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ESTIMATION OF DEMAND FOR MEAT IN KOREA

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I. Abstract

This study estimates the Korean meat demand, using a general switching AIDS model, and tests if the demand structure changes over time. The demand for beef, pork, chicken, and other meat products is estimated, using annual data from 1970 to 1989. The separability test suggests that fish does not have to be included in this meat demand analysis.

The results indicate that structural change in meat consumption occurred between 1977 and 1989, possibly with no termination during the sample period. Significant structural changes are detected in the beef and pork demands, but not in the chicken demand. While price elasticity of beef remains inelastic before and after the structural change, demand for pork becomes less price elastic and that for chicken more elastic after the structural change.

II. ESTIMATION OF DEMAND FOR MEAT IN KOREA

Over the past 20 years, per capita meat consumption in Korea has increased substantially(National Livestock Cooperative Federation). During the period, pork consumption increased about four times. Beef and chicken consumption also have increased steadily.

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Along with the increase in meat consumption, its price, especially for beef and pork, has fluctuated substantially during the last two decades, mainly because of an imbalance between demand and supply. Poor marketing facilities and inefficient operations of buffer stock escalated variations in the demand-supply imbalance. These have made Korean meat markets highly volatile, and producers have faced higher price risks and uncertainty.

Understanding demand elasticities of meat would be important to policy makers, one of whose major concern is to reduce price variability, and to meat producers and processors, who use the information to optimally adjust their production sizes and marketing strategies. The objective of this study is to estimate Korean meat demand, using a gradual switching AIDS model which allows the demand pattern to change over time.

While past studies on Korean meat demand(Kim; Hu; Koo and Park; and Bae) show consistent results for elasticity estimates to some extent, most of them suffer from model specifications that are not theoretically plausible. Except Bae, none considered structural changes that may provide biased and inefficient estimates if ignored. Bae's study used a dummy variable to capture structural change in meat consumption, but it did not capture smooth transition in demand responsiveness.

The demand for meat in the current study is estimated using a theoretically plausible model with general demand restrictions, and structural change is tested more rigorously than in the previous studies. In addition, separability between meat products and fish is tested to determine whether fish should be included in the analysis of the meat demand system.

III. The Base Model and Data

This study bases on the Almost Ideal Demand System(AIDS) developed by Deaton and Muellbauer. This AIDS model has been widely used to estimate the meat demand system in the United States (Eales and Unnevehr; Moschini and Meilke; Nayga and Capps), Canada(Reynolds and Goddard), and Japan(Hayes et al.).

From a flexible expenditure function, the AIDS model for Korean meat consumption with five meat classes is specified as

$$w_i = \alpha_i + \Sigma_j \gamma_{ij} \ln(P_j) + \beta_i \ln(Y/P^*), \text{ for all } i, \tag{1}$$

where w_i is the share of the total expenditure allocated to the i^{th} product, p_j is the price of the j^{th} product in the group, Y is the total expenditure allocated to the group, and P* is the price index for the group, defined as

$$\ln P^* = \alpha_o + \Sigma_j \alpha_j \ln(P_j) + 1/2 \Sigma_i \Sigma_j \gamma^*_{ij} \ln(P_i) \ln(P_j). \tag{2}$$

This index introduces nonlinearity in parameters and causes difficulties in estimation. Thus, Deaton and Muellbauer suggest the linear Stone index defined as

$$\ln P = \Sigma_j w_j \ln(P_j). \tag{3}$$

The AIDS model that uses the Stone index is called the "linear approximate" AIDS or LA/AIDS(Blanciforti and Green). This replacement, however, causes a simultaneity problem since the budget share w_j in the Stone index is also the dependent variable. To avoid this, lagged w_j is often used instead(Eales and Unnevehr).

The Marshallian price and expenditure elasticities are

$$\varepsilon_{ij} = -\delta_{ij} + \gamma_{ij}/w_i - \beta_i(w_j/w_i), \tag{4}$$
$$\varepsilon_{iy} = 1 + \beta_i/w_i, \tag{5}$$

where δ_{ij} is the Kronecker delta($\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ otherwise).

