To Invert or Not to Invert: The Case of Direct and Inverse AIDS Meat Demand Systems

by

Thomas I. Wahl, Ron C. Mittelhammer,

and Dermot J. Hayes

To Invert or Not to Invert: The Case of Direct and Inverse AIDS Meat Demand Systems

by
Thomas I. Wahl, Ron C. Mittelhammer
and Dermot J. Hayes*

The Almost Ideal Demand System (AIDS) of Deaton and Muellbauer has become popular for estimating agricultural demand systems both because of its relative ease of estimation and the ease with which the classical restrictions of demand theory can be imposed and/or tested. Despite its popularity, a potential deficiency of the AIDS model may be that expenditure shares are expressed as functions of prices when it may be more appropriate for agricultural demands to be expressed as inverse demands, especially for commodities such as meats where, for short enough time periods, quantities are relatively fixed because of inherent production lags.

Moschini and Vissa, and Eales and Unnevehr (1991) have independently proposed an inverse demand system that has an AIDS-like specification. While this inverse demand system might at first appear to be the dual of the direct AIDS demand system, a closed form inverse to the AIDS demand systems does not exist, and thus, the duality does not hold. However, the inverse AIDS (IAIDS) specification has particular appeal for agriculture commodities because the associated demand system expresses expenditure share as a function of quantities rather than of prices. In addition, the IAIDS models are appealing because they appear to maintain desirable properties of the AIDS, including both ease of estimation and ease of imposing/testing neoclassical demand theoretic restrictions.

Houck and Deaton have shown that the matrix of Marshallian (or uncompensated) price flexibilities and the corresponding matrix of Marshallian demand elasticities are matrix inverses of one another if the demand system is complete. Houck demonstrated the relationship via the inverse function theorem whereas Deaton utilized the dual nature of the Slutsky and Antonelli matrices. Thus, beginning with either the AIDS or IAIDS demand system, it is possible to estimate both a system of demand elasticities and a system of price flexibilities. In the event that both the AIDS and IAIDS were equally good representations of underlying preferences, one would expect elasticity and flexibility estimates generated from the models to be reasonably consistent across models. If the estimates were to differ widely, one would be led to question the appropriateness of either or both model specifications. A central issue in the use of AIDS and/or IAIDS for empirical demand analyses is which, if either, of the two model specifications is appropriate for the problem at hand?

In this paper we analyze the appropriateness of using AIDS and/or IAIDS for analyzing U.S. meat demand (beef, pork, chicken). Given that the literature contains applications of both demand systems for analyzing meat demand (e.g., Chalfant and Alston; Hayes, Wahl, and Williams; Eales and Unnevehr (1987, 1991); Moschini and Vissa), the issue of which, if either, of the demand systems is appropriate for modeling meat demand is of significant relevance. The paper also presents a number of more general methodological contributions, including a procedure for imposing local negative semidefiniteness on the AIDS Slutsky matrix or the IAIDS Antonelli matrix, a system-wide Davidson and MacKinnon-type nonnested test of model specification, and an overall strategy for analyzing the appropriateness of AIDS vs. IAIDS models that is applicable in other commodity settings.

*Assistant Professor and Professor, Department of Agricultural Economics, Washington State University, Pullman; and Associate Professor, Department of Economics, Iowa State University, Ames.

We begin with a brief review of the AIDS and IAIDS models. Then methodological considerations relating to the negative semidefiniteness of the Slutsky/Antonelli matrices under AIDS/IAIDS, and to nonnested model specification tests are discussed. Finally, AIDS and IAIDS models of quarterly U.S. meat demand from 1965-1988 are estimated, their appropriateness as models of U.S. meat demand are analyzed, and conclusions are drawn.

