View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Research Papers in Economics

Journal of Agricultural and Resource Economics 24(1):114–126
Copyright 1999 Western Agricultural Economics Association

Testing Separability of Japanese Demand for Meat and Fish Within Differential Demand Systems

James Eales and Cathy R. Wessells

The separability of meat products from fish products is investigated to gain a better understanding of Japanese consumer choices in protein demand. Rather than view fish as a single homogeneous commodity, fish and seafood are categorized into several groups of products. Separability is investigated using a demand system approach in which a generalized system of demand equations is specified and used, first to identify if any of the alternative demand structures nested within the general system are appropriate for these data, and then, conditional on those results, to test separability of meats from fish products following Moschini, Moro, and Green. Results indicate that meats and fish were separable prior to 1990; however, when examined over the entire 1981–95 study period, they are not.

Key words: consumer, differential demand systems, fish, Japan, meat, separability

Introduction

Demand for meats in Japan has elicited significant interest in the last decade (Hayes, Wahl, and Williams; Capps et al.; Mues et al.; Yang and Koo; Johnson, Durham, and Wessells). The primary reason for this interest is the importance of the Japanese market as an export destination for U.S. meat products. According to data from the U.S. Meat Export Research Center (MERC), Japan is the most important market for U.S. beef exports. More recently, the U.S. has had a significant market share in the Japanese beef market, at 55% of Japanese imported frozen beef and 41% of imported fresh and chilled beef (MERC). Due in part to the 1988 Beef Market Access Agreement and changes in other policies, imports of meats have become a large and growing proportion of total Japanese consumption (table 1). Thus, as Capps et al. point out, it is important that rigorous analysis of demand for meats in Japan be undertaken in order to provide decision makers with useful information in their efforts to penetrate this important market.

One of the issues which must be addressed when investigating demand for protein in the Japanese market is the role that fish plays in meat demand; in other words, should fish be included in a meat demand system? Seafood constitutes 50% of Japanese

---

Eales is an assistant professor in the Department of Agricultural Economics, Purdue University; Wessells is an associate professor in the Department of Environmental and Natural Resource Economics, University of Rhode Island.

The authors gratefully acknowledge financial support for this research from USDA NRI Competitive Grant No. 94-347000-0774, the Purdue University Agricultural Research Program, and the University of Rhode Island Agricultural Experiment Station. An earlier version of this manuscript appeared as Purdue University Agricultural Research Program Journal Paper No. 15572. Helpful discussions with Catherine Durham are appreciated, as is assistance from Aaron Johnson. We also wish to thank the anonymous reviewers for valuable input and suggestions which helped to improve the paper.

Table 1. Import Quantity Percentage Share of Japanese Domestic Consumption (5-year averages)

	Percentage Share		
Year Span	Beef	Pork	Broilers
1966–1970	10.6	3.0	5.3
1971–1975	23.1	10.2	4.6
1976–1980	28.6	11.8	6.0
1981–1985	27.8	14.9	8.3
1986–1990	41.9	21.3	15.1
1991–1995	53.9	33.2	26.0

Source: U.S. Department of Agriculture/Economic Research Service, "Production, Supply, and Distribution (PS&D) Database."

expenditures on animal protein products for at-home consumption. Japanese annual consumption of seafood per capita is among the highest in the world, averaging over 80 pounds in 1995 (Japan Management and Coordination Agency). Beef consumption, in contrast, averaged 27 pounds, while pork consumption averaged 35 pounds, and chicken 28 pounds. Comparable U.S. per capita consumption of fish was 15 pounds in 1995, and beef, pork, and chicken averaged 67, 52, and 70 pounds, respectively (Putnam and Allshouse, table 5, retail weight).

In their 1990 analysis of Japanese meat demand, Hayes, Wahl, and Williams first considered the question of separability of meats from fish. Their study was followed by that of Capps et al. who examined the demand for meat products in the Pacific Rim region. Both studies concluded that meats and fish are separable commodities, and suggested that fish demand be treated separately from the demand for beef, pork, and chicken. While these analyses have failed to reject separability of meat from seafood, one wonders whether this conclusion is affected by the level of aggregation of fish products. In both previous investigations, fish demand was estimated using the highest level of aggregation—i.e., the commodity "fish" aggregated over all fish products. In reality, seafood marketed in Japan is heterogeneous, with many species available. Thus it is possible that some subsets of the group "seafood" may be separable from meat, while others may not. The primary purpose of our analysis is to determine whether or not seafood remains a separable commodity when more disaggregated groupings are considered.