The general demand restrictions for this demand system are

$$\text{Adding up: } \Sigma_i \alpha_i = 1, \Sigma_i \beta_i = 0, \Sigma_i \gamma_{ij} = 0 \text{ for all } j, \tag{6}$$
$$\text{Homogeneity: } \Sigma_j \gamma_{ij} = 0, \text{ for all } i, \tag{7}$$
$$\text{Symmetry: } \gamma_{ij} = \gamma_{ji}, \text{ for all } i, j. \tag{8}$$

Since the dependent variables sum to unity, one equation should be dropped from the estimation, which otherwise causes singularity in the covariance matrix. Estimates of the omitted equation can be obtained from the adding up conditions. The AIDS model is estimated using the seemingly unrelated regression estimator(SUR) with the demand restrictions imposed.

Annual data from 1970 to 1989 are used in this study. The quantity data are per capita consumption of each meat in kilograms(Kg) obtained from *Materials on Price, Demand, and Supply of Livestock Products*, National Livestock Cooperative Federation of Korea. The price data are Won/Kg taken from *Prices of Agricultural and Fishery Products*, Korean Ministry of Agriculture, Forestry, and Fisheries (KMAFF). Fish data were from *Annual Statistics on Cooperative Sale of Fishery Products*, National Federation of Fisheries Cooperatives in Korea.

IV. Separability Between Meat Products and Fish

Previous studies simply ignored fish in the Korean meat demand model. The underlying assumption commonly imposed in those studies was separability between meat and fish. However, fish in the Korean diet is an important protein source along with meat. Although separability reduces the number of parameters to estimated, the assumption in Korean meat demand is an important empirical question. Omitting fish, when it should be included(i.e., nonseparable), would lead to misspecification of the estimated model. On the other hand, if fish is separable from meat, a two-stage budgeting implies that the within-group-substitutability is not affected by the expenditure on fish.

Separability can be tested by using parametric restrictions on the AIDS model. Following Hayes et al., the separability restriction in the AIDS model can be written as

$$\gamma_{m_i f} = w_{m_i} \gamma_{mf}, \quad i \in m, \tag{9}$$

where subscripts m and f indicate commodity groups of meat and fish and i indicate individual goods in meat group. w_{m_i} and w_f are the budget shares of good i in group m(meat) and fish, respectively. γ_{mf} is the cross-price parameter between groups m and f, estimated from an aggregate AIDS model of w_m and w_f, and $\gamma_{m_i f}$ is the cross-price parameter between individual meats in the meat group and fish. If the restriction (9) holds for all i, then the two groups, m and f, are separable.

Individual meat expenditure shares are 0.331 for beef, 0.335 for pork, and 0.096 for chicken. The estimated γ_{mf} is -0.063 with a t-value of -1.74. The joint test of the restrictions in (9) was conducted, using the Wald-F test. The calculated F-value was 1.001; and, thus, the null hypothesis of separability between meat and fish was not rejected at conventional levels of significance. The meat demand system in Korea can be estimated without including fish. Separability between meat and fish also was found in Japanese meat demand(Hayes et al.).

V. The Gradual Switching Model and Test for Structural Change

As economic and social environments change, consumer behavior changes as well. Consumers' tastes likely vary over time, and preference changes from changing income structure or demographic patterns(Senauer et al.), increasing health concerns(Brown and Schrader), habit formation(Phlips), and/or intensive advertising. These changes often result in fundamental changes in demand structures. Those factors causing structural change usually are excluded from demand models because of unobservability or difficulty in definition. Failure to address structural changes in demand analysis would lead to incorrect estimates and erroneous inferences(Martin and Porter; Moschini and Meilke; Eales and Unnevehr).

Korea has experienced tremendous changes in various dimensions of society during the last two decades. Real GNP in 1988 increased 20 times compared to that in 1961 and 4 times that in 1971. Population increased 50% over the past 20 years. In addition, the traditional diet pattern has changed because of fast economic growth, adoption of the Western culture, and increasing concerns about health. Modeling structural change is important for correct estimation of demand elasticities and inferences.

This study uses Moschini and Meilke's gradual switching AIDS model, which models smooth or abrupt transition of demand structure over time. This model is especially convenient for this study because the test for structural change is based on the AIDS estimation.

