Demand for Meat Products in the Pacific Rim Region

by

Oral Capps, Jr.*

Raymond Kirby

Reyfong Tsai

Gary W. Williams

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* Professor, Graduate Research Assistant, Graduate Research Assistant, and Professor, Department of Agricultural Economics, Texas A&M University. Support for this research comes from the Texas Agricultural Experiment Station.

Abstract

The Rotterdam and LA/AIDS models are used to obtain estimates of demand parameters for meat products in Taiwan, South Korea, and Japan. With relatively few exceptions, the elasticities are similar across model specifications. However, demand elasticities for meat products are notably different among the various Pacific Rim countries. This work provides valuable input to public and private decision makers in the United States in their ongoing efforts to penetrate foreign markets.

Key words: Pacific Rim, Rotterdam model, LA/AIDS model, demand analysis.

Demand for Meat Products in the Pacific Rim Region

Introduction

Developing marketing programs for meat products in international markets is currently of great interest to U.S. domestic producers. In a recent survey of livestock and meat industry leaders, nearly 75% of the respondents believed that events in international markets are now as important as events in domestic markets in determining potential profitability. Nearly 90% of the respondents believed that this scenario will hold in the future (Special Report to Texas Beef Industry).

Certain target markets are centered in the Pacific Rim region. In fact, the fastest growing international markets for meat products are in this region. A gradual opening of the Japanese beef market has played a positive role in boosting export demand for U.S. beef. Notable policy changes are taking place in Japan regarding the import of beef from the United States through the Beef Market Access Agreement (Lambert). At the same time, economic growth in several middle income countries in the Pacific Rim Region, including Taiwan and South Korea, has induced a substantial shift in their food consumption patterns away from traditional, low-value products like rice, toward higher quality, value-added products like beef. A number of events are currently taking shape that will likely encourage an even greater rate of growth in foreign demand for U.S. beef in the near future. The Japanese and Koreans, for example, all agreed to a phased reduction of their long-standing restrictions on beef imports. The Taiwanese government also has consistently lowered their beef import tariff. All these policy changes may stimulate beef import demands in these Pacific Rim countries.

To understand their potential demands for U.S. beef, as well as those for other meat products, it is essential that we undertake a rigorous analysis of meat demand in these potentially profitable new markets. An analysis of Pacific Rim markets would provide public and private decision makers with

guidelines in ongoing efforts to penetrate foreign markets. Little work however, has been done concerning the investigation of meat demands in the Pacific Rim region. Recently, Hayes, Wahl, and Williams and Lambert used the LA/AIDS model to estimate demand relationships for meat products in Japan.

Objectives

This paper has two related objectives. First, we wish to construct AIDS and Rotterdam models of demand systems for meat products in Japan, Korea, and Taiwan. The use of demand systems models permits the exploration of interdependencies among products. The use of two different but venerable demand systems allows for the examination of robustness of own-price, cross-price, and expenditure elasticities. Second, we wish to use the result to analyze the nature and differences of demands for different meat products among these countries. We assume that people living in different regions might cultivate different tastes and preferences for meat products, and consequently there may be different consumption patterns for meat products among the Pacific Rim countries.

Consumption Trends

This section describes historical consumption trends of meat products in the Pacific Rim over the last 20 to 25 years. A summary of the average per capita consumption levels of meat products as well as the average budget shares of meat products in recent periods is given in Table 1. The average budget shares of the meat products over the 1968-1988 period for each of the Pacific Rim countries are graphically depicted in Figures 1-4. Historical per capita consumption figures over the period 1960-1988 are shown graphically in Figures 5-8.

Both the consumption levels and average budget shares for meat products are dissimilar for Taiwan, South Korea, and Japan. Nevertheless, the principal meat product in the Pacific Rim region

Table 1. Summary of Per Capita Consumption Levels and Budget Shares for Meat Products in the Pacific Rim in Recent Years.

Commodity	Taiwan 1968-1988		South Korea 1960-1988		Japan 1962-1986	
	Avg. Per Capita Consump Levels (kg)	Avg. Budget Share of Meat Products (%)	Avg. Per Capita Consump Levels (kg)	Avg. Budget Share of Meat Products (%)	Avg. Per Capita Consump Levels (kg)	Avg. Budget Share of Meat Products (%)
Beef	1.14	3.67	1.92	5.94	2.56	12.60
Pork	24.89	39.74	4.38	7.37	6.79	18.59
Chicken	9.44	13.18	1.81	2.01	5.35	10.40
Fish	36.64	43.39	38.89	84.66	31.93	58.39