The study proceeds with an examination of consumer demand for protein products. We do not explicitly analyze Japanese meat import demand (for a study with this focus, refer to Yang and Koo). Since the separability issues pursued below are most appropriately examined in a consumer demand (rather than import demand) framework, the perspective of Japanese consumers is adopted here. We follow the approach of Wessells and Wilen, and of Eales, Durham, and Wessells, in which fish are categorized into several product groups. This perhaps allows for more reasonable comparison of the marginal rates of substitution between meat products and fish products. This application also employs data from the retail level of the market in Japan, whereas previous studies have been conducted based on wholesale-level data (Mues et al.). Consequently, the analysis should more closely reflect consumer-level demand.

The analytical approach of this research differs from previous studies in that separability is investigated using a demand system approach. A generalized system of demand equations is specified and used, first to identify if any of the alternative demand structures nested within the general system are appropriate for these data, and then, conditional on those results, to test separability of meats from fish products following Moschini, Moro, and Green. In the following section, the Generalized Ordinary Differential Demand System (Eales, Durham, and Wessells) is specified, and demand systems nested within it are discussed. Testing of separability is considered as well. The next section provides a discussion of the data on Japanese fish and meat prices and consumption. Results of specification and separability tests are then presented, followed by a final section detailing findings and conclusions.

Separability in a Generalized Ordinary Differential Demand System (GODDS)

Barten developed a synthetic differential demand model which nests some of the most widely used differential demand systems. This system was employed by Lee, Brown, and Seale to examine Taiwanese demands. An alternative parameterization of this model is developed by Eales, Durham, and Wessells in a study of Japanese demand for fish. Their Generalized Ordinary Differential Demand System (GODDS) is specified as:

$$(1) \qquad dw_i = (\beta_i + \theta_1 \bar{w}_i)\,d\ln(Q) + \sum_{k=1}^{N} \left(\gamma_{ik} + \theta_2 \bar{w}_i(\delta_{ik} - \bar{w}_k)\right) d\ln(p_k),$$

where they define the following:

(2)	$d\ln(Q) = \sum_j \bar{w}_j d\ln(q_j)$	(Divisia volume index),
	$w_i = p_i q_i / x$ and $\bar{w}_i = 0.5\left(w_i + \text{lag}(w_i)\right)$	(budget shares),
	β_i	(expenditure coefficients),
	γ_{ik}	(price coefficients),
	θ_1 and θ_2	(nesting parameters),
	δ_{ik}	(Kronecker's delta).

Nested within the GODDS are the Rotterdam demand system and the differential form of the Almost Ideal Demand System (AIDS), as well as two hybrid models—the National Bureau of Research (NBR) and the Central Bureau of Statistics (CBS) models (Barten; Lee, Brown, and Seale; Eales, Durham, and Wessells).[1] The restrictions on the nesting parameters (θ_1 and θ_2) result in the nested models listed in table 2. Note that interpretation of the coefficients of the GODDS model must be done with care. For example, $\hat{\gamma}_{ij}$ will be an Almost Ideal price effect if $\hat{\theta}_2 = 0$. Alternatively, if $\hat{\theta}_2 = 1$, then the

[1] The differential form of the AIDS is distinct from the model of Deaton and Muellbauer which has a different specification of real expenditure.

Table 2. Restrictions on the Generalized Models Which Yield Alternative Functional Forms

	Restrictions	
Model	θ_1	θ_2
AIDS	0	0
Rotterdam	-1	1
CBS	0	1
NBR	-1	0

Note: Notation follows that of equations (1) and (2) in the text.

Rotterdam price effects result. For other values of $\hat{\theta}_2$, the price effect is neither that of the Almost Ideal nor the Rotterdam systems. Neves discusses the relationship between the nested models, but does not nest them within the more general model.

Moschini, Moro, and Green report tests for the structure of preferences in three different demand systems, based on the work of Blackorby, Davidson, and Schworm. The easiest demand system within which to conduct such tests is the Rotterdam system, the system used in Capps et al. In a Rotterdam system, the restrictions used to test for separability (either asymmetric or symmetric) depend only upon coefficients and not on any variables. Thus the results of the test are global. If, however, the Rotterdam system is not consistent with a particular data set, such tests are unavailable. We test whether any of the systems nested within the GODDS are consistent with the data, given the maintained hypothesis that one of the differential forms is appropriate. Conditional on the results of those tests, we employ a demand system which does not significantly reduce the likelihood of the sample to test for separability. Next, we show how to test for separability within the GODDS model. Note that the separability restrictions appropriate for any of the systems nested within the GODDS model may be obtained by imposing the values for the θs given in table 2 on separability restrictions for the GODDS model.