Structural change defined as changes in parameters can be modeled, using a specially designed dummy variable, i.e., time path. Let the time path be h_t. The LA/AIDS model in (1), (2), and (3) can be reparameterized as

$$w_{it} = \alpha_i + \delta_i h_t + \Sigma_j(\gamma_{ij} + d_{ij}h_t)\ln(P_{jt}) + (\beta_i + d_i h_t)\ln(y_t/P_t) + \varepsilon_{it}, \quad (10)$$

with additional general demand restrictions

Adding up:	$\Sigma_i\delta_i = 0,\ \Sigma_i d_i = 0,\ \Sigma_i d_{ij} = 0$, for all j,	(11)
Homogeneity:	$\Sigma_j d_{ij} = 0$, for all i,	(12)
Symmetry:	$d_{ij} = d_{ji}$, for all i, j.	(13)

The Marshallian elasticities reflecting structural change are

$$\varepsilon_{ii} = -1 + (\gamma_{ii} + d_{ii} * h_t)/w_i^a - (\beta_i + d_i * h_t), \quad (14)$$
$$\varepsilon_{ij} = (\gamma_{ij} + d_{ij} * h_t)/w_i^a - (\beta_i + d_i * h_t)(w_j^a/w_i^a), \quad (15)$$
$$\varepsilon_{iy} = (\beta_i + d_i * h_t)/w_i^a + 1, \quad (16)$$

where w_i^a (w_j^a) is the budget share of i^{th}(j^{th}) good after structural change. The Hicksian price elasticities are

$$\eta_{ii} = -1 + (\gamma_{ii} + d_{ii} * h_t)/w_i^a + w_i^a, \quad (17)$$
$$\eta_{ij} = (\gamma_{ij} + d_{ij} * h_t)/w_i^a + w_j^a. \quad (18)$$

The gradually switching time path is constructed as follows:

$$h_t = 0, \quad \text{for } t = 1, \ldots, \tau_1, \quad (19)$$
$$= (t - \tau_1)/(\tau_2 - \tau_1), \quad \text{for } t = \tau_1 + 1, \ldots, \tau_2 - 1,$$
$$= 1, \quad \text{for } t = \tau_2, \ldots, T,$$

where τ_1 is the end of the first regime; and at $t = \tau_1$, the parameters begin to change. At $t = \tau_2$, the structural change completes. If $\tau_2 = \tau_1 + 1$, the change is abrupt. If $\tau_1 = 0$ and $\tau_2 = T$, the structural change occurs throughout the whole sample period.

To determine the gradually changing parameters, τ_1 and τ_2 should be determined jointly with the other parameters in the model. However, h_t is discontinuous with respect to τ_1 and τ_2; thus, estimates of the two parameters are obtained by searching for the pair which provides the smallest mean square error among all combinations of τ_1 and τ_2 throughout the sample period(see more details, see Moschini and

Meilke).

The hypothesis of no structural change is $\delta_i = 0$, $d_{ij} = 0$, and $d_i = 0$ for all i and j. Once the break points, τ_1 and τ_2, are determined by the search, the hypothesis is tested, using the Wald F-test conditional on the estimates of τ_1 and τ_2.

A total of 170 alternative models was estimated to determine τ_1 and τ_2. The mean square error was the lowest when $\tau_1 = 1977$ and $\tau_2 = 1989$, indicating that the structural change in Korean meat consumption occurred around 1977. Since the sample data in this study are from 1970 to 1989, the result does not indicate whether the demand structure has been changing with no termination or was completed in 1989.

The results of the F-test for the null hypothesis of no structural change in meat consumption are reported in Table 1. The hypothesis

