AE 88005 July 1988

Consumer Demand for Meat in Korea: Income Effects and Implications on U.S. Agricultural Exports

Won W. Koo
and
David L. Watt

Koo is professor and Watt is associate professor, Department of Agricultural Economics, North Dakota State University, Fargo.

Consumer Demand for Meat in Korea: Income Effects and Implications on U.S. Agricultural Exports

Consumption of meat has dramatically increased over the last two decades in Korea due mainly to increases in income. For example, per capita consumption of meat increased from 4 kg in 1965 to 21 kg in 1986 in Korea (Korean Ministry of Agriculture, Forest, and Fisheries). During the same period per capita income increased about 20 fold from $103 to $2,032 in nominal dollar terms and from $383 to $2,032 in 1985 dollars (Bank of Korea). The meat consumption in Korea is still very small compared to the per capita consumption of meat in the United States (119 kg), and its neighboring countries such as Japan (31 kg) and Taiwan (49 kg). This implies that meat consumption could continue to increase in Korea as consumers' income increase. In addition, trade liberalization would also increase meat consumption.

Increases in demand for meat in Korea have been met by increased livestock production rather than livestock imports, although livestock production in Korea is not very efficient compared to other countries such as the United States and Australia. Livestock production is regarded as a secondary income source for Korean rice farmers. Since domestic production costs for livestock, mainly beef, are much higher than those in the United States, New Zealand, and Australia, the Korean government has adopted a protectionist trade policy to protect farmers.

The objectives of this study are to analyze factors affecting demand for meat in Korea, to predict meat consumption in the near future and to evaluate impacts of Korea's meat import policy on U.S. agricultural exports.

The Demand Model and Estimation Procedure

Linear and log-linear functional forms have been frequently used to estimate demand for meat (Fuller and Ladd; Hayenga and Hacklander; Tryfos and Tryphonopoulo, Hassan and Katz; Chavas; Taizo; Wohlgenant and Hahn). The use of linear and log forms, however, often have inconsistent implications with theoretical consideration (Chang). For example, a linear form implies that income elasticity of demand for a meat rises with higher level of income. On the other hand, a log form implies that income elasticity is constant at any level of income. These implications are not consistent with theoretical effects of an increase in income on the demand for meat.[1] Chang demonstrated that the general functional form based on the Box-Cox transformation is a better specification in estimating demand for meat than the linear and log forms. The use of general functional form is especially important in estimating demand for meat when income effects are expected to be large (Chang).

Demand models for livestock items are specified, on the basis of the theory of consumer behavior, as a function of the price of the corresponding meat, the prices of closely related meat items, and consumers' disposable income. Since over 95 percent of meat consumed in Korea is beef, pork, and chicken the study includes only those three meat items. The demand model for each meat class is as follows:

(1) $Q_{it} = f_i(P_{1t}, P_{2t}, P_{3t}, Y_t, e_{it})$

where Q_{it} = demand for the i^{th} meat item (e.g., beef, pork, or chicken) in time t, P_{1t} is the price of beef in time t, P_{2t} is the price of pork in time t, P_{3t} is the price of chicken in time t, Y_t is consumer's disposable income in time t, and e_{it} is a stochastic disturbance term.

The demand function is respecified in the general functional form based on the Box-Cox transformation as follows:

$$(2)\quad Q_{it}^{*} = \beta_o + \sum_{j=1}^{3} \beta_{ij} P_{jt}^{*} + \beta_{i4} Y_t^{*} + e_{it}$$

where

$$Q_{it}^{*} = (Q_{it}^{\mu} - 1)/\mu$$

$$P_{jt}^{*} = (P_{jt}^{\mu} - 1)/\mu$$

$$Y_t^{*} = (Y_{it}^{\mu} - 1)/\mu, \text{ and}$$

e_{it} is stochastic disturbance term.

μ represents a transformation parameter for each demand model to be determined. It is obvious that equation (2) is a linear form if $\mu=1$ and that equation (2) approaches to log form when μ approaches zero (Kmenta). In general, different values of μ lead to different functional specifications of the equation. Thus, equation (2) provides a general form in which the linear and log forms are special cases.