To test whether goods in group A are asymmetrically separable from goods in group B (i.e., are meats separable from fish?), we must determine for $i \in A$ and $k \in B$ if the appropriate off-diagonal element of the Slutsky matrix is proportional to the relevant expenditure derivatives:

$$s_{ik} = \mu_k \frac{\partial q_i}{\partial x} \frac{\partial q_k}{\partial x}, \tag{3}$$

where s_{ik} is the appropriate off-diagonal element of the Slutsky matrix, x is expenditure, and the proportionality coefficient, μ_k, depends on good k being considered, but not on good i in the separable group, A (Deaton and Muellbauer; Moschini, Moro, and Green).

To make this restriction operational, it is recast in elasticity form and the proportionality coefficients are eliminated. Thus, goods $i, j \in A$ are asymmetrically separable from $k \in B$ when

$$\frac{\sigma_{ik}}{\sigma_{jk}} = \frac{e_i}{e_j}, \tag{4}$$

where σ_{ij} is the Allen-Uzawa elasticity of substitution, and e_i is the expenditure elasticity for all goods i (see Moschini, Moro, and Green).

Compensated, cross-price elasticities for the GODDS model are:

$$e_{ik}^{*} = \gamma_{ik}/w_i + (\theta_2 - 1)(\delta_{ik} - w_k), \tag{5}$$

which follows the notation of (1), and δ_{ik} is Kronecker's delta. The implied elasticities of substitution are:

$$\sigma_{ik} = \frac{\gamma_{ik} + (\theta_2 - 1)w_i(\delta_{ik} - w_k)}{w_i w_k}. \tag{6}$$

Expenditure elasticities are:

$$e_i = \beta_i/w_i + \theta_1 + 1. \tag{7}$$

So the restrictions implied by asymmetric separability for the GODDS model (again, for $i, j \in A$, which is asymmetrically separable from $k \in B$) are of the form:

$$\frac{\left(\gamma_{ik} + (\theta_2 - 1)w_i(\delta_{ik} - w_k)\right)(w_j w_k)}{\left(\gamma_{jk} + (\theta_2 - 1)w_j(\delta_{jk} - w_k)\right)(w_i w_k)} = \frac{\left(\beta_i + w_i(\theta_1 + 1)\right)w_j}{\left(\beta_j + w_j(\theta_1 + 1)\right)w_i} \tag{8}$$

or

$$\gamma_{ik} = \frac{\left(\beta_i + w_i(\theta_1 + 1)\right)}{\left(\beta_j + w_j(\theta_1 + 1)\right)}\left(\gamma_{jk} - w_j w_k(\theta_2 - 1)\right) + w_i w_k(\theta_2 - 1). \tag{9}$$

These restrictions must be imposed at some point in the data, such as the mean shares. Consequently, the tests of separability in the GODDS are local (unless the restrictions that result in the Rotterdam model are imposed). In our case, to test whether meats are separable from fish, we number the goods so that 1–3 are fish products, 4 is beef, 5 is pork, and 6 is chicken. The nonredundant restrictions that are necessary and sufficient for the asymmetric separability of meats from fish are as follows:

$$\begin{aligned} &\frac{\sigma_{15}}{\sigma_{14}} = \frac{e_5}{e_4}, \quad \frac{\sigma_{16}}{\sigma_{14}} = \frac{e_6}{e_4}, \quad \frac{\sigma_{25}}{\sigma_{24}} = \frac{e_5}{e_4}, \\ &\frac{\sigma_{26}}{\sigma_{24}} = \frac{e_6}{e_4}, \quad \frac{\sigma_{35}}{\sigma_{34}} = \frac{e_5}{e_4}, \quad \frac{\sigma_{36}}{\sigma_{34}} = \frac{e_6}{e_4}. \end{aligned} \tag{10}$$

That is, there are only three independent coefficients in the off-diagonal block of the Slutsky matrix corresponding to the substitution possibilities between meat and fish, rather than the original nine coefficients.

Symmetric separability implies two additional restrictions:

(11)
$$\frac{\sigma_{24}}{\sigma_{14}} = \frac{e_2}{e_1} \quad \text{and} \quad \frac{\sigma_{34}}{\sigma_{14}} = \frac{e_3}{e_1},$$

which leaves only one price coefficient to describe the nine substitution effects between the fish and meat groups. For example, $\sigma_{26} = \sigma_{24}(e_2/e_1) = \sigma_{14}(e_6/e_4)(e_2/e_1)$, so that all the substitution elasticities can be expressed in terms of σ_{14} and the six expenditure elasticities.

