Generalized Models of Japanese Demand for Fish

James Eales, Catherine Durham, and Cathy R. Wessells

Given a relative lack of knowledge about Japanese consumer preferences for fish, Japanese fish demand is modeled using both Marshallian (ordinary) and inverse demand systems, each of which nests a number of competing specifications. Results indicate that the inverse demand systems dominate the ordinary demand systems in forecasting performance and in nonnested tests. The inverse system suggests that Japanese fish prices are less responsive to changes in consumption than found in previous studies.

Key words: almost ideal demand system, differential demand systems, inverse demand, ordinary demand, Rotterdam.

Western researchers' interest in Japanese demand for meat and fish has been primarily motivated by interest in exporting meat to that market. This interest was enhanced by the last Beef Market Access Agreement in 1988, which significantly increased U.S. beef exporters' ability to compete in the Japanese market. From 1990 to 1994, the value of U.S. exports of beef, pork, and poultry to Japan totaled $8.7 billion (Foreign Agricultural Trade of the United States). However, in 1994 alone, Japanese imports of fisheries products were valued at $16.8 billion, of which the United States captured a 15.2% share, or $2.5 billion, the largest single supplier to Japan by value (Marine Products Importers Association). From 1990 to 1994, Japanese imports of fisheries products from the United States totaled $12 billion. This exceeded the combined value of U.S. exports of beef, pork, and poultry over the same period by $3.3 billion.

This study of Japanese demand for fish is motivated by the above statistics, combined with the fact that Japanese households spent 13.3% of their average monthly food budget on fish and seafood products in 1994, compared to 9% on meat (Management and Coordination Agency). Given the importance of fisheries products in the Japanese diet, it is not surprising that we are not the first to model Japanese consumers' demand for fish. Wessells and Wilen estimate Japanese household demand for twelve fish commodities, including seasonal and regional effects, in an almost ideal demand system (AIDS) model. Other studies have focused on Japanese wholesale- or import-level demand for meat, typically using fish as an aggregated substitute (Wahl, Hayes, and Williams). The commonality among the above mentioned studies is the assumption that the specifications of demand are price driven, or ordinary (Marshallian), demand functions. Given the relative lack of knowledge about Japanese consumer preferences for fish, the primary issue of interest in this paper is to test the specification of such demands. Specifically, we test whether demand for fish in Japan is best characterized by ordinary or inverse demand, in addition to the best functional form (Rotterdam versus AIDS). The issue of best functional form is addressed within generalized specifications of systems of inverse and ordinary demands (Barten 1993; Brown, Lee, and Seale). The advantage of the generalized specifications is that they nest either a number of ordinary or inverse demand systems. The contribution of this effort

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will be to parameterize both ordinary and inverse systems such that comparisons between systems can be made.

The intent is to model Japanese demand for six fish products using monthly per capita time series data from January 1980 through December 1994. With what may be characterized as high-frequency time-series data when modeling consumer demand, it is possible that quantities consumed are predetermined; i.e., quantities available in the market for each of our fish products within a month may be predetermined by fisheries biology, fisheries regulations, import availability, etc. Certainly, if the product is fresh fish, the quantity available in any month must be consumed, and so price must adjust. This led to the formulation of a system of inverse demands.[1] However, many of the categories included are processed fish (therefore storable), as well as storable frozen fish, which is simply thawed and sold as "fresh" fish. Given is this storability component, ordinary demands for fish are also specified, and the two specifications are tested against one another.

Renewed interest in the specification of differential ordinary demand systems of the Rotterdam family has been kindled by Barten (1993). He shows that the Rotterdam (Barten 1964, Theil 1965), the differential AIDS, and two hybrid demand systems (CBS and NBR) can be nested within a synthetic or generalized ordinary demand system.[2] Lee, Brown, and Seale use Barten's generalized ordinary system of demands to examine consumer demand in Taiwan. Brown, Lee, and Seale develop the generalized inverse demand system, which nests the inverse analogs of all of the models nested within the generalized ordinary demand system, and apply it to fresh orange demand in the United States. In each of these cases, the authors parameterize the generalized models with Rotterdam dependent variables, share-weighted, log-differentials of quantities, or normalized prices. This makes comparison between ordinary and inverse systems difficult. Both of these generalized models are applied to monthly demand for fish in Japan. What is shown is that comparison between the generalized ordinary and inverse demands can be greatly eased by simple reparameterizations of both models.

Since they are less familiar to readers, the next section is devoted to a review and extension of inverse differential demands. This is followed by the development of parameterizations of the generalized inverse and ordinary differential demand models. Next, both the ordinary and inverse versions of the generalized differential demand models are applied to the monthly demand for fish in Japan. Finally, results are summarized and conclusions drawn.