Figure 1
Pac Rim Budget Shares by Country
Beef

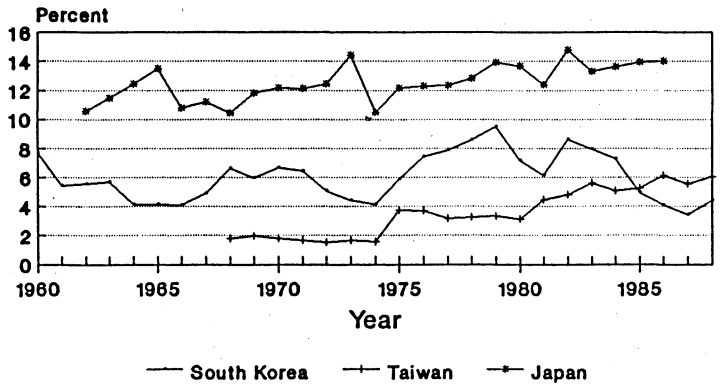


Figure 2
Pac Rim Budget Shares by Country
Pork

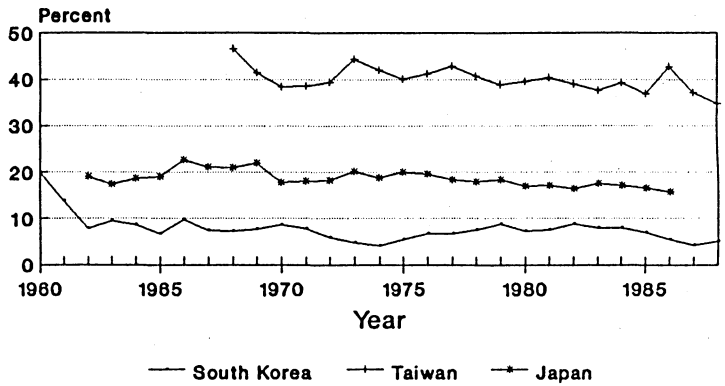


Figure 3
Pac Rim Budget Shares by Country
Chicken

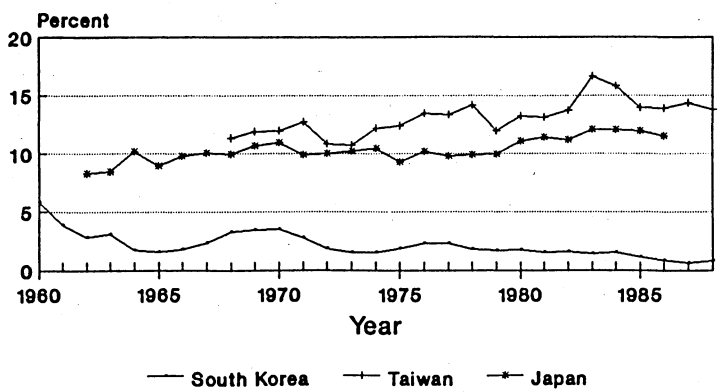


Figure 4
Pac Rim Budget Shares by Country
Marine Products

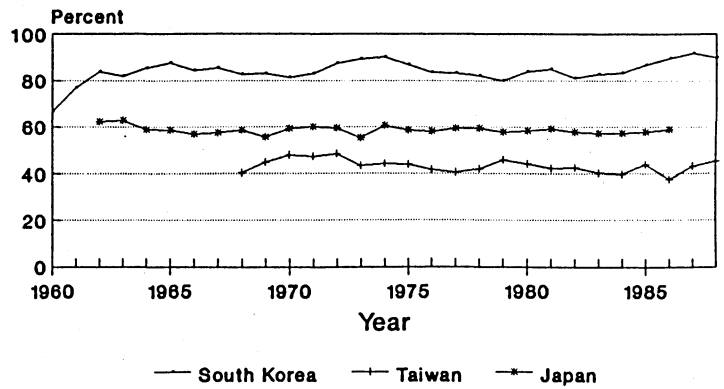


Figure 5
Per Capita Consumption by Country
Beef

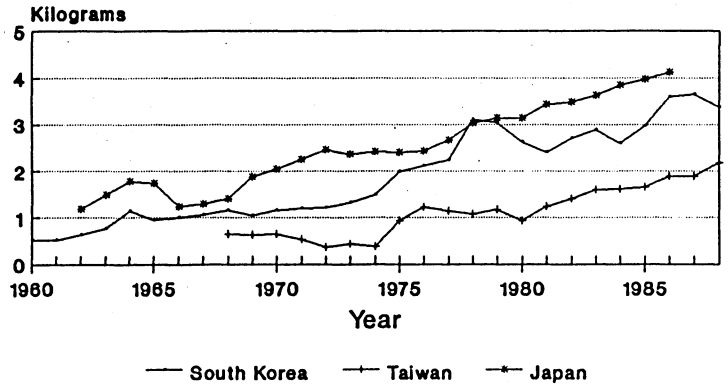


Figure 6
Per Capita Consumption by Country
Pork

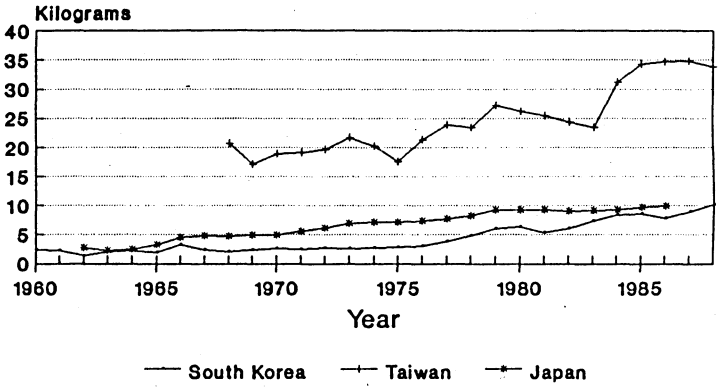


Figure 7
Per Capita Consumption by Country
Chicken

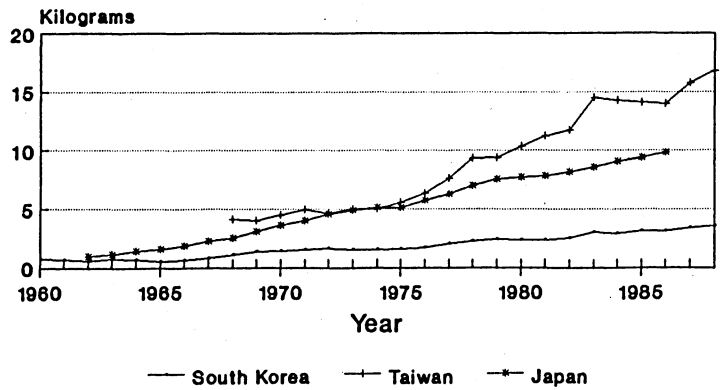
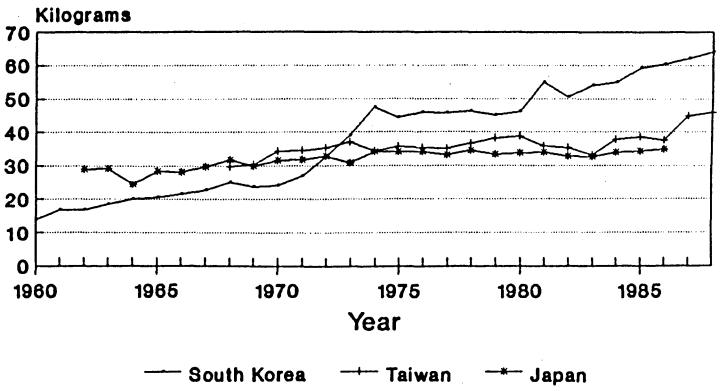


Figure 8
Per Capita Consumption by Country
Marine Products



is unequivocally fish. Marine products comprise nearly 85% of the meat budget in South Korea,compared to nearly 60% of the meat budget in Japan and nearly 45% in Taiwan. The Taiwanese spend roughly 40% of the meat budget on pork compared to 7% in South Korea and 19% in Japan. Beef and chicken comprise a relatively small share of the meat budget in the Pacific Rim. The budget shares for beef are slightly less than 4% in Taiwan, 6% in South Korea, and almost 13% in Japan. The relatively small budget share for beef may be attributable in part to import limitations. The budget shares for chicken are 13% in Taiwan, 2% in South Korea, and roughly 10% in Japan.

In Taiwan, pork is the most popular livestock product. On average, over the last twenty years, the per capita consumption of beef and chicken rose 6.2% and 7.3% per year, while per capita consumption of pork and fish grew 2.5% and 2.7% per year respectively. More than 85% of the beef supplied in Taiwan is imported, and most of the imports come from Australia.

Consumption of meat products in South Korea has been growing at rapid rates. The higher meat consumption has been attributed to higher rates of personal income and an urbanization of the Korean population (Dyck and Sillers). Per capita beef consumption moved from a low of 0.52 kg in 1963, to a high of 3.65 kg in 1987. Per capita pork consumption was at an all-time high of 10.14 kg in 1988, almost triple that of beef. In 1988, per capita consumption of chicken was at an all-time high of 3.55 kg, up from a low of 0.51 kg in 1965. In 1985, Koreans consumed an all-time high of 59.28 kg of marine products. When compared to per capita consumption of beef, pork, and chicken in 1985, per capita consumption of marine products is four times greater than all three combined.