The Almost Ideal Demand System

The basis for the AIDS model is the cost function (Deaton and Muellbauer)

$$\log c(u, p) = (1 - u) \log a(p) + u \log b(p),$$

where p represents a vector of commodity prices and u is a level of utility. The functional forms for the a(p) and b(p) terms are

$$\log a(p) = a_0 + \sum_j \alpha_j \log p_j + 1/2 \sum_i \sum_j \gamma_{ij} \log p_i \log p_j$$

and

$$\log b(p) = \log a(p) + \beta_o \Pi_j p_j^{\beta j}$$

By using Shephard's lemma and substituting the indirect utility function (obtained by inverting the cost function) for u, the expression for the ith budget share is

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log \left[\frac{X}{P}\right],$$

where X represents total expenditure and P is the nonlinear price index equivalent to the expression for a(p). The price index P is sometimes replaced with an approximation such as Stone's index, $P^* = \sum_i w_i \log p_i$. The resulting Linear Approximate AIDS (LA/AIDS) is an approximation to the nonlinear specification.

Homogeneity ($\sum_j \gamma_{ij} = 0$), symmetry ($\gamma_{ij} = \gamma_{ji}$), and adding up ($\sum_i \gamma_{ij} = 0$, $\sum_i \beta_i = 0$, and $\sum_i \alpha_i = 1$), restrictions are easily imposed. The uncompensated price and expenditure elasticities are given by

$$\varepsilon_{ij} = -\delta_{ij} + \{\gamma_{ij} - \beta_i(w_j - \beta_j \log(X/P))\}/w_i$$

and

$$\varepsilon_E = 1 + \beta_i/w_i$$

The compensated price elasticities are

$$\varepsilon_{ij}^* = \varepsilon_{ij} + w_i \varepsilon_E.$$

The Inverse Almost Ideal Demand System

Eales and Unnevehr, and Moschini and Vissa independently developed the specification for the IAIDS.[1] The IAIDS is based on the distance function

---

[1] Moschini and Vissa termed their model a Linear Inverse Demand System (LIDS).

$$\log D(u, q) = (1 - u) \log a(q) + u \log b(q).$$

where q represents a vector of commodity quantities and u is a level of utility. The distance function is specified with a and b terms analogous to the AIDS specification. Following Eales and Unnevehr's notation, the a(q) and b(q) terms are

$$\log a(q) = a_0 + \sum_j \alpha_j \log q_j + 1/2 \sum_i \sum_j \gamma_{ij} \log q_i \log q_j$$

and

$$\log b(q) = \log a(q) + \beta_o \Pi_j q_j^{\beta_j}.$$

Differentiating the distance function with respect to the q_i's results in a system of compensated inverse demand functions. Uncompensated demands can be obtained by substituting the direct utility function (obtained by inverting the distance function) into the compensated demands, leading to the expenditure share equations

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log q_i + \beta_i \log Q,$$

where Q is the nonlinear quantity index equivalent to the expression for a(q). The homogeneity, symmetry, and adding up restrictions are equivalent to the corresponding AIDS restrictions. Log Q might be replaced with a linear approximation using Stone's Index, $\log Q = \Sigma w_i \log(q_i)$. The resulting linear approximate IAIDS (LA/AIDS) is an approximation of the nonlinear IAIDS.

The uncompensated price and scale flexibilities (i.e., price flexibility with respect to Q) are

$$f_{ij} = -\delta_{ij} + \{\gamma_{ij} + \beta_i (w_j - \beta_j \log Q)\}/w_i$$

and

$$f_Q = -1 + \beta_i/w_i.$$

The compensated price flexibilities are

$$f_{ij}^* = f_{ij} - w_j f_Q.$$

THE NEGATIVITY RESTRICTIONS

For demand functions to be fully consistent with neoclassical theory, the Slutsky/Antonelli substitution matrices must be negative semidefinite, in addition to the restrictions of adding up, homogeneity, and symmetry. Deaton and Muellbauer show that this so-called negativity condition is satisfied for the AIDS iff the matrix C, with (i,j) entry defined by

$$c_{ij} = \gamma_{ij} + \beta_i\beta_j \log(X/P) - w_i \delta_{ij} + w_i w_j, \quad (1)$$

is negative semidefinite where δ_{ij} is the Kronecker delta. The c_{ij} term equals the (i,j) entry of the Slutsky substitution matrix multiplied by P_iP_j/X. Deaton and Muellbauer suggest evaluating the C matrix following estimation to determine if the negativity condition is satisfied.

