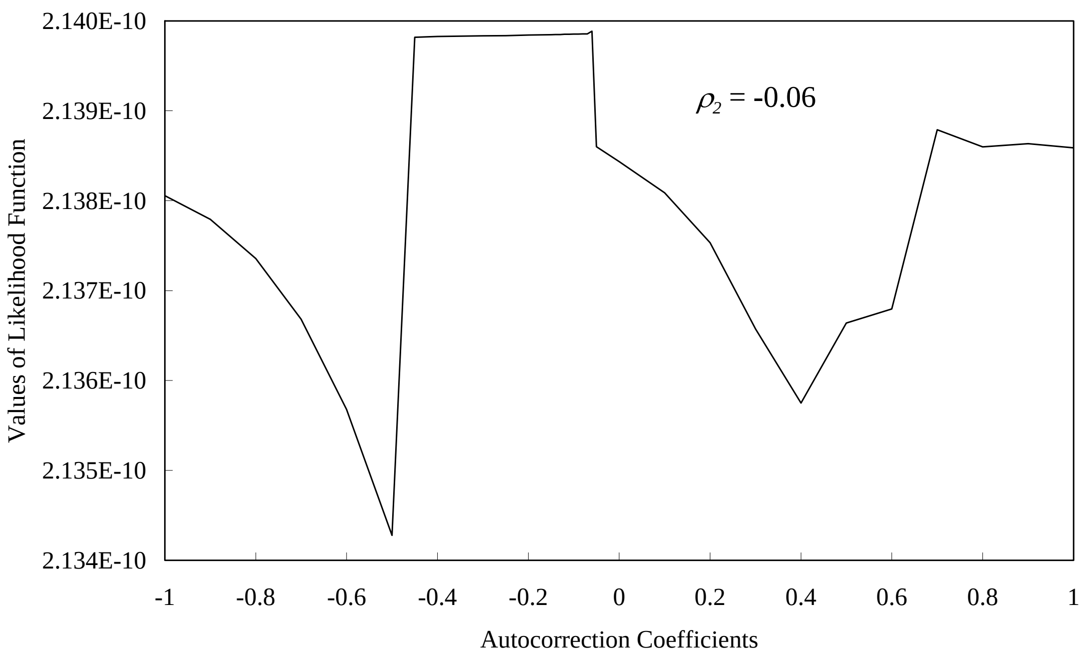

Figure 4. Values of Likelihood Functions at Various Autocorrelation Coefficients for Beef Equation in the Demand System

