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Meat Demand in South Korea: An Application of the Restricted Source-Differentiated Almost Ideal Demand System Model

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The first difference version of the restricted source-differentiated almost ideal demand system is used to estimate South Korean meat demand. The results of this study indicate that the United States has the most to gain from an increase in the size of the South Korean imported meat market in terms of its beef exports, while South Korea has the most to gain from this expansion in the pork market. Moreover, the results indicate that the United States has a competitive advantage to Australia in the South Korean beef market. Results of this study have implications for U.S. meat exports in this ever-changing policy environment.

Key Words: AIDS, source differentiation, South Korean meat demand, U.S. competitiveness

JEL Classifications: D12, Q17

Rising per capita incomes and the rapid economic growth in South Korea during the last two decades have brought about a significant change toward Western life styles and diets in urban areas. This change has led to an increase in consumption of animal protein compared with the traditional Korean staple foods, cereal and vegetables. From 1980 to 2003, per capita meat consumption (beef, pork, and chicken) changed from 11.3 kg to 30.9 kg, an increase of 173%. During the same period, self-sufficiency for beef, pork, and chicken decreased from 97.8% to 36.3%, 100% to 93.8%, and 100% to 76.7%, respectively. In 2003, South Koreans consumed the greatest amount of pork (16.9 kg/person), followed by beef (7.9 kg/person) and chicken (6.1 kg/person) (KREI). The size of the South Korean imported meat market is expected to grow even further in the future, with expectations of continued economic growth and market-access measures negotiated in bilateral and multilateral agreements.

The South Korean government has taken major steps in the last decade to open their borders to foreign meat suppliers, which had led to South Korea becoming an increasingly important player in the global markets (MAF). In 2003, South Korea was the second largest market for U.S. beef, fourth for U.S. pork, and sixth for U.S. poultry, importing $816 million, $79 million, and $50 million of U.S. beef, pork, and poultry meats, respectively. Understanding this emerging market and factors shaping it are of importance to the U.S. meat producers, marketers, and policy makers in developing effective marketing programs targeted toward expanding sales

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and market shares in South Korea and in future trade negotiations.

In this light, the primary objective of this study is to estimate a meat demand system for South Korea, differentiating meats by type and by source of origin. More specifically, the objective of this study is to analyze the impact of economic factors on U.S. competitiveness in the South Korean meat import market and to provide estimates of meat import demand elasticities for this market.

Following a historical overview of the South Korean meat trade policies and review of other studies related to Pacific Rim meat markets, a model of South Korean meat demand is specified and the estimation results are discussed.

South Korean Meat Trade Policies and Related Studies

In the past, the South Korean government restricted the importation of meats through a quota system, which had been in effect since 1988. Given the rapid growth of meat product markets in Korea, major meat-exporting countries such as the United States and Australia requested an opening of the South Korean market for beef imports through the General Agreement on Tariffs and Trade and World Trade Organization negotiations. With the establishment of the quota system, importation of beef resumed after 6 years of no trade (USDA-ERS).

During 1988–2003, significant progress was made in reducing South Korean meat import barriers. Beef quotas were raised from 123,000 tons in 1995 to 225,000 tons in 2000. The beef market became liberalized on January 1, 2001, when a tariff-only system became effective and the state trading of beef imports was discontinued. Quotas for frozen pork and chicken were raised from 1995 through the first half of 1997, and absolute quotas were ended on July 1, 1997. Tariffs were lowered from 1995 levels to 25% and 20% in 2004 for frozen pork and poultry, respectively (Dyck and Nelson). However, at the end of 2003, this liberalization progress was interrupted when South Korea banned beef imports from the United States because of a case of mad cow disease in the United States (USDA-ERS).

As a result of the liberalization, South Korea became the world's ninth largest meat importing country and the world's fourth largest beef importing country in 2003. Furthermore, among the Asian countries, South Korea has become the second largest imported meat market after Japan, with imports accounting for two-thirds of the volume of beef consumed in 2003 (MAF). In particular, Korean meat imports from the United States have increased significantly during the last several years, with the U.S. share of the Korean imported meat market in terms of volume increasing from 40% in 1993 to 53% in 2003 (KATI). As a percentage of total South Korean meat consumption volume, imports from the United States grew from 4% in 1993 to 19% in 2003 (KATI and KREI).

The South Korean market is differentiated in terms of buyers' attitudes toward meats imported from various sources. The grain-fed beef imported from the United States, accounting for 69% of volume of imports, has generally been viewed as having a higher quality than beef imported from other sources. About 70% of imports from the United States were under the high price category of ribs, loin, strip loin, and tenderloin, while this figure was only 29% for Australia. Over 88% of U.S. exports and about 42% of Australian exports to South Korea were in the form of ribs and chuck roll. It is important to recognize these quality differences in meats when analyzing the South Korean meat import demand. Through a market research survey, Kim et al. examined the attitude of the hotel sector beef purchasers toward the grain-fed beef products from major potential supplying countries. Survey results indicated that the United States has been successful in creating a positive image with the Korean international hotel sector for grain-fed "made in the U.S.A." brand beef, while the Canadian beef does not have the same perceived customer value in the hotel sector. Australian beef exporters in the past have targeted their grass-fed beef to the price-sensitive general retail sector.