Following the recommendation of Moschini, Moro, and Green, these restrictions are tested by comparing estimates of a model restricted only by homogeneity and symmetry using iterative seemingly unrelated regression (ITSUR) to those produced by estimating the system using the restrictions implied by the separability of meats from fish, given in (10), to eliminate six additional off-diagonal price coefficients in the system. A likelihood-ratio test (corrected for sample size) is asymptotically distributed χ^2 with six degrees of freedom under the null hypothesis.

Data

Meat and seafood price and expenditure data are taken from the *Annual Report on the Family Income and Expenditure Survey* (Japan Management and Coordination Agency) and consist of monthly data averaged over 8,000 randomly selected households throughout Japan. The participating households keep journals of prices paid and expenditures on a large number of food commodities. Households in agriculture, forestry, or fishery occupations, and one-person households are excluded. The published data provide monthly prices, in yen per 100-gram units, quantities (in kilograms), and expenditures for the representative household. Some commodities are quite aggregated. For example, the data reported for beef represent simply a beef category and are not disaggregated into cuts or other products. On the other hand, the report provides a significant amount of detail on seafood products. Monthly price and expenditure data on over 30 specific fish and seafood products are published, including such products as fresh salmon, tuna, yellowtail, lobster, clams, dried horse mackerel, salted salmon, and fish paste (surimi) products.

In a study of Japanese demand for fish, Eales, Durham, and Wessells found that prices and expenditure were endogenous in a system of Japanese fish and seafood demands based on monthly data. Their model incorporated six fish categories and three meat categories. Exploring separability in a nine-good GODDS model, restricted by homogeneity and symmetry and including monthly intercepts, requires estimation of 142 unrestricted coefficients. This approach, combined with anticipated simultaneity and nonlinear estimation required for the planned separability testing, presents a daunting challenge. To make the problem manageable, we aggregated the 23 individual fish products into three broader categories (rather than six as in Eales, Durham, and Wessells), based on their use in Japanese meals, diets, and culture. As will be seen, this had the serendipitous effect of simplifying our analysis even more than anticipated.

The three fish/seafood categories are identified as follows: (*a*) high quality fish (HQF), which includes tuna, sea bream, flatfish, yellowtail, lobster, shrimp, and crab; (*b*) medium quality fish (MQF), which includes horse mackerel, bonito, flounder, salmon, other fresh fish, cuttlefish, squid and octopus, oysters, scallops, and other shellfish; and (*c*) low quality fish (LQF), which includes sardines, mackerel, saury, cod, and short-necked clams.[2] The meat products are highly aggregated and include beef, pork, and chicken. More detailed data on these products are not provided in the *Annual Report on the Family Income and Expenditure Survey*.[3] To be consistent with differential demand models, aggregation was done using Divisia price indices, all of which were scaled to be 1.00 in the first quarter of 1985. Comparable quantities were derived by dividing total expenditure on the category by its price.

Results

The GODDS model (1) is estimated with homogeneity and symmetry imposed by ITSUR. The data used for this estimation were quarterly observations from 1981 through 1995 on Japanese consumption of three fish and three meat products, as identified in the data section above.[4] To account for seasonality, three quarterly dummy variables and a constant are included as intercept shifters in each equation.

The reason for aggregating the data from monthly to quarterly observations relates to the following. Before proceeding with the ITSUR procedure, the right-hand-side variables were tested for endogeneity using a Durbin-Wu-Hausman test. This was motivated by the findings of Eales, Durham, and Wessells who reported that prices and expenditures were endogenous in a system of demands which modeled six fish and three meat products using monthly data. We follow their approach in specifying instruments with which to estimate the GODDS system by iterative 3SLS. The instruments employed are first and fourth lags of all price and expenditure variables, 10 macro variables to capture the state of the Japanese economy, and quarterly dummies.[5] The Durbin-Wu-Hausman test statistic is asymptotically distributed as χ^2 with degrees of freedom equal to the number of unrestricted coefficients associated with potentially endogenous variables under the null of no endogeneity. The resulting statistic is 28.17. The 0.05 cutoff from a χ^2 with 22 degrees of freedom is 33.92. This suggests that on a quarterly basis, if prices and expenditures are endogenous, endogeneity does not produce significant biases.[6]

---

[2] These groupings are based on use of the products in Japanese meal preparation, as discussed in Wessells and Wilen, and in Johnson, Durham, and Wessells.