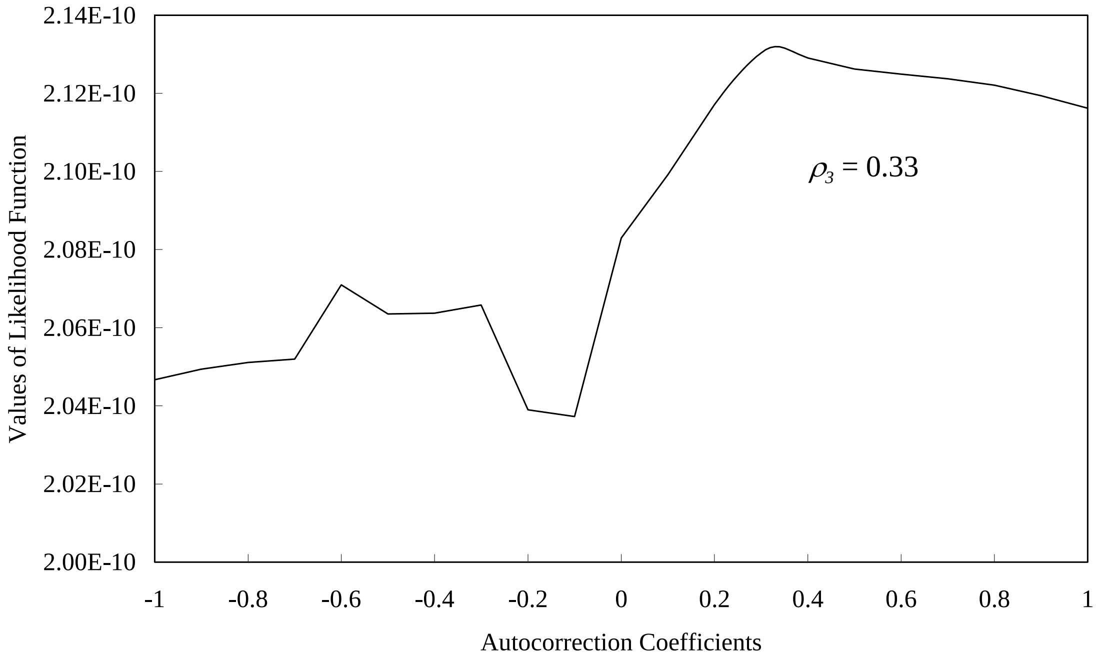

Figure 5. Values of Likelihood Functions at Various Autocorrelation Coefficients for Poultry Equation in the Demand System

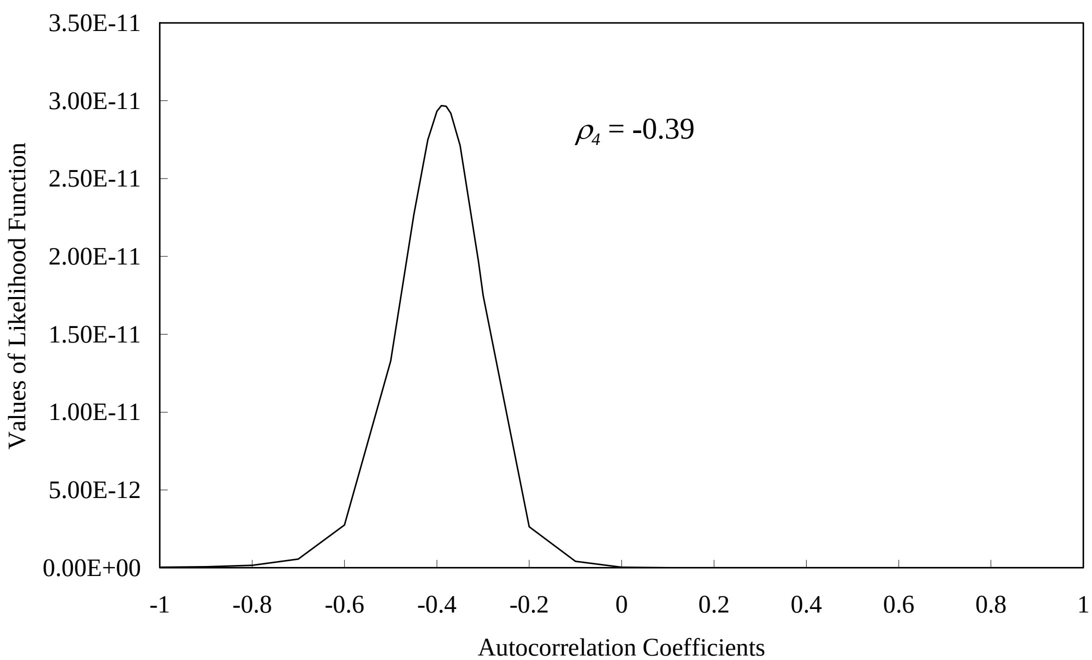

Figure 6. Values of Likelihood Functions at Various Autocorrelation Coefficients for Fish Equation in the Demand System

The estimated price and expenditure elasticities without correcting for the first-order autocorrelation nor considering time transition paths are presented in table 2. Poultry is more price elastic than other livestock and fishery products. Beef and fishery products are very price inelastic. Pork and poultry show relationships of substitution. Expenditure elasticities for beef and poultry are larger than one, having values of 2.06 and 1.97 respectively. Expenditure elasticity for pork is close to one. However, expenditure elasticity for fishery products is less than one, having value of 0.60.

