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Marshallian and Hicksian Demands and the CPI

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Abstract

The use of price indices as deflators in demand equations is considered and clarified. Deflating prices and income by the CPI imposes a type of homogeneity restriction, but invalidates the interpretation of coefficients of a double-log model as uncompensated elasticities. However, deflating income by Stone's geometric price index—not the Consumer Price Index—means that real income really is held constant. This permits interpreting price coefficients in a double-log demand equation as compensated elasticities, provided the homogeneity restriction is imposed properly. While this result has been known since Stone (1954), it does not appear to be widely recognized in the literature on applied demand analysis.

The compensated version of the double-log model has the same form as a share equation from the widely used linear approximate version of the Almost Ideal demand system, facilitating the construction of a test for choosing between these two alternative models. In an illustrative example using Theil's data for U.S. meat consumption, both the double-log and share specifications are rejected.

Key Words: Hicksian demand, Marshallian demand, deflation, homogeneity, specification test

MARSHALLIAN AND HICKSIAN DEMANDS AND THE CPI

Some people think that if one deflates income by a general price index, such as the Consumer Price Index (CPI), the resulting *real income* measure is an approximation of utility and, therefore, a demand equation that includes deflated income is a Hicksian demand (since real income is held constant). For example, Becker (pp. 35-40) draws a distinction between two types of demand equation: "pure" corresponding to Hicksian demands and "combined" corresponding to Marshallian demands. He asserts that the combined demand is almost never used in statistical studies, apparently because he believes that deflating by a price index is sufficient to produce a "pure" demand.

A more common view is that deflating by a general price index is simply a way of imposing the homogeneity condition, so that the estimated coefficients continue to represent uncompensated price responses. This interpretation is incorrect—in a double-log model, deflating by a general price index, such as the CPI, usually means that the coefficients are no longer Marshallian price elasticities.

In this paper, we show that deflating prices and income by the CPI is *never* the correct approach for obtaining measures of compensated price responses in a double-log model. The mathematical form for the CPI is incorrect, it includes the wrong goods, and the wrong variables are being deflated. Deflating money income (but not prices) by Stone's price index will, however, yield a Hicksian double-log demand model. In the work that follows, to establish these points, we derive some implications for the interpretation of elasticities estimated under alternative sets of parametric restrictions and with different deflators. We also develop a specification test for the correct functional form, in the context of single-equation demand models.

Deflation and Homogeneity in Demand Equations

The typical problem in demand analysis is one where N prices and quantities are observed over T periods, and a total expenditure variable is constructed to preserve adding-up of expenditures on the N goods. Usually the objective is to explain the allocation of expenditure among the N goods, with prices and expenditure as independent variables. The resulting endogeneity of the expenditure variable is generally ignored (LaFrance 1991, 1993). A common approach is to express the logarithms of quantities consumed as linear functions of the logarithms of prices and income.

Consider the following "double-log" demand equation for good i, in which the coefficients on prices (η_{ij}) are Marshallian demand elasticities for good i with respect to the j^{th} price and η_{iI} is the income elasticity of demand:

$$\ln Q_i = \alpha_i + \eta_{i1}\ln P_1 + \eta_{i2}\ln P_2 + \ldots + \eta_{iN}\ln P_N + \eta_{iI}\ln I \quad (1)$$

I denotes income (expenditure) and P_j denotes the price of good j. The homogeneity condition can be expressed as an adding-up condition on the elasticities:

$$\eta_{i1} + \eta_{i2} + \ldots + \eta_{iN} + \eta_{iI} = 0 \quad (2)$$

and corresponds to the familiar proposition of "no money illusion". The homogeneity condition can be imposed directly as a parametric restriction or by deflating all monetary variables by any one of the N prices or total expenditure.[1] The remaining coefficients continue to represent Marshallian elasticities, and the elasticity with respect to the variable used as a deflator can be recovered from the homogeneity restriction.