Over the period 1962 to 1986, the per capita consumption of fish in Japan is on the order of 32 kg. Per capita consumption of pork and chicken over this time period is roughly 7 kg and 5 kg respectively. Per capita beef consumption is slightly less than 3 kg on average. Although meats make up a small portion of the Japanese diet, consumption is growing due in part to income levels and "westernization" of tastes (Lambert; Hayes, Wahl, and Williams). Fifty years ago, the Japanese

consumed almost no meat, and beef consumption in particular was restricted on religious grounds (Gorman, Mori, and Lin).

On the basis of per capita consumption and budget shares for meat products, we may expect the demands for the various products to differ across Taiwan, South Korea, and Japan. To determine the demand relationships for the meat products in the Pacific Rim region, we employ the popular and venerable Rotterdam and LA/AIDS models. The data used in the ensuing empirical analysis consist of annual observations corresponding to the periods reported in Table 1. A discussion of the Rotterdam and AIDS models is given in the next section.

Demand System Models

The Rotterdam model (Barten) for empirical purposes may be written as

$$(1) \qquad w_{it}^{*} Dq_{it} = b_i[Dy_t - \sum_k w_{kt} Dp_{kt}] + \sum_j c_{ij} Dp_{jt},$$

where, $w_{it}^{*} = \frac{1}{2}(w_{it} + w_{it-1})$; $Dq_{it} = \ln[q_{it}/q_{it-1}]$; $Dy_t = \ln[y_t/y_{t-1}]$; and $Dp_{jt} = \ln[p_{jt}/p_{jt-1}]$.

The currently popular LA/AIDS model (Deaton and Muellbauer) may be written as

$$(2) \qquad w_{it} = \alpha_i + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i \ln[y_t/P_t^{*}],$$

where $\ln P_t^{*} = \sum_k w_{kt} \ln p_{kt}$ (Stone's approximation).

For the respective models, w_{it} corresponds to the expenditure share of meat item i in time period t; q_{it} denotes per capita consumption of meat item i in time period t; p_{jt} corresponds to nominal price of meat item j in time period t; y_t denotes expenditure on the set of meat products in time period t. The subscripts i and j refer to beef, pork, chicken, and marine (fish) products. Unlike the studies for Japan conducted by Hayes, Wahl and Williams and Lambert, import-quality beef and domestic beef are not treated as separate commodities in the model specifications.