[3] Unfortunately, this limits our ability to test separability of subgroups of meat products (e.g., higher priced cuts) with subgroups of fish and other seafood (e.g., high quality fish).

[4] Data are available for 1996; however, in 1996, there was an *e. coli* food poisoning outbreak in Japan. During the period of time when the source of the contaminant was unclear, demand for meat and seafood was significantly affected. Hence, the data set is cut off at 1995. Data are available from 1975–79, but were not used because of the transition of the countries of the world to the 200-mile ocean fishing limit. In order to allow for the lags used in the Durbin-Wu-Hausman tests, 1980 is reserved as well.

[5] The Japanese macro variables are as follows: exchange rates in yen per U.S. dollar (spot, middle, and monthly average, each denominated in yen/U.S.$); persons per household (Japan, workers' households); expenditure in yen (Japan, workers' households); disposable income in yen (Japan, workers' households); total population of Japan (beginning of month, 10,000 persons); Consumer Price Index (Japan-general, 1990 average = 100); average monthly cash earnings of regular workers in yen (includes bonuses for construction workers); average monthly cash earnings of regular workers in yen (includes bonuses for wholesale and retail trade workers); prime interest rate in percentages (long-term credit banks); and yields to subscribers of 10-year interest-bearing government bonds, in percentages (Downey).

[6] The effect of endogeneity of expenditures in conditional demand systems is well documented (Attfield; LaFrance). Capps et al. employ the approach of Attfield to deal with the problem. While endogeneity of expenditure is not in dispute, the results of the Durbin-Wu-Hausman test suggest that it does not seriously bias the coefficient estimates (Davidson and MacKinnon, pp. 239–40).

Table 3. Tests of Models Nested Within the GODDS Model

Model	Wald Statistic	Log-Likelihood	Likelihood-Ratio Test	Adjusted Likelihood-Ratio Test [a]
GODDS		1,381.6		
AIDS	3.63	1,379.9	3.53	2.87
CBS	1.34	1,381.0	1.21	0.98
NBR	26.92	1,369.9	23.42	19.05
Rotterdam	27.61	1,370.3	22.64	18.41

Notes: All test statistics are asymptotically distributed χ^2 with two degrees of freedom. The 0.01 cutoff is 9.21; the 0.05 cutoff is 5.99.
[a] Adjusted as suggested by Italianer.

Before proceeding with the estimation, the data were subjected to Varian's nonparametric demand test. We found the Japanese consumption data to be consistent with the Generalized Axiom of Revealed Preference (GARP). Next, using ITSUR, each of the nested demand models is tested against the GODDS. Results are shown in table 3. The Rotterdam and NBR models are rejected when tested against the GODDS using Wald, likelihood-ratio, or adjusted likelihood-ratio tests. *P*-values are effectively zero and would result in rejection of the Rotterdam or NBR models even if a Bonferroni correction were used to account for our sequential testing approach. The AIDS and CBS models are not rejected. Based on these results, separability tests are examined using the CBS model.[7,8]

For the CBS model, there are 40 coefficients in the unrestricted model and 34 coefficients in the model restricted by asymmetric separability of meats from fish. Presentation of coefficients is overwhelming and may not be helpful.[9] Instead, we present summary statistics for each of the equations in our CBS system (table 4). The R^2 statistics suggest that all demand equations fit well. The Durbin-Watson statistics show some sign of negative autocorrelation (overdifferencing). However, the distribution of the Durbin-Watson statistics in multivariate models such as this one is unknown; thus the multivariate misspecification test for independence (McGuirk et al.) is performed. This test yielded a test statistic value of 1.13, which is distributed χ^2 with 25 degrees of freedom asymptotically, showing no evidence of significant autocorrelation.[10] Therefore, autocorrelation corrections are not performed.

[7] The CBS model combines Rotterdam price effects with AIDS expenditure effects. This simplifies the separability restrictions somewhat. The tests remain local, however.

[8] Moschini, Moro, and Green show how to test for separability using an AIDS model. Separability restrictions appropriate for any of the models nested within the GODDS are obtained by imposing the restrictions which yield the nested model on the restrictions given in (9). All subsequent results are virtually identical for the GODDS, AIDS, and CBS models. Those for the CBS model are presented.

[9] They are, however, available from the authors upon request.

[10] McGuirk et al. advocate use of a very complicated finite sample correction due to Rao. Italianer's correction is performed here instead.