Differential Inverse Demands

A number of studies have examined the plausibility of theoretically consistent inverse demand systems, e.g., Barten and Bettendorf, Moschini and Vissa (1992), Eales and Unnevehr (1993, 1994), and Brown, Lee, and Seale. In fact, Barten and Bettendorf develop differential inverse demands for application to monthly demand for fish in Belgium. Specifically, they develop inverses of the Rotterdam, Central Bureau of Statistics (CBS; Keller and van Driel, Laitinen and Theil), and differential AIDS models and go into great detail developing interpretations of the coefficients. Just as the ordinary CBS demand model is a hybrid of the ordinary Rotterdam and AIDS models, the inverse CBS (originally developed by Laitinen and Theil) is a combination of inverse Rotterdam quantity effects with inverse AIDS scale effects. The National Bureau of Research demand model (NBR; Neves) is also a hybrid. It has an inverse analog, the inverse NBR, which combines inverse AIDS quantity effects with an inverse Rotterdam scale effect.

The inverse models are

(1)
$$w_i d\ln\pi_i = \alpha_i d\ln Q + \sum_j \alpha_{ij} d\ln q_j \quad \text{(inverse Rotterdam)}$$

$$w_i d\ln(p_i/P) = \beta_i d\ln Q + \sum_j \alpha_{ij} d\ln q_j \quad \text{(inverse CBS)}$$

$$dw_i = \beta_i d\ln Q + \sum_j \beta_{ij} d\ln q_j \quad \text{(inverse AIDS)}$$

$$dw_i - w_i d\ln Q = \alpha_i d\ln Q + \sum_j \beta_{ij} d\ln q_j \quad \text{(inverse NBR)}$$

[1] This approach is not unprecedented, as Barten and Bettendorf estimate inverse Rotterdam models for eight fish species in the ex-vessel market in Belgium.

[2] Some care is required here. The differential AIDS model is developed by transforming the Rotterdam and is thus a direct approximation to unknown demand functions. This is theoretically distinct from the AIDS model of Deaton and Muellbauer, although the practical differences are often small (Alston and Chalfant). In what follows, references to AIDS models will be to the differential variety.

Table 1. Price and Scale Flexibilities

	Rotterdam	AIDS
Compensated price flexibility	$f_{ij}^* = \alpha_{ij}/w_i$	$f_{ij}^* = (\beta_{ij} - w_i\delta_{ij} + w_iw_j)/w_i$
Scale flexibility	$f_i = \alpha_i/w_i$	$f_i = \beta_i/w_i - 1$
Uncompensated price flexibility	$f_{ij} = (\alpha_{ij} + \alpha_iw_j)/w_i$	$f_{ij} = (\beta_{ij} + w_j\beta_i)/w_i - \delta_{ij}$

Note: Notation follows equation (1) in the text. Flexibilities for the inverse CBS are calculated by combining the inverse Rotterdam compensated price flexibilities and the inverse AIDS scale flexibilities using the Antonelli equation. For the inverse NBR, inverse AIDS compensated price flexibilities are combined with inverse Rotterdam scale flexibilities.

where p_i and q_i are the price and quantity of good i, respectively, y is total expenditure, and

$$(2)\quad d\ln Q = \sum_j w_j d\ln q_j \quad \text{(Divisia volume index)}$$

$$d\ln P = \sum_j w_j d\ln p_j \quad \text{(Divisia price index)}$$

$$w_i = p_iq_i/y \quad \text{(budget shares)}$$

$$\pi_i = p_i/y \quad \text{(normalized prices)}$$

$$\alpha_i = \beta_i - w_i \quad \text{(coefficients of the scale effect)}$$

$$\alpha_{ij} = \beta_{ij} - w_i\delta_{ij} + w_iw_j \quad \text{(Antonelli effects)}$$

and δ_{ij} is the Kronecker delta.

The relationship among the four models given in (1) can be seen in (2). The scale and Antonelli effects coefficients are assumed constant for the inverse Rotterdam model, while they depend on budget shares for the inverse almost ideal model. As indicated, the inverse CBS and NBR models combine the effects of the inverse Rotterdam and inverse almost ideal.

When dealing with these models, one is often interested in flexibilities (or elasticities from ordinary demand systems). The safest way to proceed with any of them is to begin with compensated price and scale flexibilities (or compensated price and expenditure elasticities for ordinary demands). If uncompensated price flexibilities are desired, they may be obtained using the Antonelli analog of the Slutsky equation in flexibility form, $f_{ij}^* = f_{ij} - w_jf_i$, where f_{ij}^* is the compensated price flexibility, f_{ij} is the uncompensated price flexibility, and f_i is the scale flexibility (Anderson). The formulas for calculation of flexibilities for inverse Rotterdam and inverse AIDS models are given in table 1.