Both the Rotterdam and LA/AIDS model are examples of flexible demand systems. Both models necessitate the use of classical restrictions so that the estimates of demand parameters conform to theory. In the case of the Rotterdam model, the restrictions are as follows:

(3) $\sum_i c_{ij} = 0$ and $\sum_i b_i = 1$ (Adding-up); $\sum_j c_{ij} = 0$ (Homogeneity); and $c_{ij} = c_{ji}$ (Symmetry).

For the LA/AIDS, the restrictions are as follows:

(4) $$\sum_i \alpha_i = 1,\ \sum_i \gamma_{ij} = 0,\ \text{and}\ \sum_i \beta_i = 1\ \text{(AddingUp)};\ \sum_j \gamma_{ij} = 0\ \text{(Homogeneity)};\ \text{and}\ \gamma_{ij} = \gamma_{ji}\ \text{(Symmetry)}.$$

Operationally, when estimating demand systems, one equation must be omitted to avoid singularity of the variance-covariance matrix of disturbance terms. For each model, the omitted equation corresponds to beef. Through the classical constraints, the demand parameters associated with the omitted equation are subsequently recovered.

Empirical Results

Quantity and price data used in this analysis are from various yearbooks, and reports published by the various countries. For South Korea, quantities and price of beef, pork, and chicken are taken from *Materials on Price, Demand, and Supply for Livestock Products*, the *Agricultural Cooperative Yearbook*, the *South Korea Statistical Yearbook*, and the *Economic Statistics Annual Book*. Quantities and prices of marine products are taken from the *Yearbook of Fisheries Statistics* and the *Annual Statistics on Cooperative Sale of Fishery Products*. For Taiwan, per capita consumption figures come from the *Taiwan Food Balance Sheet*, and retail prices come from *Taiwan Agricultural Prices and Costs Monthly*. Retail and wholesale price indices come from *Commodity*

Price Statistics Monthly. For Japan, the data come from Wahl. This data series is described in detail in the work by Hayes, Wahl, and Williams (p. 558).

For Taiwan and South Korea, representative prices for marine products were difficult to obtain. For Taiwan, a weighted average price of 18 marine products was used as the price of fish. The respective products used to develop the weighted average price series were: (1) Yellow Sea Bream, (2) Red Sea Bream, (3) Crimson Sea Bream, (4) Black Pomfret, (5) Milk Fish, (6) Sailfish, (7) Silver Carp, (8) Tuna, (9) Butter fish, (10) Cuttle fish, (11) Hairtail, (12) Mackerel, (13) White Croaker, (14) Lizard fish, (15) Sea eel, (16) Nemipterid, (17) Striped Prawn, and (18) Shrimp.

South Korea has thousands of different types of marine products available to consumers. Because of the lack of quantity information for individual marine species, it was not possible to develop a weighted average price series. The retail price series for marine products in South Korea was constructed by regressing the retail price for marine products in Japan as a function of the wholesale marine price index in South Korea, available annually. The predicted price from this relationship was converted to the retail price of marine products in South Korea by using the exchange rate of Won to Yen.

Descriptive statistics of per capita consumption, nominal prices, and average budget shares are exhibited in Table 2. In the respective Pacific Rim countries, on average, beef is the most expensive product, generally because of import quotas. As well, beef (chicken) prices are the most (least) volatile. In Taiwan, on average, fish is the least expensive product; in South Korea, on average, chicken is the least expensive product, and in Japan, fish is the least expensive meat commodity.

In the respective analyses of the demand systems for the Pacific Rim countries, real prices are used. Real prices are obtained by dividing the nominal price series by the Consumer Price Index. Estimates of the structural parameters of the demand models are derived by using the method of

Table 2. Descriptive Statistics of Variables Used in the Analysis by Pacific Rim Country

	Taiwan (kg)				South Korea (kg)				Japan (kg)			
Per Capita Consumption	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Beef	1.14	.54	.37	2.18	1.92	.98	.51	3.65	2.56	.87	1.24	4.12
Pork	24.89	5.94	17.09	34.83	4.38	2.60	1.43	10.13	6.79	2.37	2.31	9.90
Chicken	9.44	4.34	4.02	16.83	1.82	.93	.50	3.55	5.35	2.77	1.14	9.81
Fish	36.64	3.58	30.32	45.83	38.90	15.79	16.71	63.99	31.93	2.49	24.56	34.76
Nominal Prices	NT$/kg				Won/kg				Yen/kg			
Beef	191.5	83.3	55.5	288.1	3016.3	3029.9	133.0	8316.0	2303.3	980.2	694	3680
Pork	89.7	26.8	43.1	128.7	1451.1	1340.6	75.0	3838.0	1224.2	368.6	694	1680
Chicken	81.9	14.2	52.5	98.9	733.4	573.1	69.0	1629.0	932.4	194.1	712	1200
Fish	67.4	26.3	26.3	100.4	2366.8	2895.9	58.3	10092.0	894.7	509.5	208	1600
Average Budget Shares												
Beef	.0367	.0162	.0151	.0612	.0594	.0163	.0341	.0949	.1260	.0122	.1041	.1478
Pork	.3974	.0228	.3485	.4430	.0737	.0196	.0413	.1379	.1859	.0180	.1568	.2268
Chicken	.1318	.0147	.1070	.1661	.0202	.0086	.0064	.0391	.1040	.0094	.0846	.1206
Fish	.4339	.0276	.3738	.4826	.8466	.0345	.7687	.9170	.5839	.1549	.5520	.6268

maximum likelihood in the econometrics package SHAZAM (White et al). As suggested by Berndt and Savin, the various systems in each Pacific Rim country are corrected for autocorrelation by using the same autocorrelation coefficient ($\hat{\rho}$) for each equation. In the Rotterdam model, $\hat{\rho}$ corresponds to .0699, .2886, and -.2780 for Taiwan, South Korea, and Japan, respectively. In the LA/AIDS model, $\hat{\rho}$ corresponds to .2578, .4853, and .2659 for Taiwan, South Korea, and Japan, respectively. The estimated coefficients and associated standard errors of the parameters in the respective demand systems for the three countries are exhibited in Tables 3 and 4.