Deflating by any one of the variables on the right-hand side of (1) is, is, in effect, merely a means of imposing the restriction in (2); a well-known result in the double-log form. On the other hand, as long as (2) is imposed, there is no need to deflate the monetary variables. The homogeneity restriction ensures that only real income and relative prices, and not the absolute levels of prices, are relevant for explaining consumption. The two alternatives—deflating or restricting elasticities—are thus perfect substitutes in this simple model.

Although imposing homogeneity as a parametric restriction makes deflating redundant, a price index is often used in demand equations to put monetary variables in real terms. In interpreting models where the CPI has been used to deflate the nominal variables, it is useful to distinguish two cases. Let the number of goods $N = m + n$, where m goods are of specific interest and the remaining n goods complete the budget set. The first case is one where $m + 1$ price terms appear in the demand equation, with the CPI capturing the effects of the remaining n prices. That is, the CPI is one of the N prices above. This specification would be consistent with a belief that a subset of the N prices is of specific interest, and the CPI is used as an approximation to represent the remaining prices in an aggregated form. In the second case, all $m + n$ prices appear in the model. Since the demand equation already includes the prices of all goods in the budget set, the use of the CPI as a deflator must have some other interpretation than in the first case. We now consider both of these cases in detail, and explore the implications of deflating with the CPI and with Stone's price index, under various circumstances.

Case 1: The CPI as a price index for an aggregate of n goods not individually included

There are m prices plus the CPI and income (expenditure on $m+n$ goods) as arguments in the demand equation. As noted above, it is common to think of the CPI, in this case, as a proxy or aggregate of the n prices that are not of direct interest.[2] The model is the same as in (1), with P_N = CPI and $m = N-1$. Deflating by any one of the prices (or income) is a way of imposing homogeneity in a Marshallian demand curve. Deflating by the CPI yields

$$\ln Q_i \;=\; \alpha_i + \eta_{i1}[\ln P_1 - \ln \mathrm{CPI}] + \ldots + \eta_{im}[\ln P_m - \ln \mathrm{CPI}] + \eta_{iI}[\ln I - \ln \mathrm{CPI}]. \qquad (3)$$

If the homogeneity restriction (2) is correct, then the interpretation of the parameters of the resulting expression clearly is the same as in the original specification, and it remains a Marshallian (uncompensated) demand equation, from which $\eta_{i,\mathrm{CPI}}$ can be obtained using the homogeneity restriction.

Case 2: The CPI as a price index of an aggregate of all goods

Suppose that the demand equation already includes all $m+n$ prices, and that the CPI is an index of those prices.[3] The homogeneity restriction implies that (2) holds. However, it is common to impose homogeneity by deflating by the CPI. The resulting demand model is homogeneous, in the sense that a doubling of all monetary variables leaves the quantity demanded unchanged, but it does not make any sense. The logarithm of the CPI now enters with the coefficient

$$\eta_{i,\mathrm{CPI}} = -[\eta_{i1} + \eta_{i2} + \ldots + \eta_{iN} + \eta_{iI}],$$

which means that another "price" has been added to the model. Only if (2) were imposed or held exactly (so that lnCPI has a zero coefficient in (3)), could the individual price coefficients still be interpreted as Marshallian price elasticities that are consistent with the homogeneity restriction. Thus, deflating by the CPI is consistent with the maintained hypotheses (1) and (2) only if the CPI represents some, but not all, relevant prices (i.e., Case 1).

Deflating by the CPI is not consistent with (1) and (2) if the CPI is meant to be an index of *all* prices—the effect is to add the overall price level as a separate argument affecting quantity demanded. This complicates the interpretation of price changes, since a change in P_j involves both the direct effect, measured by η_{ij}, and also an effect through the CPI, measured by $\eta_{1,\mathrm{CPI}}$.[4] The result is that the η_{ij}'s are no longer Marshallian elasticities consistent with (2)—because

$$\sum_{j=1}^{m} \eta_{ij} + \eta_{iI} \neq 0;$$

nor are they Hicksian price elasticities.[5] In neither case does deflating money income by the CPI lead to a demand curve in which real income has been held constant.