The local (i.e, at a point) negative semidefiniteness of the C matrix can be assured through a reparameterization of the AIDS model. Specifically, solve (1) for γ_{ij} to yield

$$\gamma_{ij} = c_{ij} - \beta_i\beta_j \log (X/P) + w_i \delta_{ij} - w_i w_j. \qquad (2)$$

Substituting the right hand side of (2) for γ_{ij} in the AIDS model reparameterizes the AIDS model in terms of a_o, α_j's, β_i's, and c_{ij}'s. In addition to the previous restrictions on α_i's and β_i's, it can be shown that the homogeneity restriction requires $\sum_j c_{ij} = 0$, symmetry requires that $c_{ij} = c_{ji}$, and adding up requires $\sum_i c_{ij} = 0$. Since the γ_{ij}'s are fixed constants in the AIDS specification, the representation of γ_{ij} via (2) must occur at a given point (i.e., at given values for X, P, and the w_i's). Given such a point, negative semidefiniteness of the C matrix can then be assured by representing C via a Cholesky decomposition, as C = -TT′, where T is a lower triangular matrix. This representation effectively reparameterizes the AIDS model once more, replacing c_{ij}'s with functions of t_{ij}'s (the elements of T). In matrix form, the matrix of γ_{ij}'s, say Γ, is then ultimately represented as

$$\Gamma = -TT' - \log(X/P)\ \beta\beta' + DIAG(w) - ww' \qquad (3)$$

where β is a column vector of β_i's, DIAG(w) is a diagonal matrix having w_i for its i^{th} diagonal entry, and w is a column vector of w_i's. The symmetry restriction on C is enforced by the symmetry of TT′, and homogeneity and adding up are enforced by the constraints i′TT′ = [0] and TT′i = [0], where i is a conformable column vector whose entries are all 1's. The parameters to be estimated in the AIDS model using the latter parameterization are a_0, α_i's, β_i's, and t_{ij}'s, with the aforementioned homogeneity and adding up constraints imposed. The negativity restriction for the IAIDS can be imposed locally in a similar manner by representing γ_{ij} as

$$\gamma_{ij} = c_{ij} + \beta_i\beta_j \log Q + w_i\delta_{ij} - w_i w_j, \qquad (4)$$

representing the C matrix via Cholesky decomposition -TT′, and imposing the appropriate constraints on the α_i's, β_i's, and on the matrix TT′ to enforce homogeneity and adding up (symmetry is again assured by the symmetry of TT′).

A Systems Nonnested Specification Test

Davidson and MacKinnon developed a single equation test to examine nonnested specifications. Their test has been used to test alternative specification hypotheses, but only in the context of testing a single equation at a time. For example, Alston and Chalfant used the P test to examine alternative definitions of income in an Australian meat demand AIDS by testing each equation individually. The single equation P-test can be extended to test the specification of a system of equations simultaneously.

Let two alternative model specifications be given by

$$H_1 : w_{kt} = f_k(x_t,\beta_k) + v_{kt},\ t=1,\ldots,n,\ k=1,\ldots,m$$

$$H_2 : w_{kt} = g_k(z_t,\gamma_k) + \varepsilon_{kt},\ t=1,\ldots,n,\ k=1,\ldots,m.$$