Generalized Demand Models

Barten (1993) shows that the Rotterdam (Barten 1964, Theil 1965), the differential AIDS, and two hybrid demand systems (CBS and NBR) can be nested within a generalized ordinary demand system. Brown, Lee, and Seale develop a generalized inverse demand system. Naturally, all these authors have worked extensively with Rotterdam demand systems and so they parameterize these demands with Rotterdam dependent variables. This is inconvenient for the current application since one of the goals is to compare results from ordinary and inverse demand systems. However, both the generalized ordinary and inverse demand systems can be reparameterized to have AIDS dependent variables, which makes such comparisons possible.

To illustrate this transformation, consider the following generalized inverse demands of Brown, Lee, and Seale (with suitable changes in notation for consistency's sake):

$$(3)\quad w_id\ln\pi_i = (\eta_i - \psi_1w_i)d\ln Q + \sum_{j=1}^{N}(\eta_{ij} - \psi_2w_i(\delta_{ij} - w_j))d\ln q_j$$

where ψ_1 and ψ_2 are nesting parameters that yield the four inverse demand systems discussed above for certain values, η's are other parameters of the generalized inverse demands, and the variables are as previously defined. If both nesting parameters in (3) are equal to one, the associated terms transform the dependent variables of the generalized model from those of the inverse Rotterdam to those of the inverse AIDS model. The conversion from a model expressed with Rotterdam dependent variables to one with AIDS dependent variables, in the generalized inverse model, is accomplished (and its implications for demand restrictions are derived) using (see Theil 1971, p. 329; Barten 1993, p. 135)

$$(4)\quad dw_i = w_i(d\ln p_i + d\ln q_i - d\ln P - d\ln Q)$$

or

$$dw_i = w_i(d\ln\pi_i + d\ln q_i).$$

To make the conversion more transparent, we rewrite (4) by adding and subtracting d ln Q on the right-hand side of (4) and note that $d \ln q_i - d \ln Q = \Sigma_{j=1}^{n} w_i(\delta_{ij} - w_j)d \ln q_j$. Then (4) becomes

$$(5)\quad dw_i = w_i(d\ln\pi_i + d\ln Q + d\ln q_i - d\ln Q) = w_i\, d\ln\pi_i + w_i d\ln Q + \sum_{j=1}^{n} w_i(\delta_{ij} - w_j)d\ln q_j$$

expressing the AIDS dependent variable as a function of the Rotterdam dependent variable. The generalized inverse demands can then be reparameterized with inverse AIDS dependent variables using (5)

$$(6)\quad dw_i = (\phi_i + \theta_1^I w_i)d\ln Q + \sum_{j=1}^{N} (\phi_{ij} + \theta_2^I w_i(\delta_{ij} - w_j))d\ln q_j$$

where the ϕ's are coefficients and θ_1^I and θ_2^I are nesting parameters for the inverse system. The inverse Rotterdam results if the nesting parameters are both equal to one. To see that this is true, set both θ^I's in (6) to one. Then subtract the terms associated with the θ^I's from both sides of the equation. According to (5), the resulting dependent variables are those of the inverse Rotterdam.

The generalized ordinary demand with AIDS dependent variables is

$$(7)\quad dw_i = (\sigma_i + \theta_1^O w_i)d\ln Q + \sum_{j=1}^{N} (\sigma_{ij} + \theta_2^O w_i(\delta_{ij} - w_j))d\ln p_j$$

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

	Restrictions	
Model	θ_1	θ_2
Inverse AIDS	0	0
Inverse Rotterdam	1	1
Inverse CBS	0	1
Inverse NBR	1	0
AIDS	0	0
Rotterdam	−1	1
CBS	0	1
NBR	−1	0

Note: Notation follows that of equations (6) and (7) in the text. The θ^I's correspond to θ^I's for the inverse generalized model and θ^O's for the ordinary generalized model.

where σ's are coefficients and θ_1^O and θ_2^O are nesting parameters for the ordinary system (Barten 1993). The Rotterdam dependent variables will result when $\theta_1^O = -1$ and $\theta_2^O = 1$. The only difference between our generalized demand models and those of Barten or Brown, Lee, and Seale is that the restrictions that give the nested models have changed to suit our choice of dependent variables.

The models, as given by (6) and (7), constitute generalized systems of inverse and ordinary demands, respectively, which may be used to test for each of the nested alternative models or as demand systems in their own right. The advantage of this parameterization is that it simplifies comparing of inverse and ordinary models.