Despite becoming an emerging market for U.S. meats, published research on the analysis of South Korean meat demand is limited. Most of the previous studies addressing global demand have focused on Japan as an important export destination for U.S. meats (Hayes, Wahl, and Williams; Wahl and Hayes; Yang and Koo). Regarding South Korean meat demand, most of the past studies have used aggregate consumer or wholesale-level data, without differentiating imported meats as a separate category (Byrne et al.; Hayes, Ahn, and Baumel; Koo, Yang, and Lee). Jung and Koo, in their study of South Korean demand for meat and fish products, differentiated beef into Hanwoo (beef from domestic cattle) and import quality beef. However, in their study, imported beef was included as an aggregate category (not differentiated by supply source) and imported pork and chicken were not included.

A Model of South Korean Meat Import Demand System

The Armington trade model and the almost ideal demand system (AIDS) have been used in the literature for the analysis of source-differentiated import demands. Although the Armington trade model differentiates goods by countries of origin, it suffers from the restrictive assumptions of a single constant elasticity of substitution (CES) and homotheticity, which may lead to biased parameter estimates (Yang and Koo). As an alternative to the Armington trade model, the AIDS model has been used in import demand estimations. The AIDS model represents a flexible complete demand system, and it does not require the additivity of the utility function. It satisfies the axioms of choice exactly and, under certain conditions, aggregates perfectly over consumers (Deaton and Muellbauer). Owing to its advantages, the AIDS model has been used in the analysis of both macroeconomic and microeconomic demand systems and has been a popular tool for researchers.

Since the main objective of this study is to analyze the impact of economic variables on U.S. competitiveness in the South Korean meat import market, a source-differentiated AIDS (SDAIDS) model is used. The SDAIDS is a modified version of the AIDS model, which allows for source differentiation of various types of meats without imposing block separability. One of the main advantages of SDAIDS includes estimates that do not suffer from aggregation bias over import sources or over goods. The SDAIDS model is generally estimated using instrumental variable techniques (Yang and Koo), which are expected to result in more reliable parameter estimates.

Following Yang and Koo, the SDAIDS model is specified as

$$(1)\quad w_{i_h} = \alpha_{i_h} + \sum_j \sum_k \gamma_{i_h j_k} \ln(p_{j_k}) + \beta_{i_h} \ln\left(\frac{E}{P^*}\right),$$

where subscripts i and j indicate goods ($i, j = 1, 2, \ldots, N$), and h and k indicate countries of origin or sources. Good i may be imported from m different origins, while good j may have n origins (where $i \neq j$, $h = 1, \ldots, m$, and $k = 1, \ldots, n$). w_{i_h} measures the budget share of good i imported from source h (product i_h), p_{j_k} is the price of good j imported from source k (product j_k), E is the total expenditure on all goods in this demand system, and P^* is a price index defined as

$$(2)\quad \ln(P^*) = \alpha_0 + \sum_i \sum_h \alpha_{i_h} \ln(p_{i_h}) + \frac{1}{2}\sum_i \sum_h \sum_j \sum_k \gamma^*_{i_h j_k} \ln(p_{i_h}) \ln(p_{j_k}).$$

The SDAIDS model in Equation (1) above is nonlinear as a result of the nonlinear price index in Equation (2). To make the system linear, Deaton and Muellbauer suggest using the Stone's price index, here specified as

$$\ln P^* = \sum_i \sum_h w_{i_h} \ln(p_{i_h}).$$

However, using the above price index may create a simultaneous-equation bias since w_{i_h}, which is used as a dependent variable in Equation (1), is employed as an independent variable in the Stone's price index. To avoid simultaneity, Eales and Unnevehr suggest using lagged w_{i_h} in the Stone's price index.

The Restricted Source-Differentiated AIDS

Given that in the meat category there are several kinds of nonseparable substitutes from various import origins, and since a large enough sample sizes in empirical applications may not be always ensured, the SDAIDS model may suffer from a degree-of-freedom problem.[1] To reduce the number of parameters, block substitutability is assumed.

The restriction imposed on the parameters of the demand system by assuming block substitutability implies that the cross-price effects of products in good j on the demand for product h in good i are the same for all products in good j (see Yang and Koo, page 399, for the block substitutability restriction specification). Hence, the prices of other goods from various origins are represented by an aggregate price for that good in the equation of a given source-differentiated product. For example, in the estimation of Korean demand for U.S. beef, the prices of pork imported from various sources are represented by one aggregate price for pork. In other words, the South Korean demand for U.S. beef is assumed to have the same cross-price response to pork from the United States as it does to pork from European Union (EU). The assumption of block substitutability leads to a reduction of the number of parameters in each equation from $MN + 2$ to $M + (N - 1) + 2$. The SDAIDS model becomes the restricted SDAIDS model (RSDAIDS) when the assumption of block substitutability is imposed.