According to Box and Cox (1964), μ and the other parameters can be estimated by using the maximum likelihood estimation method under the assumption that e_{it} in equation (2) is normally and independently distributed. The maximum likelihood value of equation (2) with respect to μ is:

$$(3)\quad Lmax(\mu) = -\frac{n}{2} \ln \hat{\sigma}_i^2(\mu) + (\mu-1)\Sigma_t \ln Q_{it}$$

where $\hat{\sigma}_i(\mu)$ is the estimated error variance of the regression with the given μ and n is the number of time series observations in the sample.

The optimal value of μ is chosen in such a way that maximizes equation (3). Box and Cox also suggested one confidence level $(1-\alpha)$ for μ is obtained by finding that value of μ on either side of $\hat{\mu}$ such that:

(4) $Lmax(\mu)-Lmax(\hat{\mu}) = 1/2\ X^2(\alpha)$

where X^2 is the chi-squares distribution at the α percent probability level.

Empirical Results

Annual time series data covering the period from 1961 to 1985 are used in this study. The price and meat consumption data are obtained from various issues of Feed Handbook (Korean Ministry of Agriculture and Fishery). Annual data for the per capita income and consumer price index are available from monthly Statistics of Korea (Korean Economic Planning Board). The prices of each meat item and per capita income used in the study are deflated by using the consumer price index for food items.

Each demand model contains per capita income and prices of three closely related meat items, mainly beef, pork, and chicken in this study. A dummy variable is also included in the beef and pork model to capture the effects of price ceiling program on beef and pork.[2] The demand models for beef, pork, and chicken are as follows:

$$(5)\quad Q_{it}^{*} = \beta_{i0} + \beta_{i1}P_{1t}^{*} + \beta_{i2}P_{2t}^{*} + \beta_{i3}P_{3t}^{*} + \beta_{i4}Y_t^{*} + \beta_{i5}D_{it}^{*} + e_{it}^{*},\ i = 1 \text{ and } 2$$

$$(6)\quad Q_{3t}^{*} = \beta_{30} + \beta_{31}P_{1t}^{*} + \beta_{32}P_{2t}^{*} + \beta_{33}P_{3t}^{*} + \beta_{34}Y_t^{*} + e_{3t}^{*}$$

where D_{it} is a dummy variable representing the price ceiling program for beef (i=1) and pork (i=2). Equation 5 is the demand model for beef and pork, and equation 6 is the demand model for chicken.

To estimate the parameters of the models, each variable was first transformed by using the procedure for Q_{it}^{*}, P_{jt}^{*}, and Y_t^{*} in equation (2). The value of μ for each demand equation is specified in the range of -2.0 and 2.0 with an incremental interval of 0.02. Following this transformation, least-squares estimation is performed on each set of transformed variables. $Lmax(\mu)$ was calculated for each regression by using

equation (3). The estimated model chosen is the one which maximizes the log likelihood function of μ (equation 3).

Preliminary estimates of equations (5) and (6) yield low D-W statistics. This suggests two possibilities: (1) either the errors may be distributed as a first-order autoregression process or (2) the model is mis-specified. Thus, the equation is extended into two enlarged models: (1) a generalized functional forms ith first-order autocorrelated errors and (2) a generalized functional form with a dynamic habit formation with independent errors (Wang et al.). The general functional form with first-order autocorrelated error appears to be better than the dynamic model in terms of the t-values associated with the variables in the model. This implies that consumer demands for beef, pork, and chicken are static rather than dynamic. This is also clarified by the following facts: since meat is not a mainstay in the Korean diet, consumers' dynamic behavior in Korea may not be significant in annual time series demand models.