Restrictions that give the models nested within the generalized models [(6) and (7)] are given in table 2. Typical demand restrictions for the generalized inverse demands are

$$(8)\quad \sum_i \phi_{ij} + \theta_2^I\left(\sum_i w_i\delta_{ij} - w_j \sum_i w_i\right) = 0 \quad \text{or}$$

$$\sum_i \phi_{ij} = 0 \quad \text{and}$$

$$\sum_i (\phi_i + \theta_1^I w_i) = 0 \quad \text{or}$$

$$\sum_i \phi_i = -\theta_1^I \quad \text{(adding up)}$$

$$\sum_j \phi_{ij} + \theta_2^I\left(\sum_j w_i\delta_{ij} - w_i \sum_j w_j\right) = 0 \quad \text{or}$$

$$\sum_j \phi_{ij} = 0 \qquad \text{(homogeneity)}$$

$$\phi_{ij} = \phi_{ji} \qquad \text{(symmetry)}$$

Table 3. Elasticities and Flexibilities for the Generalized Demand Models

	Ordinary	Inverse
Compensated price elasticity/flexibility	$e_{ij}^* = \sigma_{ij}/w_i + (\theta_2^o - 1)(\delta_{ij} - w_j)$	$f_{ij}^* = \phi_{ij}/w_i + (\theta_2^I - 1)(\delta_{ij} - w_j)$
Income elasticity scale flexibility	$e_i = \sigma_i/w_i + \theta_1^o + 1$	$f_i = \phi_i/w_i + \theta_1^I - 1$
Uncompensated price elasticity/flexibility	$e_{ij} = (\sigma_{ij} - \sigma_i w_j)/w_i + (\theta_2^o - 1)\delta_{ij} - (\theta_1^o + \theta_2^o)w_j$	$f_{ij} = (\phi_{ij} + \phi_i w_j)/w_i + (\theta_2^I - 1)\delta_{ij} + (\theta_1^I - \theta_2^I)w_j$

Note: Notation follows that of equations (6) and (7) in the text.

and that the Antonelli matrix be negative semidefinite. Those for the generalized ordinary demands are

$$(9)\quad \sum_i \sigma_{ij} = 0$$

$$\sum_i \sigma_i = -\theta_1^o \quad \text{(adding up)}$$

$$\sum_j \sigma_{ij} = 0 \quad \text{(homogeneity)}$$

$$\sigma_{ij} = \sigma_{ji} \quad \text{(symmetry)}$$

and negative semidefiniteness of the Slutsky matrix. Finally, in table 3, formulas for elasticities and flexiblities for the generalized models are given.

Monthly Japanese Demand for Fish

Data were gathered from *Annual Report on the Family Income and Expenditure Survey* (Management and Coordination Agency). The data set consists of monthly data averaged over 8,000 households throughout the country. These households keep journals of prices paid and expenditures on a large number of fish products and other food commodities. To make the problem manageable, twenty-three of the fish products were collected and aggregated into six categories based on their use in Japanese meals, diets, and culture. The categories are high-value fresh fish (HFF; includes tuna, sea bream, flatfish, and yellowtail); medium-value fresh fish (MFF; includes horse mackerel, bonito, flounder, salmon, other fresh fish); low-value fresh fish (LFF; includes sardines, mackerel, saury, and cod); lobster, shrimp, and crab (LSC); cuttlefish, squid, and octopus (CSO); and shellfish (SF; includes short-necked clams, oysters, scallops, and other shellfish).[3] To be consistent with differential demand models, aggregation was done using Divisia price indexes, all of which were scaled to be 1.00 in January of 1985. Comparable quantities were derived by dividing total expenditure on the category by its price.

Seasonality is impressive in Japanese fish consumption, driven by two demand factors. First, the Japanese receive large bonuses in December, which averaged 4% per capita over the period covered by our data. Second, there are two gift-giving seasons in Japan, one in July and a very important one in December. This leads to December peaks in both prices and quantities for some highly valued fish products. Approaches to accounting for seasonality's effects included using twelfth differences (instead of first) with a correction for first-order autocorrelation (AR1) in the errors and no seasonal dummy variables, allowing for monthly shifts in the differential demands, and substituting quarterly for monthly dummy variables. None of these had any substantial effect on the results, so results with the monthly shifts are presented because they are the most intuitive.

Both generalized demand models are estimated using data from January 1980 through December 1992. Thus, two years of data are reserved for model forecasting performance evaluation. Models were estimated with homogeneity and symmetry imposed and subsequently satisfied negativity at the mean shares. Seemingly unrelated regressions (SUR) estimates were calculated with the Shazam program (White) first with shellfish products dropped to avoid singularity of the error covariance matrix and then again with the cuttlefish, squid, and octopus category dropped. This was done both as a check of the calculations and as an easy way to generate standard errors for the omitted equation.

Evaluation of Preliminary Model Estimates

Our ultimate goal is the direct comparison of the two generalized demand systems, which

[3] Scallops are not reported from 1980–86.