The RSDAIDS is specified as follows:

$$(3)\quad w_{i_h} = \alpha_{i_h} + \sum_k \gamma_{i_h k} \ln(p_{i_k}) + \sum_{j \neq i} \gamma_{i_h j} \ln(p_j) + \beta_{i_h} \ln\left(\frac{E}{P^*}\right),$$

where

$$\ln(p_j) = \sum_k w_{j_k, t-1} \ln(p_{jk}).$$

The general demand restrictions of adding-up, homogeneity, and Slutsky symmetry can be imposed by restricting the parameters of the import demand system as follows:

Adding-up:

$$(4)\quad \sum_i \sum_h \alpha_{i_h} = 1; \quad \sum_h \gamma_{i_h k} = 0;$$
$$\sum_i \sum_h \gamma_{i_h j} = 0; \quad \sum_i \sum_h \beta_{i_h} = 0.$$

Homogeneity:

$$(5)\quad \sum_k \gamma_{i_h k} + \sum_{j \neq i} \gamma_{i_h j} = 0.$$

Symmetry:

$$(6)\quad \gamma_{i_h k} = \gamma_{i_k h}.$$

Because of block substitutability, the symmetry conditions among goods do not apply here.

Marshallian measures of price elasticities are computed from the estimated parameters as

$$(7)\quad \varepsilon_{i_h i_h} = -1 + \frac{\gamma_{i_h h}}{w_{i_h}} - \beta_{i_h},$$

$$(8)\quad \varepsilon_{i_h i_k} = \frac{\gamma_{i_h k}}{w_{i_h}} - \beta_{i_h}\left(\frac{w_{i_k}}{w_{i_h}}\right),$$

$$(9)\quad \varepsilon_{i_h j} = \frac{\gamma_{i_h j}}{w_{i_h}} - \beta_{i_h}\left(\frac{w_j}{w_{i_h}}\right).$$

Equation (7) represents own-price elasticities, Equation (8) represents cross-price elasticities between the same goods from different sources, and Equation (9) represents cross-price elasticities between different goods.

Expenditure elasticity is specified as

$$(10)\quad \eta_{i_h} = 1 + \frac{\beta_{i_h}}{w_{i_h}}.$$

To test for the statistical significance of price and expenditure elasticities, standard errors were calculated using the variance of a linear transformation of the elasticity formulas (Equations 7–10). The method offered by

[1] For example, suppose we estimate an SDAIDS model for South Korean meat import demand for three types of meats, each imported from three sources. The SDAIDS model will include 11 parameters (nine own- and cross-price parameters, plus intercept and expenditure coefficient), to be estimated in each of the nine equations for each type of source-differentiated meat.

Mdafri and Brorsen was used here to calculate the standard errors and subsequently the statistical significance of the elasticities.[2]

The Empirical Model

In the empirical analysis of the demand system, the properties of homogeneity and/or symmetry are often rejected. This is normally because consumers are unlikely to adjust instantaneously to changes in price, income, or other determinants of demand. Such consumers' behavior might be caused by psychological factors, such as habit formation, habit persistence, or inventory adjustments (Kesavan et al.). Likewise, institutional factors, such as changing from an import quota system to liberalized trade, contribute to the observed lagged effects in the analysis of import demand. Therefore, the demand behavior might be best represented by models allowing for dynamic adjustments. To allow for lagged effects, dynamic models include lagged dependent variables and lagged residuals as exogenous variables. However, owing to the small sample size in this study, the first difference AIDS model is used here as suggested by Ealse and Unnevehr.[3]

[2] For calculating the standard errors of the estimated elasticities, the estimated parameters in the model (Equation 11) were first linearly transformed as the following: e = Ab, where e is the vector of estimated elasticities (ε's, η's), b is the vector of estimated RSDAIDS model parameters (γ's, β's), and A is a matrix of constants (budget shares). Then, the variance covariance matrix of e [VAR(e)] was calculated as: VAR(e) = A VAR(b)A′, where VAR(b) is the variance covariance matrix of b.