The values of μ which maximize the likelihood value are 0.2 for beef, 1.0 for pork, and 0.6 for chicken. Maximum likelihood ratio tests based on equation (4) are performed for each livestock demand model to determine whether 95 percent confidence intervals of μ include one or zero; in other words, whether the function is linear or logarithmic. The test results are presented in Table 1. The confidence interval of μ at the 95 percent probability level is 1.02-1.88 for the beef demand model, 0.06-1.04 for the pork demand model, and 0.84-1.80 for the chicken demand model. This implies that the hypothesis of either a linear or a log functional form is rejected at the 95 percent level for beef and chicken demand models and the null

TABLE 1. 95 PERCENT CONFIDENCE INTERVAL FOR μ

Demand for	Optimum Value of μ	Confidence Interval		Hypothesis for	
		Lower Limit	Upper Limit	Linear	Log
Beef	0.2	1.02	1.88	Rejected	Rejected
Pork	1.0	0.60	1.04	Accepted	Rejected
Chicken	0.6	0.84	1.80	Rejected	Rejected

hypothesis of linear form is accepted at the 95 percent level for the pork demand model.

A major concern is whether the estimated parameters are stable over the entire sample period. The entire sample was divided into two periods; 1961-1973 and 1973-1985 to test stability of the parameters. Demand equations were estimated separately based on each set of samples to test a null hypothesis that the estimated parameters based on the sample period from 1961 to 1973 are the same as those for 1973 to 1985. According to the restricted and unrestricted F-test (Chow), the null hypothesis is accepted at the 95 percent significance level. This implies that the estimated parameters are stable over the entire sample period.

The estimated demand models for beef, pork and chicken are presented in Table 2. Income variables have the highest t-values in the three demand models, indicating that income is a dominant factor affecting demand for meat products in Korea. The estimated models also indicate that prices of beef and pork play an important role in beef and pork demand models while the price of chicken is not significant in the pork model and is marginally significant in the beef and chicken models.

The responsiveness of livestock demand to changes in prices and income can be examined by calculating elasticities. The demand elasticity

TABLE 2. THE ESTIMATED PARAMETERS OF DEMAND MODEL FOR LIVESTOCK PRODUCTS

Variable	Beef (μ = 0.2)	Pork (μ = 1)	Chicken (μ = 0.6)
Constant	-0.3151 (0.694)	1.938 (2.502)	-0.7079 (2.693)
P_1 (beef)	-0.3907 (3.426)	0.0341 (1.243)	0.0998 (3.633)
P_2 (pork)	0.1838 (1.342)	-0.2163 (4.516)	0.0067 (0.171)
P_3 (chicken)	0.1157 (1.035)	0.0182 (0.272)	-0.1114 (2.741)
Y	0.847 (9.464)	0.6863 (7.408)	0.1791 (3.917)
D_{1t}	0.242 (1.937)	-- --	-- --
D_{2t}	0.220 (1.798)	-1.1037 (2.009)	-- --
$R^{\bar{2}}$	0.962	0.945	0.9713

for the ith meat item (n_i) for a given regressor (X_{ij}) for the generalized functional form is calculated at the sample mean as follows:

(7) $n_i = \beta_{ij} (\bar{X}_{ij}/\bar{Q}_i)^{\mu}$

where β_{ij} is the estimated parameter associated with X_{ij}, $\bar{Q}_i$ is the mean of the quantity of the ith meat item demanded, and $\bar{X}_{ij}$ is the mean of X_{ij}. The elasticities (n_i) calculated from equation (7) represents demand elasticity for a regressor (X_{ij}) at mean levels of X_{ij} and Q_i.

Price elasticities obtained from the general functional form are -0.72 for beef, -1.13 for pork, and -0.38 for chicken. These elasticities reflect Koreans' meat consumption habit. Beef is generally consumed by a high income group whose consumption of beef is not very sensitive to changes

in beef price. As a result, demand for beef is inelastic. On the other hand, pork is consumed by middle and low income groups in Korea whose consumption is generally sensitive to the price of pork. Demand for chicken is very inelastic which reflects that (1) chicken is the most commonly consumed meat item in Korea, and (2) is regarded as a necessity in the Korean diet.

Income elasticities for pork and beef are larger than that of chicken. Even though beef is more expensive than pork, its income elasticity is the same as that for pork because beef is consumed by the high income group. On the other hand, income elasticity for chicken is smallest among the three meat items, further indicating that chicken is regarded as a necessity in the Korean diet.