Table 4. Elasticities and Flexibilities from Generalized Demands

Commodity	Flexibility/ Elasticity	Inverse	Ordinary	Mean Share
HFF	Own-price	−0.46	−0.99	0.24
		(0.03)	(0.09)	
	Scale-income	−1.02	0.70	
		(0.04)	(0.08)	
MFF	Own-price	−0.52	−1.18	0.33
		(0.02)	(0.09)	
	Scale-income	−1.05	0.90	
		(0.04)	(0.09)	
LFF	Own-price	−0.15	−0.67	0.07
		(0.03)	(0.19)	
	Scale-income	−1.07	2.04	
		(0.14)	(0.35)	
LSC	Own-price	−0.20	−0.85	0.14
		(0.03)	(0.14)	
	Scale-income	−0.92	1.08	
		(0.06)	(0.14)	
CSO	Own-price	−0.43	−1.09	0.09
		(0.03)	(0.09)	
	Scale-income	−1.02	1.00	
		(0.06)	(0.11)	
SF	Own-price	−0.36	−0.92	0.13
		(0.03)	(0.09)	
	Scale-income	−0.78	1.25	
		(0.08)	(0.13)	

Note: Calculated at sample mean shares using formulas in table 3. Estimates based on data from January 1980 through December 1992. Standard errors calculated by the delta method assuming mean shares are fixed. Commodities are high-value fresh fish (HFF); medium-value fresh fish (MFF); low-value fresh fish (LFF); lobster, shrimp, and crab (LSC); cuttlefish, squid, and octopus (CSO); and shellfish (SF). Own-price flexibilities/elasticities are uncompensated.

motivated our reparameterization of these models. Before we attempt this, we first present some preliminary estimated model comparisons for the generalized inverse and ordinary demands. Part of this preliminary analysis will examine the forecasting ability of the generalized demands, so we limit ourselves to the period from January 1980 through December 1992. This preserves the last two years for out-of-sample forecasts.

Both models are estimated with iterated SUR with homogeneity and symmetry imposed. While interpretations of coefficients in these models have been developed (e.g., Barten 1993, Barten and Bettendorf), they are not particularly useful. Therefore, own-price elasticities/flexibilities and expenditure elasticities/scale flexibilities (computed at mean shares) are given in table 4. The models portray the sensitivity of Japanese fish demand in an entirely different light. The inverse demands are own-price inflexible, while ordinary demands are nearly unitary own-price elastic. There is more agreement of the scale versus expenditure effects. As Thurman and Park have shown, there is actually less reason to expect agreement between expenditure and scale effects. Whatever the case, it clearly matters which model is chosen to represent demand in these markets.

Next, we compare flexibility/elasticity results with two other monthly demand studies for fish. These are the studies by Barten and Bettendorf and Wessells and Wilen. The two approaches we employ, generalized inverse and ordinary demands, produce differing pictures of demands' sensitivities. The inverse models are own-price inflexible. The ordinary models are own-price elastic. Are such findings an aberration? To compare results to others in a very gross sense, own-price elasticities/flexibilities and scale flexibilities/expenditure elasticities from the two previous studies, as well as this one, were combined as a simple average. If compensated or uncompensated values were not given, they were calculated at mean shares using the Antonelli or Slutsky relationship. The results of these calculations are given in table 5.

Results in table 5 must be interpreted with care. The comparison with Wessells and Wilen is the most directly applicable because the data set used in their paper and in this paper are

Table 5. Comparison of Results with Previous Studies of Fish Demand

	Compensated Own-Price[a]	Uncompensated Own-Price	Expenditure/ Scale	Number of Commodities[b]
Barten and Bettendorf	−0.18	−0.31[c]	−0.99	8
Generalized inverse	−0.19	−0.35	−0.98	6
Generalized Ordinary	−0.78	−0.95	1.16	6
Wessells and Wilen	−0.93[c]	−1.02	1.21	12

[a] Simple averages of presented values. Either own-price elasticities or own-price flexibilities are given as appropriate to the model.
[b] Number of demands modeled in the study.
[c] These items were not given in the original papers but were calculated from the Slutsky/Antonelli relationships at mean shares.

Table 6. Comparison of Generalized Models' Out-of-Sample Forecast

Commodity	Theil's U-Statistics		RMSE Ratio (Ordinary/ Inverse)
	Inverse	Ordinary	
HFF	0.27	0.51	1.82
MFF	0.10	0.16	1.67
LFF	0.14	0.30	2.24
LSC	0.08	0.13	1.74
CSO	0.34	0.58	1.69
SF	0.16	0.18	1.08

Note: Forecasts from models estimated with data up through December 1992, then forecast through December 1994. Commodities are high-value fresh fish (HFF); medium-value fresh fish (MFF); low-value fresh fish (LFF); lobster, shrimp, and crab (LSC); cuttlefish, squid, and octopus (CSO); and shellfish (SF).

from the same source and characterize the same market level. The comparison with Barten and Bettendorf compares our retail-level flexibilities with their ex-vessel level flexibilities for different fish species. These statistics are presented only to show that, while results from the generalized inverse and ordinary demands stand in stark contrast with each other, they are in basic agreement with those of other studies of monthly fish demand.