[3] Eales and Unnevehr mentioned that the first difference AIDS model is marginally inferior to a dynamic AIDS model but the first difference AIDS model produces similar results. In this study the first difference AIDS model was used to obtain more power due to the small sample size. Considering that it is likely for the various meat prices to affect budget shares with different lengths of lags, we employed the Schwartz information criterion (SIC) in order to determine the lengths of lags associated with various prices and expenditures. Although the results showed varying numbers of lags, because of the small sample size and subsequent degrees-of-freedom problems, we stayed with the first difference model.

$$\Delta w_{i_h} = \sum_{k} \gamma_{i_h k} \Delta \ln (p_{i_k}) + \sum_{j \neq i} \gamma_{i_h j} \Delta \ln (p_j) + \beta_{i_h} \Delta \ln \left(\frac{E}{P^*} \right). \tag{11}$$

Data and Estimation Procedure

Quarterly data from 1996 to 2003 were used to estimate the parameters of the RSDAIDS. The meats studied here are pork, poultry, and other meats. Other meats include offal, mutton, lamb, and meats of horse, rabbit, and deer. In this study, weak separability of fish and nonfish meats is assumed, since this assumption could not be tested as a result of data limitations on domestic fish consumption for the period of this study.[4] However, separability of fish and nonfish meats in South Korea has been tested and supported in the literature (Byrne et al.; Capps et al.; Koo, Yang, and Lee). Nevertheless, following Hayes, Wahl, and Williams, a test of separability in the South Korean *imported* meat market between fish and nonfish meats (as an aggregate group and non–source differentiated) was conducted. Results indicate that separability could not be rejected at the 5% significance level.

South Korea imports meats from various sources. A country was identified as a supply source if imports from that source constituted over 10% of the total South Korean imports of the selected meat. Otherwise, importations are included in the rest-of-the-world (ROW) category. With this criterion, the source-differentiated imported meats are beef from the United States and Australia; pork from

[4] In demand analysis, researchers often use multi-stage budgeting in order to reduce the number of estimated parameters (Eales and Unnevehr). This study assumes two-stage budgeting of total meat expenditure, with the first stage consisting of fish and nonfish meats. In the second stage, the nonfish meats group is divided into beef, pork, poultry, and other meats, each differentiated by supply sources. The separability of South Korean meats from imported meats was tested and separability was rejected. Therefore, South Korean produced meats were included in the model.

Table 1. Summary Statistics for Expenditure Shares of Korean Meat Imports, 1996–2003

Variable	Mean	SD	Minimum	Maximum
Beef	0.4699	0.0302	0.3995	0.5257
South Korea	0.3612	0.0395	0.2867	0.4168
United States	0.0740	0.0358	0.0307	0.1518
Australia	0.0240	0.0073	0.0099	0.0376
The rest of the world	0.0107	0.0044	0.0037	0.0200
Pork	0.3639	0.0233	0.3097	0.4214
South Korea	0.3289	0.0235	0.2801	0.3921
Canada	0.0046	0.0019	0.0004	0.0105
United States	0.0031	0.0015	0.0001	0.0069
EU	0.0198	0.0060	0.0001	0.0302
The rest of the world	0.0075	0.0035	0.0001	0.0146
Poultry	0.1539	0.0191	0.1204	0.1831
South Korea	0.1404	0.0201	0.1049	0.1725
United States	0.0070	0.0025	0.0029	0.0129
Thailand	0.0044	0.0036	0.0001	0.0114
The rest of the world	0.0021	0.0021	0.0001	0.0068
Other meats	0.0123	0.0059	0.0042	0.0229

Source: KCS

Canada, the United States, and the European Union; and poultry from the United States and Thailand. The other meats category is not separated by import sources.

Because retail/wholesale-level prices for imported meats were not available, unit value import prices were used to measure market prices for imported meats. Data on import value (in thousands of dollars) and quantity (in metric tons) were from KCS. Source-differentiated import prices (unit values) for individual meats were calculated by dividing the total import value by the total import quantity.[5] Data were then converted from U.S. dollars into Won (South Korean currency) using current exchange rates from KCS. Quantities of domestic meat consumption and prices were reported at the wholesale level and were obtained from NACF. The summary of sample statistics of source-differentiated expenditure shares for each meat is presented in Table 1.

In order to take into account the impact of the foot and mouth disease (FMD) outbreaks in 1999 and 2002, in another version of the model, a dummy variable for FMD was included as an intercept shifter. However, this dummy variable was not statistically significant. In addition, dummy variables reflecting seasonality in meat demand were included in the pretest estimation. Although the variables were significant, they were not included in the final version of the model because of the small sample size and the subsequent degrees-of-freedom problem. Instead, data were adjusted for seasonality using the X-11 method developed by the U.S. Census Bureau (SAS). The X-11 procedure provides seasonal adjustment of time series data.

Various hypotheses regarding South Korean consumer behavior were tested and applied to the RSDAIDS model of the South Korean meat import demand system (Equation 11). These hypotheses include product aggregation, block separability, and the endogeneity

[5] Owing to the lack of data on wholesale price for source-differentiated imported meats, unit values (value divided by volume of imports) are used here to proxy market prices. However, unit values might not be a perfect measure of wholesale market prices. For example, trade restrictions (such as quotas) might not change the unit value for a meat from a particular import source, but they might change wholesale market prices of meats because of supply restrictions.

of expenditure and prices. System misspecification is also tested.