Homogeneity and Hicksian elasticities using Stone's price index

The easiest way to see why deflating by the CPI does not produce a compensated demand is to consider a procedure that would do so. Stone suggested making use of the Slutsky equation, in elasticity form, to obtain compensated demands:

$$\eta_{ij} = \eta^*_{ij} - S_j \eta_{iI} \qquad (4)$$

where S_j denotes good j's budget share and η^*_{ij} is the compensated price elasticity of the demand for good i with respect to P_j.[6] Substituting (4) into (1) yields

$$\begin{aligned} \ln Q_i &= \alpha_i + \sum_{j=1}^{N}[\eta^*_{ij} - S_j\eta_{iI}]\ln P_j + \eta_{iI}\ln I \\ &= \alpha_i + \sum_{j=1}^{N}\eta^*_{ij}\ln P_j + \eta_{iI}[\ln I - \sum_{j=1}^{N}S_j\ln P_j] \\ &= \alpha_i + \sum_{j=1}^{N}\eta^*_{ij}\ln P_j + \eta_{iI}\ln(I/\mathrm{P}^*) \end{aligned} \tag{5}$$

where P^* is Stone's geometric price index:

$$\mathrm{P}^* = \prod_{j=1}^{N} P_j^{S_j}.$$

Clearly the last line of equation (5) represents a compensated (Hicksian) demand function, at least in the sense that its price coefficients are compensated elasticities. Effectively this is a double-log model in which the prices are undeflated and the nominal group expenditure is deflated by Stone's price index for the group of goods included in the model. Unless CPI = P^*, dividing income by the CPI does not keep real income constant—Stone's price index must be used.[7]

To impose homogeneity in equation (5), we must restrict the compensated price elasticities to sum to zero. This restriction could be imposed directly, or the same effect could be achieved by expressing all prices relative to one of the included prices. It should not be done, however, by deflating by P^*, since the coefficients would then be restricted to sum to zero over n+1 "prices" (i.e., the n prices of individual goods and P^*). While such a model might provide a good fit, each individual price enters in a complicated manner—through its "own" effect and through the price index. This is analogous to deflating by the CPI in Case 2 above—the new model is no longer the one specified by (1).

To summarize, if we deflate all of the monetary variables by one of the prices, we have merely imposed homogeneity. If we deflate only income by Stone's price index, we have changed from a Marshallian demand equation to a Hicksian demand, in the sense that we have defined a measure of real income consistent with the price coefficients being interpreted as compensated price elasticities.[8]

Deflating by the CPI does not yield a demand with compensated elasticities, so there is apparently no useful sense in which this procedure holds real income constant. Moreover, if we deflate all of the prices and income by a general price index—either the CPI or Stone's price index, say—we have imposed homogeneity but, at the same time, we have created a model in which the price coefficients are neither Hicksian nor Marshallian elasticities. Deflating by any price index that does not already appear as an argument in the double-log model has the effect of imposing an absence of money illusion, but simultaneously introducing a new regressor, as we have shown. Remarkably, the latter is the most common approach taken in applied work. In most studies, money income and prices are deflated by the CPI and it is noted that such deflation imposes homogeneity. We know of few examples where the income term in a double-log model has been deflated while the homogeneity restriction is enforced on price elasticities through the parametric restriction.

A Test for the Functional Form

Along with leading to a clarification of the interpretation of the parameters, deflating by Stone's price index leads to the observation that the right-hand side of the double-log model is identical to an equation from the common linear approximation of the Almost Ideal demand system (the LA model); thus, one might consider the same equation but with the expenditure share of good i as the dependent variable, rather than $\ln Q_i$:

$$S_i = \alpha_i + \gamma_{i1}[\ln(P_1/P_n)] + \ldots + \gamma_{i,n-1}\ln(P_{n-1}/P_n) + \gamma_{iI}\ln(I/\mathrm{P}^*) \tag{6}$$

where $S_i = P_i Q_i / I$. This observation leads to a test of the two specifications. While the typical double-log model in (1) seems dissimilar to the LA model, converting the double-log model to a "compensated" demand—as in equation (5)—leads to the insight that each is a special case of the compound model

$$(1-\lambda)\ln Q_i + \lambda S_i = \alpha_i + \gamma_{i1}[\ln(P_1/P_n)] + \ldots + \gamma_{i,n-1}\ln(P_{n-1}/P_n) + \gamma_{iI}\ln(I/\mathrm{P}^*) \tag{7}$$