Cross-price elasticities obtained from the general functional model (Table 3) show that pork and chicken demand are less sensitive to beef price, while beef demand is sensitive to pork and chicken prices. The cross price elasticity of pork with respect to chicken, and that of chicken with respect to pork, is very low, indicating a relatively weak substitution relationship.

TABLE 3. PRICE, CROSS PRICE, AND INCOME ELASTICITIES AT THE MEANS OBTAINED FROM GENERAL FUNCTIONAL FORM

Demand for	Price of		
	Beef	Pork	Chicken
Beef	-0.72	0.33	0.65
Pork	0.29	-1.13	0.03
Chicken	1.17	0.06	-0.38
Income	1.09	1.10	0.34

Forecasts of Meat Consumption and Its Implications on U.S. Exports

The estimated demand functions are used to forecast the per capita consumption of livestock products in 1991 and 1996 under the assumption that the real prices of beef, pork, and chicken remain constant at the current level throughout the projected period. Annual rates of real GNP growth are assumed to be 7 percent annually, and population growth at 1.6 percent annually. This implies that per capita income will grow an annual rate of .4 percent. These growth rates of per capita income are similar to those in Korea's sixth Social Economic Development plan for the period 1987-1991. The same growth rate is assumed to continue to 1996.

Per capita consumption of beef is projected at 4.1 kilograms (kg) for 1991 and 5.5 kg for 1996, which is higher than that for 1985 by 41 percent and 90 percent, respectively (Table 4). Projected per capita pork consumption increases from 8.4 kg in 1985 to 10.6 in 1991 and to 13.6 kg in 1996, 26 percent and 62 percent higher, respectively, than the 1985 level. Reflecting the relatively low income elasticity, the increase in per capita

TABLE 4. ACTUAL LIVESTOCK CONSUMPTION IN 1965 AND 1985, AND PROJECTIONS OF PER CAPITA CONSUMPTION FOR LIVESTOCK PRODUCTS,* 1991 and 1996

Livestock Product	1965	1985	1991	1996
		0 kg		
Beef	2.0	2.9	4.1	5.5
Pork	2.8	8.4	10.6	13.6
Chicken	1.6	3.1	3.7	4.6
Total	6.4	14.4	18.4	23.7

NOTE: (*) Retail weight basis

consumption of chicken is more moderate, increasing by 48 percent during the next ten years.

Increases in the per capita consumption of meat require an increase in domestic meat production, an increase in meat imports, or increases in both production and imports. The traditional policy of encouraging domestic meat production through the government subsidy and import restriction on meat is very expensive, not only for the Korean government, but also for Korean consumers. The Korean government, however, has preferred to maintain the traditional policy because beef production is an important income source for about one million farmers. The traditional policy will require a substantial increase in feed grain imports (9.2 million tons in 1996), mainly from the United States.

If Korea liberalizes beef imports in the near future, most domestic production would be replaced with imports, resulting in a substantial reduction in farm income in Korea. Beneficiaries of this policy would be Australia and New Zealand rather than the United States because these countries have a comparative advantage over the United States in exporting beef to Korea in terms of both production and transportation costs. In addition, liberalization of beef imports in Korea will result in a substantial reduction in feed grain imports since less beef production would occur in Korea while more beef is imported. This implies that a Korean policy liberalizing beef imports would lead to a reduction in feed grain imports from the United States, and a barely perceptible increase in United States exports of beef to Korea.

Concluding Remarks

This study reveals that income is the dominant factor affecting the per capita demand for meat in Korea. Income elasticities for beef and pork

are much larger than that for chicken. This implies that beef and pork are more luxurious products in the Korean diet than is chicken, and that demands for beef and pork will increase faster than for chicken as consumer's income rise.

Price elasticity for beef is inelastic because beef is generally consumed by a high income group whose consumption of beef is not very sensitive to changes in the price of the product. On the other hand, price elasticity for pork is largest in absolute value because pork is consumed by all income groups in Korea whose consumption is still generally sensitive to price of this product. Price elasticity for chicken is lowest, reflecting that chicken is a necessity and the most commonly consumed livestock product in Korea. Cross price elasticities show that Korean consumers tend to substitute beef for chicken and pork, but they do not like to substitute chicken and pork for beef. This is mainly because beef is considered as a superior meat item. The cross price elasticity of pork with respect to the price of chicken and that of chicken with respect to the price of pork is very low, indicating that there is almost no substitution between these two meat items as their prices change.