The P-test of the appropriateness of system specification H_1 can be accomplished in three steps. First, the parameters of both models H_1 and H_2 are estimated using appropriate econometric techniques. Then a general compound model is estimated in the form

$$w_{kt} - f_k(x_t,\hat{\beta}_k) = \tau_k\left[g_k(z_t,\hat{\gamma}_k) - f_k(x_t,\hat{\beta}_k)\right] + \hat{F}_{kt}\, b_k + e_{kt},\ t=1,\ldots,n\ k=1,\ldots,m, \tag{5}$$

where $\hat{F}_{kt}$ represents the gradient vector of $f_k(x_t,\beta_k)$ evaluated at $\hat{\beta}_k$, and τ_k and b_k are parameters to be estimated. Finally, a χ^2 (Wald) test of the null hypothesis $H_o : \tau_i = [0]$, $i=1,\ldots,m$, is conducted using the statistic

$$\xi = \hat{\tau}'[\text{cov}(\hat{\tau})]^{-1}\hat{\tau} \sim \chi^2_m \tag{6}$$

where the parameter estimates $\hat{\tau}$ and their estimated covariance matrix cov($\hat{\tau}$) are obtained from the estimation of the compound model (5). If H_1 is accepted (i.e., ξ is smaller than the critical value) then system specification H_1 is compatible with the data. If H_1 is rejected, then H_1 is not compatible with the data. In order to test the appropriateness of model specification H_2, the roles of $f_k(x_t, \beta_k)$ and $g_k(Z_t, \gamma_k)$ are reversed in the P-test procedure. It is possible for either, neither, or both of $f_k(X_t, \beta_k)$ and $g_k(Z_t, \gamma_k)$, $k=1,\ldots,m$, to be compatible with the data.

An AIDS and IAIDS Comparison

To compare the AIDS and IAIDS, U.S. quarterly data for beef, pork, chicken, and total consumer expenditures spanning the period 1965-1988 were used. Data sources are the same as those cited in Eales and Unnevehr (1991), and are available upon request. In brief, data on quarterly per capita consumption and prices of beef, pork, chicken, and the U.S. population are from USDA sources. Quarterly personal consumption expenditures and the consumer price index for urban consumers were obtained from U.S. Department of Commerce publications.

Both AIDS and IAIDS models were estimated using a nonlinear iterated 3SLS estimator incorporating a first order autocorrelation structure for the disturbance terms of the share equations. Given that a system of share equations were being estimated in which the dependent variables sum to 1, the implied restrictions on the autocorrelation parameters, as discussed by Berndt and Savin, were imposed. Final estimates of model parameters can be interpreted as asymptotically equivalent to nonlinear maximum likelihood estimates assuming multivariate normality for the disturbance terms. Both models accepted homogeneity and symmetry restrictions. Based on the findings of Eales and Unnevehr (1987) both models incorporate structural change by including a time trend shift and an intercept shifter beginning in 1975. This is also consistent with other meat demand studies that have found structural change to have occurred beginning in the mid-1970s. The aforementioned procedure of using a Cholesky decomposition to restrict γ_{ij} parameter values so as to ensure local negative semidefiniteness of the Slutsky/Antonelli matrices was utilized in estimating both models. The restriction was applied at the sample means of the data, and the converged parameter estimates of both models were consistent with the restrictions and, thus, satisfied the local negative semidefiniteness condition. The estimated parameters, standard errors, R^2, Durbin Watson statistics, and mean-level expenditure shares for the non-linear version of each model are presented in Tables 1 and 2. Because the systems represent complete sets of consumer demands, the uncompensated price flexibilities implied by the AIDS can be derived by inverting the matrix of uncompensated AIDS demand elasticities, and the uncompensated demand elasticities implied by the IAIDS can be derived by inverting the matrix of uncompensated IAIDS price flexibilities. The estimated mean level elasticities and flexibilities are presented in tables 3 and 4.

The derived AIDS price flexibilities appear to be relatively large in absolute magnitude, and suggest a demand structure that is quite price flexible. We note that the general magnitudes of the derived flexibilities are consistent with those obtained by inverting the demand elasticities reported by Eales and Unnevehr (1987) for their complete demand system based on annual data. The derived price flexibilities from the AIDS are in stark contrast to the price flexibilities estimated directly using the IAIDS, the latter model suggesting a much more price inflexible demand structure. The IAIDS results of Eales and Unnevehr (1991) are also consistent with a more price inflexible demand structure.[2] Conflicts between the AIDS and IAIDS models are also evident when comparing the uncompensated demand elasticities derived (via inversion) from the IAIDS with the uncompensated demand elasticities obtained directly from the AIDS. The IAIDS derived demand elasticities suggest a much more elastic demand structure than the AIDS demand elasticities, the latter being considerably more inelastic.