TABLE 1. Wald F-test Results for Structural Change

Null Hypothesis	F-value	Prob>F-value	Results
System			
No structural change in			
all parameters	9.1427	0.0001	Reject
intercept	8.8012	0.0002	Reject
prices and expenditure	9.1427	0.0001	Reject
Beef			
No structural change in			
all parameters	4.1612	0.0048	Reject
intercept	2.5445	0.1202	Fail to Reject
prices and expenditure	1.3298	0.2795	Fail to Reject
Pork			
No structural change in			
all parameters	8.4158	0.0001	Reject
intercept	15.4183	0.0004	Reject
prices and expenditure	10.5093	0.0001	Reject
Chicken			
No structural change in			
all parameters	2.2651	0.0708	Fail to Reject
intercept	0.1739	0.6794	Fail to Reject
prices and expenditure	2.2065	0.0898	Fail to Reject

is rejected at the 1% level. However, the results differ for each meat type. For beef, the null hypothesis of no structural change either in intercept or in price and expenditure parameters is not rejected, while the null hypothesis of no structural change in beef consumption is rejected at a 1% level. Significant structural change is detected for all parameters in pork consumption, while the hypothesis is not rejected for the chicken demand at the 5% level.

VI. Estimated Models and Elasticities

According to the separability test results, fish as a whole was not included in the meat demand system. Since significant structural changes were

TABLE 2. Estimated Demand Models for Beef in Korea During 1970-1989

Variables	Gradual Switching AIDS Model		AIDS Model	
	Coefficients	t-value	Coefficients	t-value
INTERCEPT	-0.1032	-1.22	0.1779	2.67
LPB[a]	0.1562	3.57	0.0900	2.66
LPP	-0.0266	-0.86	0.0062	0.22
LPC	-0.0796	-3.16	-0.0280	-1.63
LPO	-0.0499	-7.11	-0.0682	-9.31
LYI[b]	0.1443	3.42	0.0367	1.21
HT[c]	0.7660	1.94	-	-
HLPB[d]	-0.1388	-1.37	-	-
HLPP	-0.0245	-0.43	-	-
HLPC	0.1227	1.55	-	-
HLPO	0.0407	0.94	-	-
HLYI[e]	-0.2860	-2.11	-	-
System Weighted R-square:	0.9382		0.8273	

[a] LPB LPP LPC LPO: Logarithm of price of beef, pork, chicken, and other meat.
[b] LYI: Logarithm of expenditure of meat divided by Stone's index.
[c] HT: Structural change path.
[d] HLPB HLPP HLPC HLPO: Logarithm of beef, pork, chicken, and other meat multiplied by structural change path.
[e] HLYI: LYI multiplied by structural change path.

TABLE 3. Estimated Demand Models for Pork in Korea During 1970-1989

Variables	Gradual Switching AIDS Model		AIDS Model	
	Coefficients	t-value	Coefficients	t-value
INTERCEPT	0.2355	3.27	0.1926	0.01
LPB[a]	-0.0266	-0.86	0.0062	0.22
LPP	0.0979	3.21	0.0949	3.27
LPC	-0.0545	-2.80	-0.0793	-5.55
LPO	-0.0167	-3.00	-0.0218	-3.07
LYI[b]	0.0287	0.85	0.0448	1.63
HT[c]	1.4649	4.77	-	-
HLPB[d]	-0.0245	-0.43	-	-
HLPP	-0.0017	-0.03	-	-
HLPC	0.0552	1.26	-	-
HLPO	-0.0290	-0.89	-	-
HLYI[e]	-0.4826	-4.34	-	-
System Weighted R-square:	0.9382		0.8273	

[a] LPB LPP LPC LPO: Logarithm of price of beef, pork, chicken, and other meat.
[b] LYI: Logarithm of expenditure of meat divided by Stone's index.
[c] HT: Structural change path.
[d] HLPB HLPP HLPC HLPO: Logarithm of beef, pork, chicken, and other meat multiplied by structural change path.
[e] HLYI: LYI multiplied by structural change path.

detected, inferences are based on the estimates of the gradual switching AIDS model.

Tables 2 through 4 present the estimated gradual switching AIDS and conventional AIDS models of beef, pork, and chicken demand, respectively. System-weighted R-squares of the gradual switching AIDS model is 0.94, which is greater than that of the AIDS model, 0. 83. For all cases, the structural change coefficients of own price and expenditure terms show negative signs. This means that the coefficients of own price and expenditure terms change in negative directions over time in all cases. In other words, the meat demand became more sensitive to price changes and less sensitive to expenditure changes.

In the beef model(Table 2), parameters of beef and chicken expenditure shares are significant at the 5% level. Time-varying parameters of intercept and expenditure terms are significant at the same level. This confirms the structural change in beef consumption. The demand for beef is sensitive to its own and chicken prices and expenditure.