Product Aggregation and Block Separability

The RSDAIDS model used in this study is based on the assumption that consumers place different values on the same commodity originating from different countries. However, this assumption needs to be tested. The product aggregation test is used to assess whether various products (e.g., beef supplied from various origins) could be considered as one aggregate group (non–source differentiation).[6]

Additionally, in a two-stage demand analysis, weak separability is frequently assumed as a maintained hypothesis. Here, for parsimonious estimations, we are interested to know whether we could study various types of meats separate from each other. The meats studied here are beef, pork, poultry, and other meats (including mutton and lamb). If separability is assumed, each type of meat (e.g., beef) could be considered as separable from other meats (e.g., pork and poultry) at a more aggregate level. Block separability allows for each type of meat to be estimated individually, without having to incorporate the prices of other meats. In this study, the test by Moschini, Moro, and Green is used to test for block separability. Using the following parametric restrictions, the block separability in the RSDAIDS model is tested,

$$(12)\qquad \frac{(\gamma_{i_h j} + w_{i_h} w_j)}{(\gamma_{k_h m} + w_{k_h} w_m)} = \frac{(w_{i_h} + \beta_{i_h})(w_j + \beta_j)}{(w_{k_h} + \beta_{k_h})(w_m + \beta_m)},$$

for (i_h, k_h) A and (j, m) B, for all $A \neq B$, where A and B refer to commodity groups (e.g., beef or pork) and other variables are as defined before.

Table 2. Test Results of Block Separability and Product Aggregation

Block Separability[a]:
H_0: Beef is separable from all other meats.
$LR^b = 195.39^{**}$ $df^c = 23$
H_0: Pork is separable from all other meats.
$LR = 352.99^{**}$ $df = 31$
H_0: Poultry is separable from all other meats.
$LR = 483.13^{**}$ $df = 8$
H_0: All of the above (beef, pork, and poultry)
$LR = 19.12^{*}$
Product Aggregation[d]:
H_0: Beef can be aggregated.
$F = 216.63^{**}$ df: 18 for numerator and 306 for denominator
H_0: Pork can be aggregated.
$F = 574.60^{**}$ df: 28 for numerator and 306 for denominator
H_0: Poultry can be aggregated.
$F = 792.96^{**}$ df. 18 for numerator and 306 for denominator
H_0: All of the above
$F = 535\ 33^{**}$ df: 64 for numerator and 306 for denominator

[a] The critical values of $\chi^2_{\alpha=0.01,df=23}$, $\chi^2_{\alpha=0.01,df=31}$, and $\chi^2_{\alpha=0.05,df=8}$ are 41.64, 52.19, and 15.51, respectively.
[b] LR is the statistic of log-likelihood ratio test.
[c] df is the degrees of freedom
[d] The critical values of $F_{\alpha=0.01,df_1=18,df_2=306}$, $F_{\alpha=0.01,df_1=28,df_2=306}$, and $F_{\alpha=0.01,df_1=64,df_2=306}$ are 1.993, 1.787, and 1.530, respectively.
* Indicates significance at 5% level.
** Indicates significance at 1% level.

The Wald F-test was used to test the hypothesis of product aggregation over different supply sources. This test was conducted by imposing restrictions related to the assumptions of product aggregation (as described earlier) on the parameters of the RSDAIDS model.

Test results for block separability indicate the rejection of the null hypothesis that beef, pork, poultry, and other meats are separable from one another at the 1% significance level (Table 2). Therefore, the results indicate that studying each meat separate from the others is not an appropriate assumption for the South Korean source-differentiated meat import demand estimation. Subsequently, the null

[6] The assumption of product aggregation has been used in part, in the literature to test perfect substitutability among products. Perfect substitutability implies that the source-differentiated product prices are expected to be perfectly correlated and to react similarly to relevant price changes (Hayes, Wahl, and Williams). However, product aggregation may not necessarily imply perfect substitutability. For details of the product aggregation test refer to Yang and Koo, pp. 400–01.

hypothesis of product aggregation was tested and was rejected at the 1% significance level, supporting the use of a source-differentiated model. More specifically, the results give support to studying domestically produced meats along with source-differentiated imported meats.

Test of Endogeneity

Endogenous prices and expenditure might lead to biased and inconsistent parameter estimates. In the model used in this study, the expenditure variable (E in Equation 11) might not be truly exogenous since expenditure is used to compute the dependent variable (Henneberry, Piewthongngam, and Qiang; Thompson). In addition, since the import quota system was in effect during part of the estimation period of this study, this would have meant that meat import quantities were first set by source of origin and then prices were determined by forces of demand and given the fixed supplies. Therefore, meat prices may be endogenous during the study period. Moreover, long lags (exceeding 1 year in the case of beef) in production response to prices might result in relatively fixed meat supply in the short run, leading to simultaneous-equation bias (Wahl and Hayes).