Estimating λ along with the parameters on the right-hand side can be interpreted as a test of either specification. Subject to the qualification that testing one equation of a system is not the same as testing the whole system, this also can be interpreted as a test of the adequacy of the specification of the LA model for demand systems.[9]

An Example Using Meat Consumption Data

To illustrate the above test, we estimate single demand equations for beef, pork, chicken, and lamb using Theil's data. These data consist of annual prices and per capita consumption for the United States for the years 1950 to 1972 and are comparable to the typical time-series data set used in applied demand analysis.

Excluding some goods is virtually mandatory for empirical work (except for studies involving highly aggregated goods), and is generally justified by an assumption about separability. Assuming weak separability of the meat group, the appropriate expenditure variable is expenditure on the group of four meats.[10] Elasticities obtained—as well as results concerning the double-log versus the share specification—are thus conditional on the separability assumption and the particular level of meat expenditure. Expenditure and price elasticities are *within-group* elasticities. One could argue that an unconditional demand equation could be obtained by including a price index as the fifth price term, and using total expenditure on all goods as the income variable. As we noted earlier, in such a model the elasticities are still conditional, but now they are conditional on an aggregation assumption, rather than a separability assumption. The separability approach is the one taken by most studies, but the results should be interpreted with caution, due to their conditional nature.

We estimated two double-log models for each meat, a conventional one that corresponds to equation (1) with (2) imposed for estimation, and one using the alternative procedure we suggest—deflating income by Stone's price index, while the coefficients on logged prices are required to sum to zero. The first one holds money income constant, while the second one holds real income constant. The estimated coefficients from the traditional model are shown in table 1. These coefficients are plausible when interpreted as Marshallian price elasticities or expenditure elasticites (keeping in mind that the latter are with respect to group expenditure, not total income or expenditure on all goods). For instance, we find that lamb and beef are relatively income-elastic, and all own-price effects are negative.

Table 2 shows the corresponding estimates for the double-log model with real income constant. The expenditure coefficients are different, but not dramatically so. There are some significant differences in the estimated price coefficients, however. For pork and chicken, the estimated own-price elasticities are slightly smaller in magnitude, but still negative. This outcome is consistent with the interpretation that they are compensated elasticities corresponding to the uncompensated elasticities in table 1, i.e., that they have been corrected for income effects. For beef, the estimated compensated own-price coefficient is positive, although not significantly different from zero. While a positive point estimate of the compensated own-price elasticity, even if not significant, is disconcerting, the estimate is consistent with the results from table 1.[11] The surprising compensated own-price effect for beef may be interpreted as evidence that the double-log model is not appropriate for beef demand, since the estimated share equation for beef did show a negative compensated own-price effect. It is the particular specification, not the data, that is responsible for the perverse outcome.[12]

More formal support for the hypothesis that the double-log model is not a correct specification comes from the compound models. The restrictions on λ for either the double-log or share models to be true are rejected; every estimate of λ is statistically significantly different from both 0 and 1. Thus, neither the double-log nor the share model provides an adequate representation of these data. Both beef and pork are characterized by values of λ that are well above 1. Although the double-log model is not supported by these results, the appropriate response may not be to estimate the model in share form. The share model does better for both chicken and lamb, with estimated λ's much closer to 1. Relying on the asymptotic standard errors, these estimates still are statistically different from 1. In the absence of information on the statistical behavior of $\hat{\lambda}$, however, rejecting either model should be tentative.[13]

Conclusion

For double-log demand equations, we have shown that deflating income (but not prices) by Stone's price index holds real income constant, so that estimated coefficients on logarithms of prices may be interpreted as compensated price elasticities. This is not the case, however, if the CPI is used. The interpretation of models where the CPI has been used as a deflator depends on the particular role the price index is meant to play, but in neither case we considered does deflating by the CPI keep real income constant in the Hicksian sense. Only in a case where the CPI can reasonably be regarded as a good approximation for an index of the prices of "all other goods" does it make sense to deflate by the CPI. Then, such deflation is a way of imposing homogeneity that does not invalidate the interpretation of coefficients as Marshallian elasticities; otherwise the model no longer makes sense as a Marshallian demand.