As a final preliminary comparison of the general demands, data on the final twenty-four months were employed to assess out-of-sample forecasting performance of the two generalized demand models. Each model was used to forecast from January 1993 through December 1994 without updating. Results are in table 6. Both models performed reasonably well. Among other things, Theil's U-statistics and ratios of ordinary to inverse demands' root-mean-square forecast errors are given. U-statistics show that both models out perform naive (no change) forecasts by factors ranging from 2.7 to 12.5 for the inverse demands and from 1.5 to 6.2 for the ordinary demands. The generalized inverse demand model out performed the generalized ordinary model in every case, in terms of the root-mean-square prediction error, by factors ranging from 1.08 for shellfish up to 2.24 for low-valued fresh fish. The forecasting performance of the generalized ordinary model is worse than that of the generalized inverse model using these measures.

Direct Comparison of the Generalized Demands

Direct comparison of the two generalized demand systems is an issue that is not so easily resolved. Which is appropriate for Japanese fish demand, the inverse or the ordinary demand system? Since the reparameterization of the generalized demand systems has identical dependent variables, this allows us to test them against one another using a modification of the nonnested testing techniques (Davidson and MacKinnon 1983). The intuition behind Davidson and MacKinnon's *p*-test for SUR systems is to determine whether the difference in predictions from the competing models have explanatory power in an appropriately specified regression, where the null model's residuals serve as dependent variables. Suppose, for a moment, that the generalized inverse model is the null and that it is correct. This implies that prices are endogenous. Thus, the predictions from the alternative model are linear combinations of endogenous variables, which must be correlated with the errors, and one would expect the alternative model's predictions to have explanatory power even when the null model is correct. Thus, Davidson and MacKinnon's *p*-test requires modification to account for endogeneity of the alternative model's right-hand-side variables. To overcome this, we specify instrument sets for each demand system.

The instruments are first-order lags—the first-order lag in first differences of logarithms of all potentially endogenous right-hand-side (RHS) variables (prices and expenditures in the ordinary demands and quantities and scale in the inverse demands); twelfth-order lags—the twelfth-order lag of all potentially endogenous RHS variables; and macroeconomic variables—eleven variables that are meant to characterize the overall Japanese economy. The macroeconomic variables include 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); CPI (Japan-general; 1990 average = 100); cumulated diffusion indexes-leading indicator, with March 1953 = 0; 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 ten-year interest bearing government bonds, in percentages (Downey). These

Table 7. Nonnested Tests of the General Demand Models and Their Sensitivity to Instrument Choice

Instruments Included in the Instrument Set[a]		First Lags, Twelfth Lags, and Macro Variables	First Lags and Twelfth Lags	First Lags and Macro Variables	Twelfth Lags and Macro Variables
Null versus alternative models	Ordinary versus inverse	−0.337[b]	−0.348[b]	−0.309[b]	−0.320[b]
		(0.005)	(0.005)	(0.005)	(0.005)
	Inverse versus ordinary	0.295	0.303	1.893[b]	0.244
		(0.227)	(0.173)	(0.143)	(0.201)

Note: Entries in the table are coefficients and standard errors for nonnested tests. Their ratios are asymptotically standard normal given the null model.
[a] The instruments are defined in the text.
[b] Ratio of the coefficient to its standard error exceeds two in absolute value.

choices are motivated by data availability and a priori reasoning. For monthly data, such as ours, inclusion of first- and twelfth-order lags of RHS variables seems natural. Including the macroeconomic variables to characterize the health of the overall economy also seems natural. Both expenditures and income are included because they differ dramatically in Japan, two wage rates are included to capture labor costs, and two interest rates are used since the prime rate was pegged for much of the data period. What are missing from this list are specific supply instruments (except for effects captured by some of the macroeconomic variables), but such data were unavailable.