Table 2. Marshallian Elasticities without Time Transition Paths

Quantities	Prices				Expenditures
	Pork	Beef	Poultry	Fish	
Pork	-0.8562	0.0098	0.3917	-0.6518	1.1065
Beef	-0.1337	-0.2801	-0.5737	-1.0678	2.0552
Poultry	0.4045	-0.0707	-1.0809	-1.2215	1.9686
Fish	-0.1957	-0.0115	-0.1534	-0.2388	0.5992

Note: Elasticities are evaluated at the mean data values

The estimated price and expenditure elasticities with time transition paths and corrected for the first-order autocorrection are listed in table 3. The own-price elasticities for pork, beef, and fishery products became more elastic than the corresponding price elasticities without time transition paths. Own-price elasticity for pork changed from -0.86 to -0.99, beef changed from inelastic (-0.28) to elastic (-1.51), also did the fishery products from inelastic (-0.23) to elastic (-1.31). With the structural shifting factors taken into consideration, the estimated elasticities show that these three commodities are more responsive to their own-price changes. The cross-price elasticities show that relationships for beef and poultry have changed to substitution. Cross-price elasticities for pork and poultry became larger when time transition paths are considered. This finding may suggest an increased degree of substitutability between pork and poultry.

Table 3. Marshallian Elasticities with Time Transition Paths

Quantities	Prices				Expenditures
	Pork	Beef	Poultry	Fish	
Pork	-0.9926	-0.0054	0.4973	0.2683	0.2324
Beef	0.1114	-1.5089	1.2777	0.5480	-0.4281
Poultry	1.1220	0.1712	-0.9034	0.4922	-0.8819
Fish	-0.3605	-0.0307	-0.3369	-1.3143	2.0425

Note: Elasticities are evaluated at the mean data values

Changing in expenditure elasticities is more obvious. Without the structural shifting factors taken into consideration, the expenditure elasticity for fishery products is less than one, while pork is close to one. Considering the structural shifting factors and correcting for the first-order autocorrelation, expenditure elasticities for pork, beef, and poultry decreased dramatically. Expenditure elasticity for pork dropped from 1.11 to 0.23, for beef dropped from 2.06 to -0.43, and for poultry dropped from 1.97 to -0.88. For fishery products, expenditure elasticity increased from 0.60 to 2.04. This suggests beef and poultry exhibit the expenditure characteristics of inferior goods. In contrast, fishery products exhibit a sign of superior food items. Pork has an inelastic expenditure, which provides an evidence of expenditure characteristics of necessary food items. Therefore, for an additional percentage of total income distributed to food expenditures based on two-stage budgeting process, expenditures on fishery products and pork will increase by 2.0% and 0.2%, respectively, while expenditures on beef and poultry will decrease by 0.4% and 0.9%, respectively.

CONCLUSIONS

This paper evaluates gradual structural changes of meat consumption in Taiwan. Linear approximate version of the Almost Ideal Demand System was utilized in analysis. Time transition paths for each commodity were identified and first-order autocorrelation was taken into consideration. Structural changes of beef consumption were completed before other structural changes had started. Shifting in consumption patterns of pork and poultry took about the same time length. Structural changes of fishery products occurred toward the end of the time period.

With the gradual switching time paths, estimated elasticities show that own-price elasticities for pork, beef, and fishery products became more responsive to their own-price changes. Cross-price elasticities show that relationships of beef and poultry changed to substitution, and suggest an increased level of substitutability of pork and poultry. Considering the structural shifting factors, expenditure elasticity for fishery products has increased to larger than one, but expenditure elasticities for pork, beef, and poultry have decreased, and beef and poultry have negative expenditure elasticities.

The demand system which incorporates gradual switching time paths could reflect consumption patterns in livestock and fishery more accurately. Results from this research could provide a guideline for further dynamic demand analyses. Limits of degree of freedom due to reconstruction of annual per capita consumption data inhibit the comparisons of elasticities before and after structural changes.

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