The Wu-Hausman endogeneity test as described by Johnston and DiNardo (see p.342) was employed in this study to test for endogeneity of price and expenditure variables. This test was performed by regressing potentially endogenous variables (prices and expenditures) on a set of instrumental variables (auxiliary regression).[7] From this regression, the residuals were calculated and were included in the RSDAIDS as additional explanatory variables. A joint test was conducted to see whether the coefficients of these residuals equal zero. If these coefficients

Table 3. Endogeneity Test Results of Expenditure and Prices

Variables	Test results[c]
Expenditure ($df_1{}^a = 13$, $df_2{}^b = 290$)	$F = 2.85^{**}$
Price ($df_1 = 13$, $df_2 = 303$)	
Beef	
Korea	$F = 1.00$
United States	$F = 3.45^{**}$
Australia	$F = 2.06^{*}$
ROW	$F = 2.66^{**}$
Pork	
Korea	$F = 0.45$
Canada	$F = 1.87^{*}$
United States	$F = 1.23$
EU	$F = 1.94^{*}$
ROW	$F = 1.59$
Poultry	
Korea	$F = 1.62$
United States	$F = 1.31$
Thailand	$F = 0.88$
ROW	$F = 1.06$
Other meats	$F = 1.10$

[a,b] df_1 and df_2 are the degrees of freedom for numerator and denominator, respectively.
[c] The critical values of $F_{\alpha=0.01,df_1=13,df_2=290}$, $F_{\alpha=0.01,df_1=13,df_2=303}$, and $F_{\alpha=0.05,df_1=13,df_2=303}$ are 2.191, 2.189, and 1.753, respectively.
* Indicates significance at 5% level.
** Indicates significance at 1% level.

statistically equal zero, it can be concluded that endogeneity does not exist. From the test results, the endogeneity of the expenditure; prices of beef from the United States, Australia, and the ROW; and prices for pork from Canada and EU could not be rejected (Table 3). Interestingly, test results suggest that poultry prices are uniformly exogenous. These results are expected since the production cycle for poultry is less than 1 year, allowing producers to respond to price changes within the observation period.

System Misspecification Tests

Functional form, static and dynamic homoskedasticity, and autocorrelation tests, as suggested by McGuirk et al., are used here to test for system misspecification. Test results are presented in Table 4. From the results of the system misspecification tests (Table 4), it

[7] In auxiliary regressions, the following instrumental variables were used in the estimation of predicted values of prices and expenditures: source-differentiated lagged prices, consumer price index, gross domestic product, lagged real expenditure, and unit price of imported feed corn.

Table 4. Misspecification Test Results

Test	df_1[a]	df_2[b]	*F*-value	*p*-value
Functional form	13	99	1.52	0.1294
Static homoskedasticity	109	268	1.03	0.4269
Dynamic homoskedasticity	13	195	0.84	0.6170
Independence	13	86	1.16	0.3255

[a,b] df_1 and df_2 are the degrees of freedom for numerator and denominator, respectively.

can be concluded that the null hypotheses of linearity, static and dynamic homoskedasticity, and no autocorrelation cannot be rejected at the 1% significance level. To test for parameter stability, this study employed the single-equation Chow test, and the period at the elimination of trade barriers was determined as a dividing point for the Chow test. From the test results, the null hypothesis that variance during the first period equals variance during the second period cannot be rejected at the 5% significance level. To test for normality, the Jarque-Bera test was performed. Results show that the assumption of normality of the error terms, in each of the estimated equations, cannot be rejected at the 5% significance level.

Results

Prior to model estimation, it is necessary to test the stochastic properties of the data. Thus, using the standard augmented Dickey-Fuller (ADF) unit root test, it was checked whether data were stationary or nonstationary. From the results of the ADF unit root test, it was concluded that all variables in levels were nonstationary, while all the first difference variables were stationary.[6] Therefore, the results imply that given the data used in this study, the first difference RSDAIDS model, as compared with the static RSDAIDS, is appropriate for estimations. Moreover, the adjusted Wald *F*-test as described in Eales and Unnevehr was used to test for homogeneity and symmetry restrictions. Results for homogeneity (across commodities) and symmetry (for each commodity, across sources) in the first difference RSDAIDS (Equation 11) showed that these properties could not be rejected at the 5% significance level.

Because of the endogeneity of some of the prices and expenditure, the model (Equation 11) was estimated using an iterative three stage least squares (3SLS) method of estimation, assuming block substitutability and with homogeneity and symmetry (applied to products belonging to same category of good) imposed. Because of the assumption of block substitutability, the symmetry condition among goods could not be imposed.