Estimated parameters of pork and chicken prices in the pork demand are significant at the 5% level(Table 3). However, the expenditure term is not significant in the model. Time-varying parameters for the intercept and expenditure terms are significant, showing that the structural changes of pork demand are significant. The demand for pork is sensitive to its own and chicken price.

All parameters in the chicken model are significant at the 5% level(Table 4). However, none of the time-varying parameters except for own price are significant. Chicken consumption is sensitive to all

TABLE 4. Estimated Demand Models for Chicken in Korea During 1970-1989

Variables	Gradual Switching AIDS Model		AIDS Model	
	Coefficients	t-value	Coefficients	t-value
INTERCEPT	0.0610	1.30	0.1165	3.51
LPB [a]	-0.0796	-3.16	-0.0280	-1.63
LPP	-0.0545	-2.80	-0.0793	-5.55
LPC	0.1490	6.77	0.1226	8.13
LPO	-0.0149	-3.83	-0.0153	-4.54
LYI [b]	0.0715	2.92	0.0254	1.47
HT [c]	0.1545	0.51	-	-
HLPB [d]	0.1227	1.55	-	-
HLPP	0.0552	1.26	-	-
HLPC	-0.1937	-2.06	-	-
HLPO	0.0159	0.70	-	-
HLYI [e]	-0.1493	-1.70	-	-
System Weighted R-square:	0.9382		0.8273	

[a] LPB LPP LPC LPO: Logarithm of price of beef, pork, chicken, and other meat.
[b] LYI: Logarithm of expenditure of meat divided by Stone's index.
[c] HT: Structural change path.
[d] HLPB HLPP HLPC HLPO: Logarithm of beef, pork, chicken, and other meat multiplied by structural change path.
[e] HLYI: LYI multiplied by structural change path.

TABLE 5. Estimated Marshallian Elasticities at Sample Means[a]

	Beef	Pork	Chicken	Other Meat	Expenditure
		Before Structural Change			
Beef	-0.6410	-0.2131	-0.2565	-0.1610	1.4652
	(-3.69)	(-2.03)	(-4.26)	(-4.88)	(10.78)
Pork	-0.0974	-0.6709	-0.1993	-0.0611	1.1049
	(-0.66)	(-5.84)	(-3.94)	(-2.11)	(8.91)
Chicken	-0.7704	-0.5607	0.0562	-0.2060	1.5410
	(-3.36)	(-3.64)	(0.37)	(-4.82)	(8.31)
Other	0.0913	0.1766	0.0614	-0.4686	0.1394
		After Structural Change			
Beef	-0.7894	-0.0473	0.1814	0.0093	0.4381
	(-1.59)	(-0.10)	(0.76)	(0.03)	(0.81)
Pork	-0.1722	-0.1984	-0.1740	-0.0567	-0.6415
	(-0.47)	(-1.02)	(-3.21)	(-0.22)	(-1.58)
Chicken	0.9862	-0.4321	-1.6263	0.3512	-0.2237
	(0.96)	(-0.79)	(-1.13)	(0.34)	(-0.16)
Other	-0.6305	-0.5713	-0.1472	-1.5749	3.3702

[a] Numbers in parentheses are t-values.

variables included, but no significant structural change is found.

Table 5 shows the estimated Marshallian elasticities at means. Before the structural change, own price elasticities of individual meats, except chicken, are negative, which is consistent with theory. The price elasticity of chicken is positive but is not significant. After the structural change, all own price elasticities become negative; none of them is significantly different from zero.

Marshallian cross elasticities of individual products before structural change are negative, which imply the greater negative income effect than the positive substitution effect. After the structural change, however, most t-values of cross-price elasticities are not significant; and some are positive. Either increasing substitution effects or decreasing income effects may explain these changes in elasticities.

To see net substitution effects, the compensated Hicksian elasticities are calculated in Table 6. Before the structural change, beef and pork are net substitutes, while pork-chicken and beef-chicken are net complements. After the structural change, however, only pork and chicken are net complements.