The modification of the p-test is as follows. Estimate both models by iterated three-stage least squares (3SLS) using the appropriate set of instruments in each case. Save the predicted values and error covariance matrices from each model and the residuals from the null model. A new variable—the difference in the predicted values weighted by the product of the error covariance of the null model and inverse of the error-covariance of the alternative—is then created. The null's residuals are then regressed on the RHS variables of the null and the new variable using the null error covariance to generate the estimates. This is implemented by stacking the equations of the p-test model, maintaining any coefficient restrictions, and then using a Cholesky decomposition of the null's error covariance to transform the data. Due to the correlation between the predictions of the alternative model and the errors of the null model, this stacked system of equations must be estimated by instrumental variables as well. We choose as the instruments those associated with the null model. Other choices are possible and, as pointed out by MacKinnon, White, and Davidson, our choice makes the results conditional on the instrument choice as well as the models. The advantages of our choice are twofold. As Davidson and MacKinnon (1993) point out, there is a trade-off between variance and bias as one increases the number of instruments. Second, the check of the complicated calculations suggested by Davidson and MacKinnon (1983) is still valid for our instrument choice; i.e., if the new variable is left out of the p-test regression, the resulting t-statistics of the coefficients should all be zero, i.e., on the order of 10^{-6} in absolute value.

Test results are in table 7. The first column of statistics in the table gives results of testing the generalized ordinary demand system against the generalized inverse demand system; the table also presents results when the models' roles are reversed, employing all of the instruments described above. The ordinary system is rejected by the inverse; the standard normal test statistic z is -63.01. The inverse system, however, is not rejected by the ordinary system ($z = 1.30$). The other three columns give test results when one of the groups of instruments, first-order lags, twelfth-order lags, or macro variables, is omitted from the instrument list. In every case, the generalized ordinary demand system is rejected by the inverse system. In every case except one, we fail to reject the inverse demand system. The one exception is when the twelfth-order lags of the potentially endogenous variables in the inverse system are omitted. Then it is rejected by the ordinary system ($z = 13.27$). This indicates that the ordinary demand system test results are not fragile to the instruments used in conducting the tests, while the inverse test results show some fragility. However, given this caveat, results of the p-tests support the choice of the inverse demand system for modeling Japanese fish demand.

Table 8. Statistics for Durbin-Wu-Hausman Tests of the General Demand Models

Hausman and Taylor Approach[a]		McGuirk et al. Approach[b]	
Ordinary	Inverse	Ordinary	Inverse
45.589	82.525	113.64	167.43
		130.75	178.86
		104.97	143.58

[a] Entries in the table are asymptotically chi-squared with twenty-two degrees of freedom for the tests that use the Hausman and Taylor approach. The 0.05 critical value is 33.92 and the 0.01 critical value is 40.29. Instruments are the first and twelfth lags of potentially endogenous variables and the macro variables (defined in the text).

[b] The first line of numbers gives the Wald statistic, the second gives the likelihood ratio statistic, and the third gives the likelihood ratio statistic adjusted using the small sample adjustment of Italianer. All three lines of numbers are asymptotically chi-squared with eighty degrees of freedom. The 0.05 critical value is 101.88 and the 0.01 critical value is 112.33.

A final specification issue that we wish to examine is related; i.e., it is possible that some sort of mixed demand system (e.g., Moschini and Vissa 1993) would be appropriate for Japanese fish demand. Because of institutional arrangements, such as import quotas and processing (e.g., freezing), some demands may be best specified as q-dependent and some as p-dependent. We do not tackle this problem because the fish commodities we analyze are highly aggregated over species, qualities, and product forms. However, we do approach the problem indirectly by examining the endogeneity of the RHS variables in both the generalized inverse and ordinary demand systems, employing the same instruments we used for the nonnested tests. Two approaches were taken to these tests. The first approach is that suggested by Hausman and Taylor, where the test statistic is a quadratic form of the difference in coefficient estimates between SUR and 3SLS and the generalized inverse of the difference in their covariance matrices, calculated using consistent estimates of the error covariance matrices. The test statistic is asymptotically distributed chi-squared with twenty-two degrees of freedom. The other approach is to take the reduced-form residuals for each of the potentially endogenous variables and add them to the demand system and test their joint significance with Wald, likelihood ratio, and adjusted likelihood ratio tests (see McGuirk et al.). Results are reported in table 8. With either approach, we find that the RHS variables of either system are endogenous. This implies that our preliminary results suffer from simultaneous equation bias. However, assuming our choice of instruments is appropriate, the 3SLS results are consistent and asymptotically efficient.