In order to further illustrate the nature of the conflicting implications of the IAIDS and AIDS demand structure, figures 1-3 present graphs of the bootstrapped asymptotic distributions (sample size = 1000) of the mean-level beef, pork, and chicken demand elasticities estimated directly via the AIDS, and derived via inversion from the IAIDS price flexibilities. The graphs clearly suggest that the range of elasticity results implied by the AIDS and IAIDS have no appreciable intersection, and underscores the need for an analysis of the appropriateness of AIDS and IAIDS model specifications (graphs comparing the bootstrapped distributions of flexibilities exhibited analogous separations of flexibility ranges).

The aforementioned nonnested systems specification test was used to evaluate the compatibility of the AIDS and IAIDS models with the data. The value of the Wald test statistic for testing the appropriateness of the AIDS model was 5.67, which implies that the AIDS specification is found to be data compatible at the .05 level of significance (the critical value for the χ^2 test with 3 degrees of freedom is 7.82 at the .05 level, and 6.25 at the .10 level). The Wald test statistic for testing the appropriateness of the IAIDS model was 8493, which soundly rejects the hypothesis that the IAIDS is compatible with the data. We conclude that the IAIDS model is inappropriate for modelling U.S. meat demand during the period examined, and suggest that the results of the AIDS model should be considered as more representative of the structure of U.S. meat demand.

CONCLUSIONS

In many cases of modelling the demands for agricultural commodities, it is not clear, a priori, whether a direct or inverse demand structure is more appropriate. It might be argued, albeit rather loosely, that the deciding factor is which argument, price or quantity, is "relatively more fixed" for the commodities being analyzed. If it is price, then a direct demand structure is indicated, or if it is quantity, then an inverse demand structure should be analyzed. However, in most cases, the polar case of fixity of prices, or quantities, does not hold, and it is an empirical question as to which demand structure, direct or inverse, is appropriate.

The estimated AIDS and IAIDS demand structures for U.S. meats presented in this paper illustrate how strikingly different the structural implications of direct and inverse demand systems can be. A prudent modelling strategy would be to analyze both types of demand systems when there is any doubt as to the fixity of prices or quantities, and to statistically test for the appropriateness of the direct versus

---

[2]Estimated direct price flexibilities were -.947, -.990, -.755, and -.975 for beef, pork, chicken, and the other category, respectively. Differences between their and our modelling procedures include: 1) they used nonlinear iterated SUR, we used nonlinear iterated 3SLS; 2)we have used an additional 4 data points (1965); 3) their model was estimated in first difference form, ours was undifferenced but included first order autocorrelation correction; and 4) their model evidently did not include any structural break mechanism over the estimation period, despite their findings in a previous paper that structural break did occur in the mid 1970's.

inverse demand specification along the lines presented in this paper. Within the context of U.S. quarterly meat demand from 1965-1988, and examining both direct and inverse AIDS demand structures, we conclude that the direct demand system more faithfully represents the structure of quarterly U.S. retail meat demand.

REFERENCES

Alston, J.M., and J.A. Chalfant. "Weak Separability and a Test for the Specification of income in Demand Models with an Application to the Demand for Meat in Australia," Australian J. of Agric. Econ., Vol. 31, No. 1(1987) pp.1-15

Berndt, E.R., and N.E. Savin. "Estimation and Hypothesis Testing in Singular Equation Systems with Autoregressive Disturbances," Econometrica, Vol. 43, No. 5-6(Sept.-Nov., 1975), p. 937-957.

Davidson, R., MacKinnon J.G. "Several Tests for Model Specification in the Presence of Alternative Hypotheses," Econometrica, Vol. 49, No. 3(May, 1981), pp. 781-793.