The dominant income effects before the structural change are also demonstrated by expenditure elasticities(Table 5). The expenditure elasticity of each individual product, except for other meat, is significant and greater than unity before the structural change. After the structural change, however, meat consumption are inelastic with respect to income changes. In addition, those elasticities after the structural change are not significantly different from zero.

To summarize the changes in elasticities, Figures 1 through 4 show the evolutions of own price and expenditure elasticities over time. The gap between the Marshallian and Hicksian elasticities represents the income effect. For all three products, the gap is decreasing over time, which indicates decreasing income effects. This implies that, as income

TABLE 6. Estimated Hicksian Elasticities at Sample Means [a]

	Beef	Pork	Chicken	Other
	Before Structural Change			
Beef	-0.1864	0.1877	-0.1244	0.1231
	(-1.32)	(1.87)	(-1.53)	(5.46)
Pork	0.2129	-0.3687	-0.0672	0.2230
	(1.87)	(-3.31)	(-0.94)	(10.96)
Chicken	-0.2922	-0.1392	0.2598	0.2318
	(-1.53)	(-0.94)	(1.57)	(7.91)
Other	0.1350	0.2147	0.0798	-0.4290
	After Structural Change			
Beef	-0.6790	0.0738	0.2346	0.2469
	(-1.19)	(0.14)	(1.52)	(1.54)
Pork	0.0673	-0.3758	-0.1136	0.2132
	(0.16)	(-3.18)	(-0.21)	(1.95)
Chicken	0.9298	-0.4940	-1.6405	0.2877
	(1.31)	(-0.96)	(-1.18)	(0.67)
Other	0.2191	0.3605	0.0672	-0.6175

[a] Numbers in parentheses are t-values.