Because meat expenditure shares (w_{ih}) sum to one, the demand system composed of expenditure share equations for the four source-differentiated meats would be singular. Therefore, the last equation (other meats) was dropped from the system for estimation purposes. The coefficients of the dropped equation were then calculated from the adding-up restriction. Here, we dropped another equation and reestimated the system in order to determine the parameters and the standard errors of the last equation. The results are the same as calculating the parameters of the last equations from the adding-up condition.

Marshallian demand elasticities were calculated from the estimated parameters (Table 5).[7] In the beef market, all expenditure elasticities are positive, and beef from Korea and the United States has statistically significant expenditure elasticities. Beef from the South Korean domestic cattle (Hanwoo) shows the highest expenditure elasticity (1.67), as compared with the imported beef.

[6] To save space, these results are not reported here.

[7] Hicksian elasticities were not presented here since meats account for only a tiny fraction of Korean consumers' income, and thus Marshallian and Hicksian elasticities are nearly identical.

Table 5. Marshallian Demand Elasticities, South Korean Meat Demand, 1996:I–2003:IV

	Beef				Pork					Poultry			
Price	S. Korea	U.S.	Aust.	ROW	S. Korea	Canada	U.S.	EU	ROW	S. Korea	U.S.	Thail.	ROW
Beef													
S. Korea	−1.238***	−0.317	0.063	0.118									
U.S.	−0.071	−0.904***	0.386	−0.267									
Aust.	−0.023	0.099	−1.830***	0.145									
ROW	−0.009	−0.050	0.065	−1.082***									
Pork													
S. Korea					−0.881***	−0.031	1.148	−0.423	0.403				
Canada					0.005	−0.501**	1.069***	−0.303**	0.011				
U.S.					0.015*	0.735***	0.494	−0.578***	−0.187				
EU					−0.009	−1.326**	−3.673***	0.496	−0.836*				
ROW					0.020*	0.019	−0.446	−0.311*	−0.354				
Poultry													
S. Korea										−0.255**	0.726*	−0.605	0.252
U.S										0.033*	−0.795***	1.556***	−1.383***
Thail.										−0.017	0.979***	−3.212***	−0.008
ROW										0.006	−0.414***	−0.002	−0.034
Beef					0.476***	−1.177	−0.507	0.063	−0.950	0.085	1.143	0.427	−1.888
Pork	0.076	−0.295	0.076	−0.333						−0.263*	−1.920***	0.584	1.293**
Poultry	−0.356***	−0.086	0.884**	0.363	−0.027	0.565	0.194	0.105	0.095				
Other meats	−0.050	−0.038	−0.163	0.509	0.016	0.038	−0.016	−0.251	0.023	0.053	0.328	0.433	0.214
Expenditure	1.672***	1.590***	0.518	0.547	0.386*	1.677	1.737	1.202	1.794	0.359*	−0.049	0.818	1.554

* Indicates significance at 10% level.
** Indicates significance at 5% level.
*** Indicates significance at 1% level.

This result is consistent with the general preference of South Korean consumers for Hanwoo beef over any imported beef, because of its perceived superior quality. Among the imported beef products, the demand for U.S. beef is more expenditure elastic (1.59) compared with the demand for Australian beef (0.52 and nonsignificant) and beef from the ROW (0.55 and nonsignificant), implying a higher percentage of beef would be imported from the United States compared with Australia and the ROW, given an increase in the size of the meat market in South Korea. This is also consistent with the South Korean consumer preferences; as in general, U.S. grain-fed beef is preferred to the Australian grass-fed beef.

With regard to pork expenditure elasticities, all elasticities are positive, but only the elasticity for South Korean pork is statistically significant (0.39). These results are also consistent with South Korean consumer strong preferences for fresh domestically produced pork.[10] Consistent with what is expected from economic theory, the results of this study show negative source-differentiated own-price elasticities for individual meats (except for the statistically nonsignificant elasticities for pork imported from the United States, EU, and the ROW and poultry from the ROW). Among these, own-price elasticities for South Korean domestically produced beef, beef from Australia and the ROW, and poultry from Thailand are greater than one and statistically significant. Inelastic and significant own-price responses were found for beef from the United States, pork from South Korea and Canada, and poultry from South Korea and the United States.

Cross-price elasticities may indicate substitutability or complementary relationships among products from various sources. The nonsignificant cross-price elasticities between Korean produced Hanwoo beef and source-differentiated imported beef and pork imply no significant impact on Hanwoo consumption as a result of imported beef or pork price changes. Therefore, results confirm prior expectations that Hanwoo beef has the high-quality product image and therefore is not expected to be a substitute for imported beef or for pork. The cross-price elasticities between U.S. and Australian beef, although positive, implying a substitute relationship, are not significant. This is consistent with the fact that during a segment of the period of this study, import quotas were in effect and, therefore, prices were not necessarily determinant of the quantity of imports (as confirmed by price endogeneity test described earlier).