Table 4. Summary Statistics from CBS Demands Restricted Only by Homogeneity and Symmetry

Commodities	R^2	Durbin-Watson Statistic
HQF	0.98	2.80
MQF	0.96	2.33
LQF	0.70	2.41
Beef	0.83	2.10
Pork	0.95	2.36
Chicken	0.79	2.49

Next, the separability of the meats and fish is tested. The tests are conducted in the manner suggested by Moschini, Moro, and Green. That is, to test the asymmetric separability of the meats from fish, the restrictions (10) are imposed on the model and it is estimated by nonlinear SUR using the SHAZAM program (White). Since the restrictions involve shares, the test is performed at the sample means of the relevant sample. The resulting log-likelihood function value is compared to a model which only imposes homogeneity and symmetry by using an adjusted likelihood-ratio test suggested by Italianer.[11] To test for symmetric separability, the model is restricted by (10) and (11).

Several hypotheses are of interest. Were meats separable from fish prior to 1990? Do the outcomes of each of the previous tests change as we extend our sample to 1995? These hypotheses were tested and results are shown in table 5. In the third and fourth columns of the table, the sample is restricted to the period 1981–90. Applying Italianer's adjustment, neither asymmetric nor symmetric separability of meats from fish is rejected, supporting the conclusions of Hayes, Wahl, and Williams, and of Capps et al., that during the 1981–90 period, meat and fish can be considered separately. Alternatively, when the sample is extended to 1981–95 (columns five and six in table 5), neither meats nor fish are found to be asymmetically or symmetrically separable from the remaining commodities.[12]

Finally, to address the question of economic significance, we employ the technique of Edgerton to calculate unconditional elasticities from models where separability is imposed over the 1981–95 sample period and from models where separability is not imposed. This requires estimation of demand models for the first-stage allocation of expenditures. Estimates of CBS models for nonfood, nonmeat/seafood, and either a

---

[11] Moschini, Moro, and Green employ this test in a Monte Carlo simulation and find its actual size is quite close to the nominal size. As suggested by a reviewer, separability is tested at every data point. Results are substantially the same as the tests at the means. That is, there is no evidence against separability in the earlier period, while there is strong evidence that fish are not separable from meats in the extended period, and weaker evidence that meats are not separable from fish. Finally, it is possible to test for separability nonparametrically (Varian). The test rejects separability of either group in both the early and extended samples. However, as pointed out by Moschini, Moro, and Green, this is a test of sufficient conditions, and thus will reject separability too often.

[12] What one would like to do is to run the demand system post-1990 to test the separability hypothesis; however, there simply are not enough degrees of freedom to allow this.

Table 5. Separability Test Results

Description	No. of Restrictions	1981–90 Sample Log-Likelihood	1981–90 Sample Adjusted LRT[a]	1981–95 Sample Log-Likelihood	1981–95 Sample Adjusted LRT[a]
CBS-Unrestricted by separability		929.7		1,381.0	
		Asymmetric Weak Separability			
Meats from Fish	6	923.3	9.5	1,373.4	12.6*
Fish from Meats	6	921.8	11.7	1,370.4	17.5*
		Symmetric Weak Separability			
Fish and Meats	8	921.6	12.1	1,370.3	17.8*

Notes: An asterisk (*) denotes significance at the 0.05 level. Cutoffs for four, six, and eight degrees of freedom are 9.5, 12.6, and 15.5, respectively. Cutoffs for a 0.01 significance level are 13.3, 16.8, and 20.1, respectively.

[a] Adjusted LRT is the likelihood-ratio statistic adjusted as suggested by Italianer. It is asymptotically χ^2 with degrees of freedom equal to the number of restrictions. The adjustment factor is $(MT - 0.5(K_u + K_r) - 0.5M(M + 1))/MT$, where M is the number of equations, T is the number of observations, K_u is the number of coefficients in the unrestricted model, and K_r is the number of coefficients in the restricted model (Italianer). For the smaller sample the adjustment is about 0.74, and for the larger sample the adjustment is about 0.83.