Given the interest in elasticities, the formulae used to calculate uncompensated and compensated price elasticities and expenditure statistics from the structural parameters are given in Table 5. Standard errors of the elasticities are calculated by using the method used by Chalfant. This method assumes that the budget shares are exogenous and hence, the standard errors are only approximations. Both Marshallian and Hicksian measures are exhibited in Table 6 (Rotterdam model) and Table 7 (LA/AIDS model). The resulting t-statistics are given in parentheses. Because expenditure on meats is used rather than total expenditures, the system of demand functions is a conditional set of relationships. The elasticities are therefore second-stage estimates. The estimated elasticities for the Taiwanese, South Korean, and Japanese meat demand systems are, in general, in accordance with a priori expectations. All own-price elasticities are negative while most of the compensated cross-price elasticities are positive, indicative of net substitutes.

Comparisons Across Models

Taiwan

Except for chicken, the own uncompensated and compensated elasticities are similar across model specifications for Taiwan. The own uncompensated (compensated) elasticities are roughly -1.20 (-1.14) for beef, -0.80 (-0.30) for pork, and -0.47 (-0.10 to -0.20) for fish. The own uncompensated

Table 3. Parameter Estimates and Associated t-Statistics for the Rotterdam Model[a]

	Pacific Rim Country		
	Taiwan	South Korea	Japan
Beef			
c11	-.0423* (-3.21)	.0300* (-4.16)	-.0745* (-3.37)
c12	.0510* (3.53)	.0177* (2.21)	.0476* (2.54)
c13	-.0329* (-2.46)	.0070* (2.10)	-.0228* (-2.25)
c14	.0238 (1.76)	.0054 (0.69)	.0498* (2.00)
b1	.0235 (1.07)	.0123 (0.59)	.0739 (0.48)
Pork			
c22	-.1090* (-2.31)	-.0374* (-2.13)	-.0970* (-3.18)
c23	.0731* (2.58)	-.0009 (-0.29)	-.0155 (-0.79)
c24	-.0145 (-0.40)	.0206 (1.13)	.0649 (1.58)
b2	.5230* (6.57)	.0936* (2.04)	.2020* (2.47)
Chicken			
c33	-.0759* (-2.30)	-.0051 (-1.25)	-.0506* (-3.16)
c34	.0357 (1.40)	-.0009 (-0.32)	.0890* (4.35)
b3	.0975* (2.02)	.0179* (2.52)	.0964* (2.25)
Fish			
c44	-.0450 (-1.19)	-.0258 (1.16)	-.2040* (-3.71)
b4	.3560* (5.08)	.8768* (16.82)	.6240* (5.22)
ρ	.0699 (0.13)	.2886* (2.06)	-.2780 (-1.36)

[a] Asterisk indicates significance at the 0.05 level.

Table 4. Parameter Estimates and Associated t-statistics for the LA/AIDS Model[a]

	Pacific Rim Country		
	Taiwan	South Korea	Japan
Beef			
$\alpha 1$	-.1553	.0010	.0099
	(-1.68)	(0.03)	(0.06)
$\gamma 11$	-.0066	.0314*	.0142
	(-0.49)	(4.22)	(0.55)
$\gamma 12$	.0373*	.0061	.0305
	(1.98)	(0.81)	(1.48)
$\gamma 13$	-.0391*	.0060	-.0323*
	(-2.91)	(1.55)	(-3.71)
$\gamma 14$	.0084	-.0435*	-.0123
	(0.49)	(-5.30)	(-0.55)
$\beta 1$	.0464*	.0144	.0250
	(2.19)	(1.56)	(0.64)
Pork			
$\alpha 2$	-.1207	.0743	.1178
	(-0.58)	(1.56)	(0.53)
$\gamma 22$	.1195*	.0208	.0609*
	(2.64)	(1.68)	(2.10)
$\gamma 23$	.0402	-.0016	-.0276*
	(1.58)	(-0.35)	(-1.96)
$\gamma 24$	-.1971*	-.0253*	-.0637*
	(-5.05)	(-2.01)	(-2.20)
$\beta 2$	.1012*	-.0009	.0043
	(2.17)	(-0.07)	(0.07)
Chicken			
$\alpha 3$	.0721	.0347*	-.0459
	(0.61)	(2.28)	(-0.25)
$\gamma 33$	-.0367	.0096*	.0481*
	(-1.82)	(1.93)	(2.95)
$\gamma 34$	.0356	-.0139*	.0118
	(1.59)	(-4.49)	(0.53)
$\beta 3$	.0228	-.0029	.0497
	(0.86)	(-0.59)	(1.07)
Fish			
$\alpha 4$	1.2040*	.8898*	.9182*
	(4.69)	(13.63)	(2.55)
$\gamma 44$	.1531*	.0827*	.0642
	(3.01)	(4.48)	(1.40)
$\beta 4$	-.1705*	-.0106	-.0791
	(-3.01)	(-0.61)	(-0.87)
ρ	.2578	.4853*	.2659
	(1.46)	(4.03)	(1.38)

[a] Asterisk indicates significance at the 0.05 level.