Regarding the pork market, the statistically significant and positive cross-price elasticity shows that pork from the United States is a substitute for Canadian pork. This strong competition is consistent with prior expectations since Canada and the United States both produce pork of similar quality. The South Korean pork shows a statistically significant, although weak, substitute relationship with pork from the United States and the ROW. As expected, Korean pork shows a substitute relationship with beef. However, a statistically significant complementary relationship is found between the EU pork on one hand and the U.S. and Canadian pork on the other hand. The lack of competitiveness might be due to different pork products and cuts of meat originating from North America and the EU. In the poultry market, the United States and Thailand show a strong competitive relationship. Other cross-price elasticities are not statistically significant.

Among other cross-commodity relationships, Korean beef and poultry show a weak complementary relationship, while Australian beef shows substitutability with poultry, and South Korean and U.S. poultry show a complementary relationship with pork. In the next section, we will look at the implications of these relationships.

Elasticities were also estimated from other estimations using other types of data on consumption and imports, as well as prices.

[10] However, Korean consumers do also have a preference for a small segment of the imported pork (mainly from the EU) that is in the form of Sam-Gyup-Sal. This is one of the most preferred parts of the pork belly. It consists of alternating meat and fat layers and is used in traditional Korean dishes.

The model (Equation 11) was estimated using retail (instead of wholesale) level data for the domestic meat prices and quantities obtained from NACF. The estimated elasticities were very similar, in the pattern of change among supply sources and commodities, to the elasticities reported in Table 5. One way in which they were not similar is that the elasticities were slightly larger in absolute values. The model (Equation 11) was also estimated assuming exogenous prices and expenditures, using seemingly unrelated regression analysis. Although some of the price and expenditure elasticities were similar to those reported in Table 5, others were quite different in their magnitude and significance. Following Eakins and Gallagher, another version of the dynamic AIDS model was also estimated that included the first difference of the lagged values (two-lags) of variables in addition to the variables included in Equation (11). Although the likelihood ratio test showed that the model was a slightly better fit for the data, the results were not presented here due to the increase in the number of parameters (more than double of those included in Equation 11) and the significant decrease in the degrees of freedom associated with the Eakins and Gallagher model.

Summary and Conclusions

This study estimates the impact of prices and expenditures on the South Korean quantity demanded of source-differentiated meats, using the first difference version of the restricted source-differentiated almost ideal demand system and assuming block substitutability. Tests of three hypotheses regarding the behavior of South Korean meat consumers were conducted: (a) separability of meat categories from one another (beef, pork, poultry, and other meats), (b) non–source differentiation (product aggregation) of individual meats, and (c) price and expenditure endogeneity.

Results of separability tests indicate that the various studied meats are not separable from one another. Additionally, non–source differentiation was rejected, and therefore domestically produced meats as well as meats from various sources were treated as different products and demand estimation was conducted for these disaggregated products. Moreover, the endogeneity of the price and expenditure variables were not rejected, and therefore the demand system was estimated using an iterative 3SLS method of estimation.

Results of this study shed light on South Korean consumer preferences with regard to imported meats. This is one of the first studies that analyzes the South Korean meat demand, differentiated by supply source. The calculated expenditure elasticities indicate that the United States has the most to gain from an increase in the size of the imported meat market in terms of its beef exports. Moreover, the results of this study show that in the South Korean beef market, the United States has a competitive advantage compared with Australia. This is determined by the United States' relatively low own-price elasticity and high expenditure elasticity compared with Australia and considering the growth in South Korean consumers' per capita incomes and the type of meats that the United States exports. As was mentioned earlier, most of the U.S. exports are in the form of highly valued grain-fed beef, compared with Australia's grass-fed lean beef. Therefore, the growing per capita incomes in South Korea are expected to expand marketing potentials for U.S. beef exporters.

For pork, estimation results show that South Korea has the only significant expenditure elasticity, which may reflect South Korean consumer preference for fresh domestically produced pork. Moreover, the results indicate a competitive relationship between the United States and Canada. In the poultry market, Thailand and the United States have the largest (in absolute value) and statistically significant own-price elasticities compared with the competitors.

In an ever-changing policy environment, the results of this study would have implications for the U.S. meat market share in South Korea. For example, U.S. pork producers might be interested in knowing by how much they can increase their market share in South Korea after the U.S. beef ban resulting from the discovery of bovine spongiform encephalitis in December 2003 is lifted. A reduced beef supply in South Korea has driven up local beef prices and has led to higher prices for domestic pork. Judging from the cross-price elasticities, it can be concluded that the United States does not have much to gain in terms of its pork exports from beef price increases in South Korea, while most of the gain will be incurred by the South Korean domestic pork producers. Another current application of this study is the implication of the recent avian influenza pandemic scare that has reduced the consumption of poultry in South Korea. The competitive relationship between poultry and Australian beef supports higher beef consumption in South Korea and might imply benefits to the Australian beef producers in terms of increased exports. Although all imported pork shows a competitive relationship with poultry, none of the relationships are statistically significant.

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