Table 9. Flexibilities from Generalized and CBS Inverse Demands

Commodity	Flexibility	Generalized	CBS	Mean Share
HFF	Own-price	−0.60	−0.59	0.24
		(0.07)	(0.08)	
	Scale	−1.15	−1.17	
		(0.08)	(0.09)	
MFF	Own-price	−0.55	−0.55	0.33
		(0.05)	(0.06)	
	Scale	−1.02	−1.04	
		(0.07)	(0.08)	
LFF	Own-price	−0.32	−0.21	0.07
		(0.08)	(0.10)	
	Scale	−0.97	−0.90	
		(0.27)	(0.31)	
LSC	Own-price	−0.24	−0.21	0.14
		(0.06)	(0.07)	
	Scale	−0.93	−0.89	
		(0.12)	(0.13)	
CSO	Own-price	−0.42	−0.38	0.09
		(0.06)	(0.06)	
	Scale	−1.02	−1.07	
		(0.11)	(0.11)	
SF	Own-price	−0.46	−0.46	0.13
		(0.06)	(0.07)	
	Scale	−0.60	−0.52	
		(0.15)	(0.16)	

Note: Calculated at sample mean shares using formulas in table 3. Estimates based on data from January 1980 through December 1992. Standard errors calculated by the data method assuming mean shares are fixed. Commodities are high-value fresh fish (HFF); medium-value fresh fish (MFF); low-value fresh fish (LFF); lobster, shrimp, and crab (LSC); cuttlefish, squid, and octopus (CSO); and shellfish (SF). Own-price flexibilities are uncompensated.

Finally, because the generalized inverse model is preferred, we use this model to test for the models nested within it. Since the model is estimated by 3SLS, we use a Wald test, which is distributed asymptotically chi-squared with two degrees of freedom. The results indicated that the inverse AIDS, NBR, and Rotterdam models are rejected (test statistics of 114.2, 143.8, and 188.5, respectively) while the inverse CBS model (test statistic of 2.5) is not. Rather than present detailed tables of results for the inverse generalized and CBS models, own-price and scale flexibilities, estimated at the sample mean shares, are reported in table 9. The models were estimated with homogeneity and symmetry imposed and satisfied negativity (at the means for the generalized model and globally for the CBS). The impacts of the restrictions inherent in the inverse CBS on the flexibilities are marginal except for the own-price flexibility of low-value fresh fish, which decreases in magnitude by one-third.

Conclusions

The generalized inverse demand system of Brown, Lee, and Seale was reparameterized with AIDS dependent variables. The generalized ordinary demand system of Barten (1993) was reparameterized, so it too has AIDS dependent variables. Each of these generalized models nest four differential demand systems of the Rotterdam family. The generalized models were then applied to monthly Japanese fish demand. Preliminary comparison of the generalized inverse model with the generalized ordinary model was done by contrasting their implications as to the sensitivity of Japanese fish demands to their determinants. Own-price responses in the ordinary demand model are inelastic, while they are inflexible for the inverse demands. These are diametrically opposed to one another, so it clearly makes a difference which is employed in specification of Japanese fish demand. Next, these results, while different from each other, are shown to be similar to previous findings on fish demand. As a final piece of preliminary evidence, the out-of-sample forecasting performance of both models was presented. By this criterion, the inverse model is preferred for monthly Japanese fish consumption.

The reparameterization of the generalized demands is then exploited to construct a nonnested test of the specifications. Davidson and MacKinnon's multivariate *p*-test is modified to account for the endogeneity of RHS variables in the alternative models. Calculation of the test statistics requires the specification of instrumental variables that can be used to calculate consistent estimates of both models and auxiliary test regression as well. The generalized inverse demand system strongly rejects the generalized ordinary demands, with no sensitivity to the instruments employed in estimation. The generalized ordinary demands fail to reject the generalized inverse demands with one exception, when the twelfth-order lags of potentially endogenous RHS variables are omitted from the instrument set. According to Durbin-Wu-Hausman tests, the RHS variables in both generalized models are not predetermined. These results lead us to use 3SLS estimates of the generalized inverse demands to test among the nested alternative models. All but the inverse CBS demand system (Laitinien and Theil) are rejected. Finally, the own-price and scale flexibilities of the generalized and CBS inverse models are compared; small differences between them are indicated, for the most part.

A number of questions remain to be answered. What underlies the starkly different portraits that the ordinary and inverse models give of demand? Inverse demands suggest that reaction of prices to changes in available quantities are small, about a 0.3% decrease in price for a 1% increase in quantity. Ordinary demands suggest the trade-off is nearly one to one. Logic suggests that at least part of the cause of this difference in our preliminary estimates must lie in the endogeneity of right-hand-side variables. Only one of the generalized systems can produce consistent estimates. Calculation of consistent estimates of both generalized demand systems led to smaller differences between the elasticities/flexibilities. Another potential cause, suggested by Huang, is that one should not expect congruence between the two models because, if the ordinary model minimizes vertical residuals, then the inverse model minimizes horizontal residuals. Another potential source of the contrasting views of demand lies with the nature of monthly or quarterly data versus annual. For example, Eales and Unnevehr (1993) found much closer agreement between ordinary and inverse demand sensitivities using annual data. A final potential source of the discrepancy is the separability of the commodities. Since separability of fish in the direct utility function implies nothing about separability in the indirect utility function, it may be that one of the conditional demands systems is inconsistent with two-stage budgeting in Japan.

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