Table 5. Formulae Used to Calculate Point Estimates and Variances of Uncompensated and Compensated Price Elasticities and Expenditure Elasticities.

	LA/AIDS Model	Rotterdam Model
Uncompensated Price Elasticity	$-\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i w_j}{w_i}$	$\frac{1}{w_i}(c_{ij} - w_j b_i)$
Variance of Uncompensated Price Elasticity	$\frac{1}{w_i^2}[\text{var}(\gamma_{ij}) + w_j^2 \text{ var}(\beta_i) - 2w_j \text{ cov}(\gamma_{ij}, \beta_i)]$	$\frac{1}{w_i^2}[\text{var}(c_{ij}) + w_j^2 \text{ var}(b_i) - 2w_j \text{ cov}(c_{ij}, b_i)]$
Compensated Price Elasticity	$-\delta_{ij} + w_j + \frac{\gamma_{ij}}{w_i}$	$\frac{c_{ij}}{w_i}$
Variance of Compensated Price Elasticity	$\frac{1}{w_i^2}\text{var}(\gamma_{ij})$	$\frac{1}{w_i^2}\text{var}(c_{ij})$
Expenditure Elasticity	$1 + \frac{\beta_i}{w_i}$	$\frac{b_i}{w_i}$
Variance of Expenditure Elasticity	$\frac{1}{w_i^2}\text{var}(\beta_i)$	$\frac{1}{w_i^2}\text{var}(b_i)$

δ_{ij} is the Kronecker delta, 1 if i=j and 0 otherwise.

γ_{ij} and β_i are the structural parameters of the LA/AIDS model

c_{ij} and b_i are the structural parameters of the Rotterdam model

w_i and w_j refer to the average budget shares for meat products i and j respectively.

Table 6. Uncompensated and Compensated Price Elasticities and Expenditure Elasticities for Meat Products in Taiwan, South Korea, and Japan -- Rotterdam Model.

Taiwan

Uncompensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-1.1719 (-3.26)	1.1332 (2.89)	-0.9774 (-2.65)	0.3696 (0.73)
Pork	0.0800 (2.18)	-0.7959 (-7.08)	0.0104 (0.13)	-0.6072 (-8.56)
Chicken	-0.2764 (-2.72)	0.2604 (1.26)	-0.6732 (-2.52)	-0.0503 (-0.19)
Fish	0.0246 (0.78)	-0.3595 (-4.32)	-0.0261 (-0.41)	-0.4598 (-3.54)

Compensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-1.1484 (-3.20)	1.3871 (3.54)	-0.8932 (-2.47)	0.6468 (1.77)
Pork	0.1284 (3.54)	-0.2732 (-2.31)	0.1839 (2.58)	-0.0364 (-0.40)
Chicken	-0.2492 (-2.47)	0.5541 (2.58)	-0.5758 (-2.30)	0.2703 (1.40)
Fish	0.0548 (1.77)	-0.0334 (-0.40)	0.0822 (1.40)	-0.1037 (-1.19)

Expenditure Elasticities

Beef	Pork	Chicken	Fish
0.6388 (1.07)	1.3151 (6.57)	0.7388 (2.03)	0.8206 (5.09)

South Korea

Uncompensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-0.5125 (-4.41)	0.2900 (2.03)	0.1136 (2.05)	-0.0771 (-0.24)
Pork	0.1692 (1.53)	-0.6065 (-2.43)	-0.0390 (-0.87)	-0.8086 (-1.54)
Chicken	0.2936 (1.76)	-0.1126 (-0.67)	-0.2704 (-1.35)	-0.7970 (-2.42)
Fish	-0.0554 (-5.62)	-0.0519 (-2.33)	-0.0221 (-5.88)	-0.9074 (-15.49)

Compensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-0.5009 (-4.24)	0.3044 (2.23)	0.1176 (2.11)	0.0882 (0.66)
Pork	0.2457 (2.23)	-0.5117 (-2.12)	-0.0130 (-0.29)	0.2805 (1.13)
Chicken	0.3463 (2.11)	-0.0474 (-0.29)	-0.2525 (-1.25)	-0.0472 (-0.32)
Fish	0.0062 (0.66)	0.0244 (1.13)	-0.0011 (-0.32)	-0.0305 (-1.15)

Expenditure Elasticities

Beef	Pork	Chicken	Fish
0.1952 (0.56)	1.2865 (2.07)	0.8856 (2.53)	1.0358 (16.69)

Japan

Uncompensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-0.6653 (-2.76)	0.2690 (1.08)	-0.2424 (-1.70)	0.0529 (0.07)
Pork	0.1190 (1.07)	-0.7239 (-5.32)	-0.1967 (-2.42)	-0.2865 (-1.23)
Chicken	-0.3361 (-2.72)	-0.3212 (-2.15)	-0.5826 (-3.88)	0.3145 (0.79)
Fish	-0.0494 (-0.90)	-0.0877 (-1.86)	0.0411 (0.62)	-0.9737 (-4.99)

Compensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-0.5913 (-3.37)	0.3782 (2.55)	-0.1813 (-2.27)	0.3955 (2.01)
Pork	0.2562 (2.55)	-0.5215 (-3.18)	-0.0834 (-0.79)	0.3490 (1.59)
Chicken	-0.2194 (-2.27)	-0.1490 (-0.79)	-0.4862 (-3.17)	0.8550 (4.36)
Fish	0.0853 (2.01)	0.1112 (1.59)	0.1524 (4.36)	-0.3493 (-3.71)

Expenditure Elasticities

	Beef	Pork	Chicken	Fish
	0.5868 (0.48)	1.0883 (2.48)	0.9257 (2.25)	1.0692 (5.22)

Table 7. Uncompensated and Compensated Price Elasticities and Expenditure Elasticities for Meat Products in Taiwan, South Korea, and Japan -- LA/AIDS Model.