Deaton, A. "Optimal Taxes and the Structure of Preferences," Econometrica, 49(1981a), pp. 1245-1268.

Deaton, A. "The Distance Function in Consumer Behavior with Applications to Index Numbers and Optimal Taxation," Review of Economic Studies, University of Bristol, pp. 391-405.

Deaton, A., J. Muellbauer. "Economics and Consumer Behavior," Cambridge University Press, 1980.

Deaton, A., J. Muellbauer. "An Almost Ideal Demand System," Am. Econ. Rev., Vol. 70 No. 3(June, 1980), pp. 312-326.

Eales J.S., L.J. Unnevehr. "Demand for Beef and Chicken Products: Separability and Structural Change," Am. J. of Agric. Econ., Vol. 70 No. 3(August, 1988), pp. 521-532.

Eales, J.S., L.J. Unnevehr. "The Inverse Almost Ideal Demand System," University of Illinois Research Board, Proj. No. 358, 1991.

Houck, J.P. "The Relationship of Direct Price Flexibilities to Direct Price Elasticities," J. of Farm Econ., Vol. 47, No. 3(August, 1965), pp. 789-792.

Moschini, G., A. Vissa. "A Linear Inverse Demand System," Iowa Agriculture and Home Economics Experiment Station, Proj. No. 2875, March 1991.

Table 1. AIDS Parameter Estimates[1]

Shares	Beef Price	Pork Price	Chicken Price	Other Price	Expend -ture	Inter -cept	Qtr1	Qtr3	Qtr4	Time	Dum75	R^2/DW	Mean Share
Beef	1.014 (0.164)	0.334 (0.078)	0.138 (0.043)	-1.509	-0.785 (0.368)	6.655 (2.474)	0.171 (0.012)	0.057 (0.012)	0.009 (0.014)	-0.020 (0.042)	-0.055 (0.009)	0.989 2.028	0.0238
Pork		0.336 (0.078)	0.038 (0.033)	-0.724	-0.975 (0.137)	7.220 (0.890)	0.071 (0.008)	0.012 (0.009)	0.138 (0.010)	-0.094 (0.026)	-0.003 (0.005)	0.980 2.001	0.0134
Chicken			0.345 (0.037)	-0.521	0.094 (0.076)	0.942 (0.511)	-0.035 (0.003)	-0.002 (0.003)	-0.041 (0.004)	-0.009 (0.011)	0.111 (0.002)	0.966 2.111	0.0047

Table 2. IAIDS Parameter Estimates[1]

Shares	Beef Quantity	Pork Quantity	Chicken Quantity	Other Price	Expend -ture	Inter -cept	Qtr1	Qtr3	Qtr4	Time	Dum75	R^2/DW	Mean Share
Beef	0.644 (0.296)	0.047 (0.155)	-0.313 (0.107)	-0.379	-0.930 (1.080)	-1.390 (8.717)	-0.026 (0.017)	0.049 (0.017)	0.045 (0.022)	-0.078 (0.100)	-0.065 (0.024)	0.975 2.047	0.0238
Pork		0.446 (0.126)	-0.225 (0.073)	-0.269	0.904 (0.453)	9.421 (3.443)	0.046 (0.011)	0.033 (0.010)	0.086 (0.015)	-0.047 (0.063)	-0.016 (0.010)	0.962 1.551	0.0134
Chicken			0.043 (0.115)	-0.495	-0.765 (0.224)	3.952 (1.775)	-0.020 (0.009)	0.016 (0.006)	-0.018 (0.012)	-0.053 (0.033)	-0.005 (0.005	0.879 2.303	0.0047

[1]Standard errors are in parentheses.