FIGURE 1. Change of Own Price Elasticity of Beef

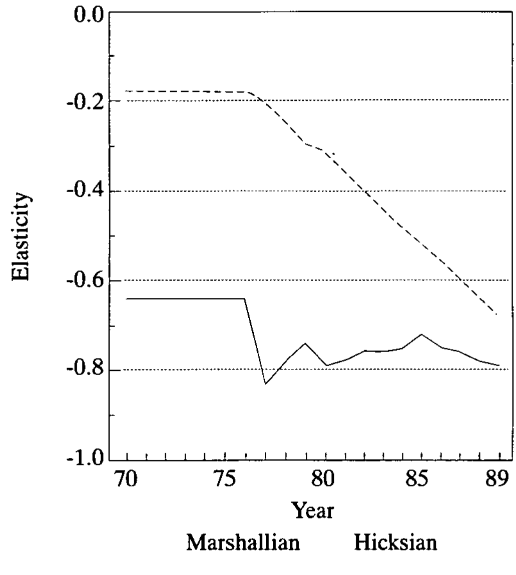


FIGURE 2. Change of Own Price Elasticity of Pork

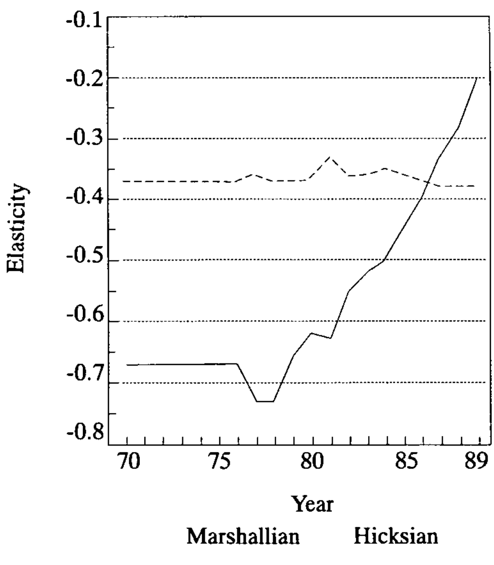


FIGURE 3. Change of Own Price Elasticity of Chicken

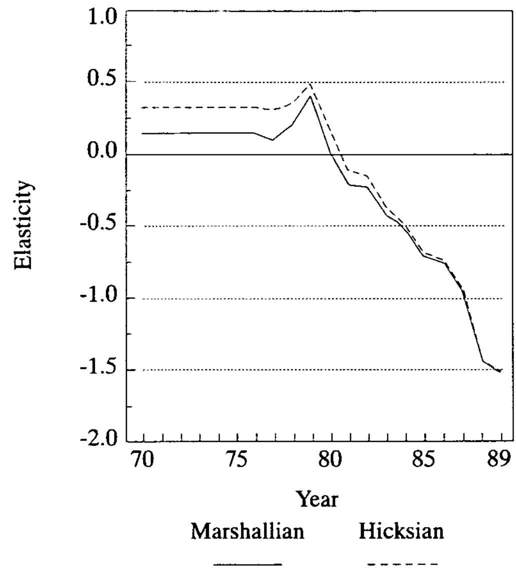
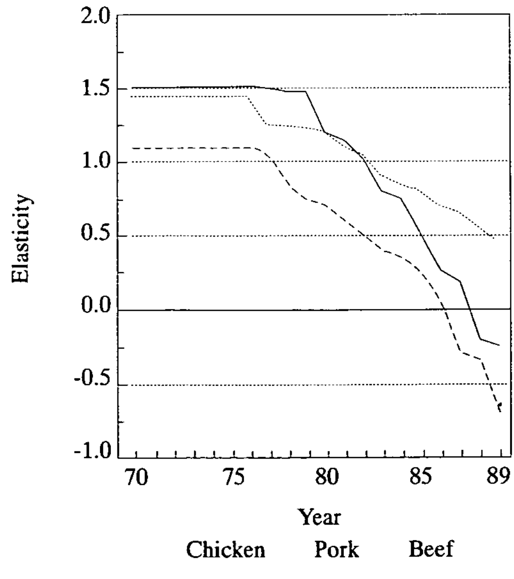


FIGURE 4. Changes of Income Elasticities for Chicken, Pork, and Beef



grows, the income effect due to price changes becomes negligible.

However, individual patterns of changes in own price elasticity differ across meat types. While the income effect for beef in Figure 1 is getting smaller, the own price effect is increasing; the two opposite movements tend to cancel one another out. As a result, the gross price effect is relatively stable over time. In Figure 2, the Hicksian own elasticity of pork is stable while the income effect is decreasing; thus, the demand is less elastic with respect to price changes. However, the demand for chicken becomes more price elastic because of the decreasing income effect but increasing negative price effect. Figure 4 shows that the demand for each meat product becomes less sensitive to the changes in expenditure.

VII. Conclusions

During the last two decades, meat has become important in the daily diet in Korea. A growth in population and per capita income has increased meat consumption rapidly in both absolute and relative terms compared to other agricultural products. While the demand for meat has increased, its production and marketing activities have not adjusted appropriately. Insufficient information on price variations and/or inefficient marketing system is a reason of instability. Lack of knowledge about consumer behavior in meat demand could be another cause.

This study analyzed the characteristics of Korean meat demand. The demands for beef, pork, chicken, and other meat were estimated, using the annual data from 1970 to 1989. The separability test suggested that fish does not have to be included in this meat demand analysis. Korean consumers allocate the budget on meat consumption to each meat product without being limited by the expenditure on fish.

The estimated gradual switching AIDS model indicated that structural change in meat consumption has occurred between 1977 and 1989, possibly without termination during the sample period. Significant structural changes were detected in the beef and pork demands, but not in the chicken demand.

Demand responsiveness of each meat differs across meat types and over the sample period. The income effect of price changes decreased for all types of meat over the time. The expenditure elasticity of each product exceeded unity before the structural change, indicating that meat is a loosely defined luxury good but became a necessity over time. While price elasticity of beef was relatively inelastic before and after the structural change, price elasticities of pork and chicken changed substantially. Demand for pork became less price elastic and demand for chicken became more price elastic after the structural change.

Two findings are noteworthy. The deceasing responsiveness of meat demand to an increase in income indicates that the consumption pattern in Korea becomes similar to what has been found in more developed countries. The meat consumption is near saturation with respect to income.

Second, the inelastic demand for beef explains, to some extent, why this market has been so volatile(see Chavas and Holt for a detailed discussion on this issue). Since the market is likely to remain inelastic, more careful government intervention is required to manage and reduce market variability. This would be especially important when the Korean meat market becomes more dependent upon foreign suppliers due to the recent bilateral and multilateral trade negotiations including the GATT agreements.

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