Per capita beef consumption was projected to increase 90 percent during the 1985-1996 period, and that of pork and chicken to increase 62 percent and 48 percent, respectively. Among the meat items, beef shows the most significant increase in consumption as income increases, followed by pork and chicken. This study also found that a Korean import liberalization policy for meat items would not necessarily increase U.S. exports of beef to Korea. The liberalization policy would lead to the following: (1) a reduction in feed grain imports from the United States because less beef production would occur in Korea while more beef is imported and (2) a barely

perceptible increase in United States exports of beef to Korea because most beef imports will come from Australia and New Zealand rather than from the United States.

Footnotes

[1]As income increases, meat tends to be regarded as less of a luxury and the income elasticity declines. This implies that the income elasticity declines as income level increases rather than that it is either constant (log form) or rising (linear form).

[2]The Korean government set the maximum price from 1970 to 1981.

References

Bank of Korea. National Income Accounts. Seoul, Korea, 1984.

Bank of Korea. Monthly Bulletin. Seoul, Korea, Various issues.

Box, G.E.P., and D.R. Cox. "An Analysis of Transformation," Journal of the Royal Statistical Society, Series B, 26:211-243, 1964.

Chang, Hui-shyong. "Functional Forms and the Demand for Meat in the United States," Review of Economics and Statistics, 59: 335-359, 1977.

Chavas, J.P. "Structural Changes in the Demand for Meat," American Journal of Agricultural Economics, 65(1): 148-153, 1984.

Fuller, W. and Ladd, G.W. "A Dynamic Quarterly Model of the Beef and Pork Economy," Journal of Farm Economics, 43: 797- 812, 1961.

Hassan, A.A. and Katz, L. "Demand for Meat in Canada," Canadian Journal of Agricultural Economics, 23(1): 53-63, 1975.

Hayenga, M.L. and D. Hacklander. "Monthly Supply Demand Relationship of Fed Cattle and Hogs." American Journal of Agricultural Economics. 52(1970):535-544.

Korean Ministry of Agriculture and Fisheries (Korea) Food Balance Sheets. Seoul, Korea. 1985.

Korean Ministry of Agriculture and Fisheries Agricultural Policy Handbook. Seoul, Korea. 1985.

Korean Ministry of Agriculture and Fisheries (Korea) Feed Handbook. Seoul, Korea. Various Issues.

Korean Ministry of Agriculture and Fisheries, Livestock Handbook. Seoul, Korea. 1985.

Korean Economic Planning Board (Korea) Monthly Statistics of Korea. Seoul, Korea. Various Issues.

Moschini, Giancarlo and Meilke, Karl D. "Parameter Stability and the U.S. Demand for Beef," Western Journal of Agricultural Economics, 9(2): 271-282, 1984.

Pope, R.; Green, R.; and Eales, J. "Testing for Homogeneity and Habit Formations in a Flexible Demand Specification of U.S. Meat Consumption," American Journal of Agricultural Economics, 62: 778-84, 1980.

Taizo, Shinohara. Japanese Import-Requirement: Projections of Agricultural Supply and Demand for 1965, 1970 and 1975, Department of Agricultural Economics, University of Tokyo, Tokyo, Japan. March 1964.

Tryfes, P. and N. Tryphonopoulo. "Consumer Demand for Meat in Canada," American Journal of Agricultural Economics, 55: 647-652, 1973.

Wang, G., W. Maling, and E. McCarthy. "Functional Forms and Aggregate U.S. Domestic Air Cargo Demand: 1950-1977. Transportation Research, 15A:249-56, 1981.

Wohlgenant, M.K. and Hahn, W.F. "Dynamic Adjustment in Monthly Consumer Demand for Meat," American Journal of Agricultural Economics, 66:553-57, 1982.

WWK/crs
Meat
2/28/88