Table 3. AIDS Elasticities and Flexibilities (evaluated at mean level of data)[2]

Shares	ε_{iB}	ε_{iP}	ε_{iC}	ε_{iO}	ε_{iE}	ε^*_{iB}	ε^*_{iP}	ε^*_{iC}	ε^*_{iO}	f_{iB}	f_{iP}	f_{iC}	f_{iO}
Beef	-0.553	0.169	0.063	-0.378	0.699	-0.536	0.179	0.066	0.292	-2.704	-0.766	-0.732	1.766
Pork	0.310	-0.705	0.034	0.015	0.346	0.318	-0.700	0.036	0.346	-1.369	-1.832	-0.551	1.055
Chicken	0.311	0.090	-0.281	-0.998	0.877	0.332	0.102	-0.276	-0.158	-3.723	-1.577	-4.711	6.171
Other	-0.017	-0.009	-0.006	-0.986	1.017	0.007	0.005	-0.001	-0.011	0.080	0.038	0.044	-1.089

Table 4. IAIDS Flexibilities and Elasticities (evaluated at mean level of data)[2]

	f_{iB}	f_{iP}	f_{iC}	f_{iO}	f_{iQ}	f^*_{iB}	f^*_{iP}	f^*_{iC}	f^*_{iO}	ε_{iB}	ε_{iP}	ε_{iC}	ε_{iO}
Beef	-0.764	-0.012	-0.157	-0.461	-1.394	-0.731	0.006	-0.150	0.875	-1.615	-0.225	0.306	0.876
Pork	-0.029	-0.710	-0.219	-0.745	-1.702	0.011	-0.688	-0.210	0.887	-0.404	-1.780	0.458	1.460
Chicken	-0.781	-0.583	-1.009	-0.182	-2.555	-0.720	-0.550	-0.997	2.267	1.481	1.201	-1.491	-1.335
Other	-0.001	-0.001	0.007	-0.978	-0.973	0.022	0.012	0.012	-0.045	0.013	0.010	-0.011	-1.034

[2]The symbols ε, ε^*, and f refer to uncompensated elasticities, compensated elasticities, and uncompensated flexibilities, respectively. Subscripts B, P, C, O refer to beef, pork, chicken, and other respectively. Subscript E refers to personal consumption expenditures, and subscript Q refers to scale (the IAIDS quantity index).