Table 6. Unconditional Own-Price and Expenditure Elasticities

Commodities	Own-Price Elasticities Non-Separable	Own-Price Elasticities Separable	Own-Price Elasticities % Change	Expenditure Elasticities Non-Separable	Expenditure Elasticities Separable	Expenditure Elasticities % Change
HQF	-0.818	-0.723	-11.6	0.455	0.370	-18.5
MQF	-0.746	-1.000	34.1	0.893	0.727	-18.6
LQF	-0.977	-0.954	-2.4	-0.006	0.010	-253.0
Beef	-0.516	-0.166	-67.9	0.478	0.222	-53.7
Pork	-0.350	-0.217	-38.1	0.488	0.270	-44.6
Chicken	-0.485	-0.395	-18.5	0.691	0.405	-41.4

meat-seafood aggregate or separate meat and seafood aggregates are used for the calculation of the unconditional elasticities in the nonseparable and separable cases, respectively. Own-price and expenditure elasticities are given in table 6. Elasticities from the nonseparable models are more elastic in 10 of the 12 cases. The meats seem to be the most affected by the separability assumption. For example, beef's own-price elasticity drops from -0.516 to -0.166 when separability of meats from fish is imposed, and beef's expenditure elasticity drops from 0.478 to 0.222. Certainly, for any analysis of an increase in the tariff on imported beef, these two sets of estimates would lead to conclusions of differing magnitudes, if not actual reversals.

Summary and Conclusions

Demand for seafood and meat in Japan is examined employing a Generalized Ordinary Differential Demand System (GODDS). The AIDS and CBS models, which are nested within the GODDS model, are found to be consistent with the data. Thus, the CBS model is employed to test the separability of meats from fish, and individual products from other meats and fish, during the period 1981–90, and then over the longer period 1981–95.

Separability tests show that prior to 1990, meats are separable from fish (and vice versa), supporting previous research results. Tests conducted using the entire time period (1981–95) reversed these findings with respect to meats and fish as groups. It is possible that our findings are explained by the disaggregation of fish from one commodity to three groups of commodities, as well as by an extension of the time period studied, and that the time intervals were quarterly rather than annual (as in Capps et al., and in Hayes, Wahl, and Williams). Although further disaggregation of fish products would be preferable, it would make the problem addressed here significantly more cumbersome and complicated. Further disaggregation of the meat products is also desirable, such that high-valued meat products could be compared to high-valued fish and other meat products. However, the data limited our ability to conduct these tests.

It is useful to compare and contrast the elasticity estimates that result from this study with those from Capps et al., and from Hayes, Wahl, and Williams. Taking first the Marshallian own-price elasticities, the conditional elasticity for beef reported by Capps et al. is -1.01, while Hayes, Wahl, and Williams report conditional elasticities for Wagyu beef and non-Wagyu beef of -1.89 and -0.46, respectively. These findings contrast with our unconditional, nonseparable elasticity of -0.52; thus we find that removing the impact of separability and conditioning produces a beef demand which is less elastic than in the other two studies. This is true for pork as well. Compared to -0.35 in this study, the pork price elasticity shown by Capps et al. is -0.90, with Hayes, Wahl, and Williams showing -0.76. The price elasticities for chicken compare more favorably across the three studies, at -0.45 in Capps et al., -0.59 in Hayes, Wahl, and Williams, and -0.48 in our study.

Consistent with the theoretical concept of separable utility functions, these differences in the results during the 1981–90 period versus the extended 1981–95 period indicate there has been a structural change in Japanese households' preferences related to meat and fish. As researchers undertake analyses of the consumer demand for protein in Japan, consideration must be given to analyzing meats and fish as a group, rather than focusing specifically on only meats versus only fish.

While a Western bias toward meat consumption is common in published research, our findings suggest that this bias should not be applied to the Japanese market. Researchers investigating the Japanese markets for meats would be well served by paying close attention to events shaping the fish markets in Japan. Such events include increased stress on wild stocks of popular fish in the Japanese market, which results in increased prices of some species and may actually improve their appeal as luxury items. In addition, increasing world production of aquacultured products is driving down the prices of some seafood products that may have been considered luxury products in the past. These factors are all converging to make the Japanese market for animal proteins much more dynamic and rapidly changing than in the past. Further research using data which are more disaggregated in meat products would certainly be useful. The primary data source used for our study (Japan's *Annual Report on the Family Income and Expenditure Survey*) did not permit such an approach. Perhaps as beef, pork, and chicken approach the status of fish in Japanese household consumption, more comprehensive price and expenditure data for these meats will be included in the *Annual Report*, similar to the current detailed data provided for fish and other seafood.

[*Received August 1998; final revision received February 1999.*]

References

Attfield, C. L. F. "Homogeneity and Endogeneity in Systems of Demand Equations." *J. Econometrics* 27(1985):197–209.

Barten, A. P. "Consumer Allocation Models: Choice of Functional Form." *Empirical Econ.* 18(1993): 129–58.