When income is deflated by Stone's price index, prices should not be deflated by the same index. The way to impose homogeneity, given that the coefficients on the prices are compensated price elasticities, is to impose the restriction that they sum to zero. The CPI could be used to impose this restriction, but only if it is one of the included prices (i.e. an index of the price of "all other goods"), in which case dividing all the other prices by the

CPI is a substitute for the parametric restriction. However, the income term still must be divided by Stone's price index, not the CPI, if it is desired to estimate compensated price responses directly.[14]

The result of deflating income by Stone's price index is a slightly modified double-log model, but one that is just as easy to estimate as the one in the more common Marshallian form. In this modified model, the price coefficients may be interpreted as compensated price elasticities, so that estimating such a model provides direct estimates of compensated price responses and measures of precision of those estimates. The modified model has the added virture of sharing a right-hand side with the linear-approximate version of the almost ideal demand system. This permits constructing a specification test appropriate for either model.

In an example using data from Theil, we found that the double-log model was never appropriate. The share model—representing one equation from an almost ideal demand system—also was rejected, although it may be less restrictive for chicken and lamb than for beef and pork. Overall, however, the evidence is that neither model is an entirely adequate representation of the data.

References

Alston, Julian M., and Douglas M. Larson. "Hicksian vs. Marshallian Welfare Measures: Why Do We Do What We Do?" Invited paper presented at the ASSA meeting, Anaheim, CA, January 5-7, 1993.

Alston, Julian M., and James A. Chalfant. "The Silence of the Lambdas: A Test of the Almost Ideal and Rotterdam Models" *American Journal of Agricultural Economics* 75 (May 1993):304–313.

Becker, Gary S. *Economic Theory.* New York: Knopf, 1971.

Deaton, Angus S., and John M. Muellbauer. *Economics and Consumer Behavior.* Cambridge: Cambridge University Press, 1980.

LaFrance, Jeffrey T. "When is Expenditure 'Exogenous' in Separable Demand Models?" *Western Journal of Agricultural Economics* 16(1991):49-62.

LaFrance, Jeffrey T. "Incomplete Demand Systems, Weak Separability, and Weak Complementarity in Applied Welfare Analysis" Invited paper presented at the ASSA meeting, Anaheim, CA, January 5-7, 1993.

Stone, J. R. N. *The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom, 1920-1938, Vol I.* Cambridge: Cambridge University Press, 1954.

Theil, Henri. *Theory and Measurement of Consumer Demand, Vol. II.* Amsterdam: North-Holland Publishing Co., 1976.

Notes

[1] Deflating all monetary variables by *any* nominal variable—relevant or not—imposes an absence of money illusion.

[2] This use of the CPI presumably introduces some specification error, especially since the CPI is an index of the prices of all $m+n$ goods. However, it is often argued that the resulting estimates of elasticities are not conditional on a separability assumption, since all prices are included. Thus, including the CPI might be preferable to making a separability assumption, although the estimated elasticities are instead conditional on an aggregation assumption.

[3] As already noted, the CPI presumably includes all prices in case 1 as well—including the m prices of direct interest—but this problem is likely to be assumed away in most applications. For some choices of m, an appropriate CPI may be available. For instance, if m denotes all foods, a non-food CPI seems preferable to the one defined for all goods. However, such indices normally would not be available—for instance, m might be the number of meats or beverages, and a non-meat or non-beverage CPI is not readily available or computed.

[4] This latter effect requires knowledge of $\partial\text{CPI}/\partial P_j$—it does not seem appropriate to view this derivative as zero, nor would that condition be sufficient to restore consistency with (1) and (2).