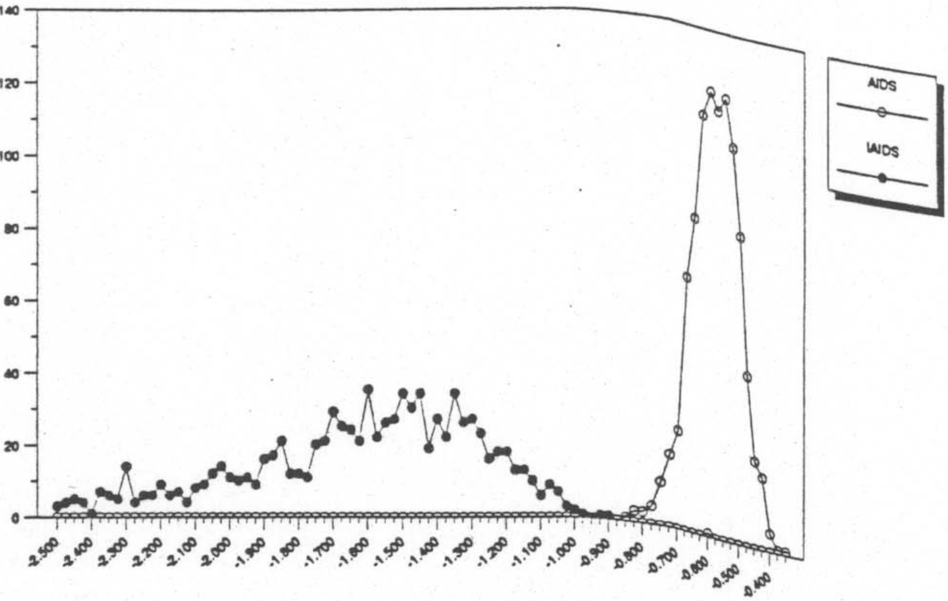

Figure 1. Beef Own-Price Elasticity Distributions

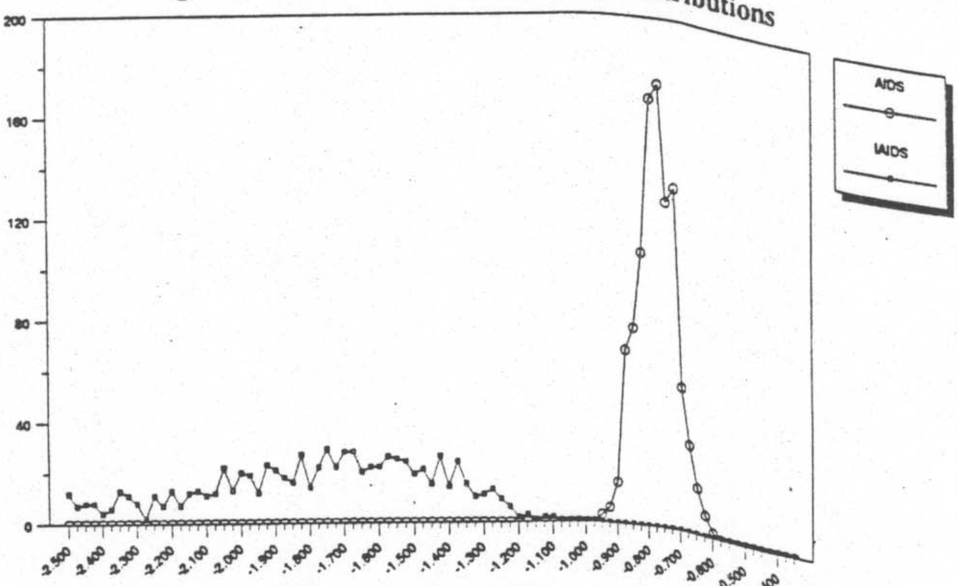

Figure 2. Pork Own-Price Elasticity Distributions

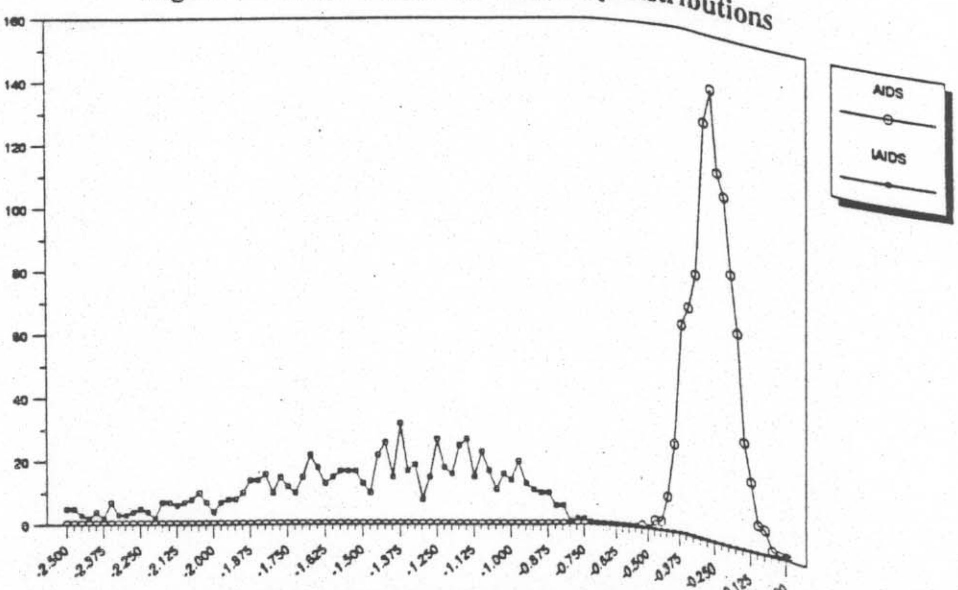

Figure 3. Chicken Own-Price Elasticity Distributions