Blackorby, C., R. Davidson, and W. Schworm. "Implicit Separability: Characterization and Implications for Consumer Demands." *J. Econ. Theory* 55(December 1991):364–99.

Capps, O., Jr., R. Tsai, R. Kirby, and G. W. Williams. "A Comparison of Demands for Meat Products in the Pacific Rim Region." *J. Agr. and Resour. Econ.* 19,1(1994):210–24.

Davidson, R., and J. G. MacKinnon. *Estimation and Inference in Econometrics.* New York: Oxford University Press, 1993.

Deaton, A., and J. Muellbauer. *Economics and Consumer Behavior.* London: Cambridge University Press, 1980.

Downey, R. A. "Japanese Macro-Economic Data in BCI Format." Sophia University, Tokyo, Japan. Online. Available at: http://econom10.cc.sophia.ac.jp/needs/index.htm. Retrieved 1998.

Eales, J., C. Durham, and C. Wessells. "Generalized Models of Japanese Demand for Fish." *Amer. J. Agr. Econ.* 79(November 1997):1153–63.

Edgerton, D. L. "Weak Separability and the Estimation of Elasticities in Multistage Demand Systems." *Amer. J. Agr. Econ.* 79(February 1997):62–79.

Hayes, D. J., T. I. Wahl, and G. W. Williams. "Testing Restrictions on a Model of Japanese Meat Demand." *Amer. J. Agr. Econ.* 72(August 1990):556–66.

Italianer, A. "A Small-Sample Correction for the Likelihood Ratio Test." *Econ. Letters* 19(1985):315–17.

Japan Management and Coordination Agency, Statistics Bureau. *Annual Report on the Family Income and Expenditure Survey.* Tokyo, Japan. Various years, 1980–95.

Johnson, A. J., C. A. Durham, and C. R. Wessells. "Seasonality in Japanese Household Demand for Meat and Seafood." *Agribus.: An Internat. J.* 14(1998):337–51.

LaFrance, J. T. "When Is Expenditure 'Exogenous' in Separable Demand Models?" *West. J. Agr. Econ.* 16,1(1991):49–62.

Lee, J. Y., M. G. Brown, and J. L. Seale, Jr. "Model Choice in Consumer Analysis: Taiwan, 1970–1989." *Amer. J. Agr. Econ.* 76(August 1994):504–12.

McGuirk, A., P. Driscoll, J. Alwang, and H. Huang. "System Misspecification Testing and Structural Change in the Demand for Meats." *J. Agr. and Resour. Econ.* 20,1(1995):1–21.

Meat Export Research Center. *U.S. Meat Export Analysis and Trade News* 5,5(May 1997). MERC, Iowa State University, Ames.

Moschini, G., D. Moro, and R. D. Green. "Maintaining and Testing Separability in Demand Systems." *Amer. J. Agr. Econ.* 76(February 1994):61–73.

Mues, C., D. Harris, R. Horton, and N. Baskerville. "Substitution Relationships Between Beef and Other Meats in Japan." Tech. Paper No. 91.6, Australian Bureau of Agricultural and Resource Economics, Canberra, Australia, 1991.

Neves, P. D. "A Class of Differential Demand Systems." *Econ. Letters* 44(1994):83–86.

Putnam, J. J., and J. E. Allshouse. "Food Consumption, Prices, and Expenditures, 1970–95." Statis. Bull. No. 939, USDA/Economic Research Service, Food and Consumer Economics Div., Washington DC, 1997.

Rao, C. R. "An Asymptotic Expansion of the Distribution of Wilks' Criterion." *Bull. Internat. Statistical Institute* 33(1951):177–80.

U.S. Department of Agriculture, Economic Research Service. "Production, Supply, and Distribution (PS&D) Database" [electronic database]. Stock No. 93002, USDA/ERS, Washington DC, November 1997. Online. Available at: http://usda.mannlib.cornell.edu.

Varian, H. R. "The Nonparametric Approach to Demand Analysis." *Econometrica* 50(July 1984):945–73.

Wessells, C., and J. Wilen. "Seasonal Patterns and Regional Preferences in Japanese Household Demand for Seafood." *Can. J. Agr. Econ.* 42(March 1994):87–103.

White, K. J. "A General Computer Program for Econometric Models—SHAZAM." *Econometrica* 46(January 1978):239–40.

Yang, S.-R., and W. W. Koo. "Japanese Meat Import Demand Estimation with the Source Differentiated AIDS Model." *J. Agr. and Resour. Econ.* 19,2(1994):396–408.