Taiwan

Uncompensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-1.2261 (-3.34)	0.5135 (1.03)	-1.2312 (-3.82)	-0.3198 (-0.49)
Pork	0.0846 (1.76)	-0.8005 (-8.08)	0.0677 (1.12)	-0.6066 (-4.27)
Chicken	-0.3031 (-3.07)	0.2364 (1.15)	-1.3017 (-8.67)	0.1952 (0.79)
Fish	0.0338 (0.87)	-0.2981 (-3.95)	0.1340 (2.95)	-0.4767 (-2.85)

Compensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-1.1429 (-3.14)	1.4131 (2.75)	-0.9327 (-2.61)	0.6625 (1.43)
Pork	0.1307 (2.75)	-0.3018 (-2.64)	0.2331 (3.63)	-0.0620 (-0.63)
Chicken	-0.2600 (-2.61)	0.7027 (3.63)	-1.1470 (-6.71)	0.7043 (4.15)
Fish	0.0561 (1.43)	-0.0568 (-0.63)	0.2140 (4.15)	-0.2133 (-1.82)

Expenditure Elasticities

Beef	Pork	Chicken	Fish
2.2635 (3.93)	1.2549 (10.73)	1.1732 (4.46)	0.6070 (4.64)

South Korea

Uncompensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-0.4862 (-3.84)	0.0846 (0.69)	0.0959 (1.51)	-0.9362 (-4.25)
Pork	0.0834 (0.81)	-0.7168 (-4.41)	-0.0215 (-0.36)	-0.3329 (-1.22)
Chicken	0.3053 (1.53)	-0.0689 (-0.31)	-0.5230 (-2.17)	-0.5709 (-1.98)
Fish	-0.0506 (-5.66)	-0.0290 (-2.03)	-0.0162 (-4.54)	-0.8916 (-26.79)

Compensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-0.4124 (-3.30)	0.1762 (1.40)	0.1210 (1.87)	0.1152 (0.84)
Pork	0.1421 (1.40)	-0.6437 (-3.85)	-0.0016 (-0.03)	0.5034 (2.96)
Chicken	0.3563 (1.87)	-0.0057 (-0.03)	-0.5057 (-2.06)	0.1551 (1.01)
Fish	0.0081 (0.84)	0.0438 (2.96)	0.0037 (1.01)	-0.0556 (-2.55)

Expenditure Elasticities

Beef	Pork	Chicken	Fish
1.2419 (8.04)	0.9878 (5.64)	0.8575 (3.56)	0.9875 (47.86)

Japan

Uncompensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-0.9125 (-4.38)	0.2049 (1.45)	-0.2769 (-2.27)	-0.2141 (-1.08)
Pork	0.1610 (1.39)	-0.6768 (-5.15)	-0.1511 (-2.57)	-0.3562 (-1.09)
Chicken	-0.3706 (-3.61)	-0.3545 (-3.08)	-0.5877 (-4.84)	-0.1650 (-0.34)
Fish	-0.0041 (-0.04)	-0.0840 (-2.44)	0.0344 (1.36)	-0.8109 (-4.87)

Compensated Elasticities

	Beef	Pork	Chicken	Fish
Beef	-0.7614 (-3.71)	0.4278 (2.62)	-0.1522 (-2.21)	0.4858 (2.74)
Pork	0.2899 (2.61)	-0.4865 (-3.13)	-0.0446 (-0.59)	0.2412 (1.55)
Chicken	-0.1843 (-2.20)	-0.0797 (-0.59)	-0.4339 (-2.77)	0.6979 (3.27)
Fish	0.1049 (2.76)	0.0768 (1.55)	0.1244 (3.27)	-0.3061 (-3.92)

Expenditure Elasticities

Beef	Pork	Chicken	Fish
1.1987 (3.85)	1.0231 (3.42)	1.4778 (3.32)	0.8646 (5.54)

(compensated) elasticity for chicken is -0.67 (-0.57) from the Rotterdam Model but -1.20 (-1.15) from the LA/AIDS model. The magnitudes of the uncompensated and compensated cross-price elasticities among the meat products for Taiwan are in most cases similar across model specifications. Except for beef and chicken as well as for fish and pork, the meat products are net substitutes. Notable differences exist in the expenditure elasticities across models, particularly for beef and chicken. This result may be due in part to the relatively small magnitude of the average budget shares for these products.

South Korea

Similar to the case of Taiwan, the own uncompensated and compensated elasticities are similar across model specifications, with the exception of chicken. In South Korea, the own uncompensated (compensated) elasticities are roughly -0.50 (-0.40 to -0.50) for beef, -0.60 to -0.70 (-0.50 to -0.60) for pork, and -0.90 (-0.03 to -0.05) for fish. The own uncompensated (compensated) elasticity for chicken is -0.27 (-0.25) from the Rotterdam model but -0.52 (-0.50) from the LA/AIDS model. With several exceptions, the magnitudes of the uncompensated and compensated cross-price elasticities among the meat products for South Korea are similar across model specifications. Except for pork and chicken and perhaps chicken and fish (at least from the Rotterdam model), the meat products are net substitutes. Salient differences exist in the expenditure elasticities across models, particularly for beef and pork.

Japan

As before, the own uncompensated and compensated elasticities are similar across model specifications, but in this case, the exception is beef. In Japan, the own uncompensated (compensated) elasticities are -0.70 (-0.50) for pork, -0.58 (-0.43 to -0.48) for chicken, and -0.81 to -0.97 (-0.30 to -0.35) for fish, respectively. The own uncompensated (compensated) elasticity for beef is -0.66 (-0.59) from the Rotterdam Model and -0.91 (-0.76) from the LA/AIDS model. Lambert estimated the uncompensated own-price elasticity for beef in Japan to be -1.05 for Wagyu (domestic) beef and -0.58 for imported beef (from the United States, New Zealand, and Australia). Hayes, Wahl, and Williams estimated the own-uncompensated (compensated) elasticity for Wagyu beef in Japan to be -1.89 (-1.78) and for import-quality

beef to be -0.46 (-0.29). The uncompensated own-price elasticities for beef reported in this paper thus fall in the interval reported by Lambert and by Hayes, Wahl, and Williams.

Hayes, Wahl, and Williams estimated the own-uncompensated (compensated) elasticities for pork, chicken, and fish to be -0.76 (-0.66); -0.59 (-0.42); and -0.70 (-0.24) respectively. These estimates are also in line with those obtained from our analyses. Again, except in several instances, the magnitudes of the uncompensated and compensated cross-price elasticities among the meat products for Japan are similar across model specifications. Except for beef and chicken as well as pork and chicken, the meat products are net substitutes. Differences are evident, however, in the expenditure elasticities across models, particularly for beef and chicken.

Intercountry Comparisons

Except for beef in Taiwan and possibly chicken in Taiwan, the demand for the respective meat products is price inelastic. The demands for beef and chicken are most (least) sensitive to own-price changes in Taiwan (South Korea). The own-price elasticity of demand for pork is in the range of -0.60 to -0.80 in the Pacific Rim. The own-price elasticity of demand for fish is almost the same in South Korea and Japan, roughly -0.90. However, this elasticity in Taiwan (-0.45) is about half the corresponding elasticities in South Korea and Japan.

Beef and pork, beef and fish, and chicken and fish are net substitutes in the Pacific Rim nations. Pork and chicken appear to be net substitutes in Taiwan, but net complements in South Korea and Japan. However, the compensated cross-price elasticities between pork and chicken in South Korea and Japan are not statistically different from zero. Beef and chicken appear to be net complements in Taiwan and Japan, but net substitutes in South Korea. The net complementary relationships are, in these cases however, statistically different from zero. Pork and fish are net substitutes in South Korea and Japan, but net complements in Taiwan. However, this net complementary relationship in Taiwan is not statistically different from zero. Thus, the only statistically significant net complementary relationship among meat products in the Pacific Rim is between beef and chicken in Taiwan and Japan. One could impose net substitutability

econometrically as done by Hayes, Wahl, and Williams, but in light of our compensated cross-price elasticities, this restriction may not be necessary.

Finally, all the meat products are normal goods. However, the magnitudes of the expenditure elasticities differ, in some cases substantially, not only by country but also by model specification. For example, for the Rotterdam model (LA/AIDS model) the expenditure elasticity for beef in South Korea was estimated to be 0.195 (1.241); the expenditure elasticity for pork in South Korea was estimated to be 1.286 (0.987) using the Rotterdam (LA/AIDS) model. Similarly, the expenditure elasticity for beef in Japan was estimated to be 0.586 (1.198) using the Rotterdam (LA/AIDS) model, while the expenditure elasticities for chicken and fish were estimated to be 0.925 (1.472) and 1.069 (0.864) respectively.

The income elasticity of Japanese demand for meats was estimated to be 1.54 by Sasaki and Fukagawa. The income elasticity of demand for meats in South Korea was estimated to be 1.25 by Kim. No information is available regarding the income elasticity of demand for meats in Taiwan. Multiplying these figures by the various expenditure elasticities for the meat products in Japan and South Korea gives rise to income elasticities for the individual commodities in these countries (Blanciforti and Green). Therefore, a 10% increase in real income in South Korea (Japan) leads to a 2.4% to 15.5% (9.0% to 18.4%) increase in the demand for beef; a 12.3% to 16.0% (15.7% to 16.7%) increase in the demand for pork; a 10.7% to 11.0% (14.2% to 22.7%) increase in the demand for chicken; and a 12.3% to 12.9% (13.3% to 16.4%) increase in the demand for fish.

Concluding Remarks

The Rotterdam and LA/AIDS models provide theoretically consistent estimates of demand parameters for meat products in Taiwan, South Korea, and Japan. In general, the results are similar across models (although some exceptions occur). This robustness adds to our confidence in estimated demand elasticities of meat products in these countries. However, the demand parameter estimates are indeed notably different for the various Pacific Rim countries.

The next step is to integrate the estimates of the demand systems with livestock supply models in Taiwan, South Korea, and Japan. The purpose of this integration is to conduct simulations to analyze the effects of fewer restrictions, particularly on beef imports, into major Pacific Rim markets. Alternate beef import policy schemes include the 1988 Japanese Beef Market Access Agreement and the removal of the South Korean embargo against beef imports. Given that Hayes, Wahl, and Williams reject the hypothesis that in Japan domestic (Wagyu) and import-quality beef are perfect substitutes, future analyses in the Pacific Rim region may need to consider treating each type of beef as separate commodities in order to analyze more appropriately the effects of beef import policies. In sum, the demand systems work not only provides information in regard to meat demands in the Pacific Rim region but also gives rise to valuable input to analyze alternative international trade scenarios.

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