[5] The best one can say is that the CPI represents an irrelevant regressor; a correct restriction was not imposed, so the estimates of the other coefficients remain unbiased, but the estimates

are inefficient and (2) does not hold to the extent that the estimate of $\eta_{1,\mathrm{CPI}}$ differs from zero.

[6] See Deaton and Muellbauer for a discussion. The case they present illustrates an advantage of this approach that emphasizes the problems of large N. One would like simply to drop the n prices from Case 1, and assume that only m prices have non-zero coefficients. The other n could be neither substitutes nor complements. Deaton and Muellbauer note that this does not imply zero Marshallian cross-price elasticities, due to the income effect. It does, however, imply zero compensated cross-price elasticities. Thus, Stone's motive in working with compensated price elasticities was to permit a parsimonious demand equation, making it possible to omit unimportant prices as regressors.

[7] It is important to note that, although (5) is identical to (1) in terms of its economic content, as an empirical matter there may be virture in estimating (5), to measure the Hicksian responses directly. In particular, estimating (5) yields measures of precision of the estimates of the compensated price responses directly, which may be valuable in welfare analysis (e.g., Alston and Larson, 1993).

[8] This specific result is true in the double-log model, but may not hold exactly in other models. Diffferent functional forms for demand may imply different functional forms for the price index to be used to hold real income constant.

[9] The double-log model bears a close relationship to the Rotterdam model, if the parameters of the latter model are viewed as constants. The derivation of the Rotterdam model given in

Deaton and Muellbauer, for instance, begins with the double-log model, although the validity of the double-log model is not necessary for the Rotterdam to be a useful approximation. Thus, rejecting the hypothesis that λ is 0 can also be interpreted as evidence that the data may not be consistent with the Rotterdam model, at least if the parameters of that model are treated as constants. Alston and Chalfant (1993) showed that the systems of demand equations based on the LA and Rotterdam models could be tested in this manner; however, it was necessary to estimate the LA model in first-differenced form, which may not be appropriate. The test based on λ above does not require first-differencing.

[10] We acknowledge the issue identified by LaFrance (1991) and more recently shown to be potentially important empirically (LaFrance, 1993), but our example here is intended to be purely illustrative. We wish to avoid problems of instrument choice, etc., that are created by attempting to deal with the simultaneity that results from endogenous expenditures.

[11] The mean value of beef's share in the meats group is roughly 0.5 over the 23 observations. The point estimate from table 1 for the own-price elasticity of beef demand is -.9 and the income elasticity of beef demand is approximately 1.7. The compensated price elasticity implied by this is thus -.9+0.5*1.7, or roughly -0.05. The estimate in table 2 is not significantly different from this value.

[12] To conserve space, share equation results, corresponding to the restriction that $\lambda = 1$ in table 3, are not reported.

[13] Since these models were estimated with nonlinear methods, due to the nature of the depen-

dent variable in equation (7), the standard errors are based on asymptotic approximations. Thus, some small-sample adjustment may be appropriate. It may be that a better understanding of the small sample behavior of the λ-test would indicate that the share models are satisfactory for chicken and lamb, but we do not have any evidence on what adjustment, if any, might be necessary.

[14] In that case, the appropriate Stone's price index should include the CPI as one of the prices in the index, weighted by the sum of the budget shares of all of the goods whose influence the CPI is meant to measure.

Table 1: Parameter Estimates for the Double-Log Models: Money Income Constant

Parameter	Beef	Pork	Chicken	Lamb
α_i	-4.253*	2.486*	1.514*	-5.874*
	(0.517)	(0.547)	(0.608)	(1.721)
η_{i1}	-0.994*	0.015*	-0.249*	1.110*
	(0.065)	(0.069)	(0.076)	(0.216)
η_{i2}	-0.095	-0.888*	0.167*	0.135
	(0.067)	(0.071)	(0.079)	(0.222)
η_{i3}	-0.185*	0.182*	-0.841*	0.424*
	(0.030)	(0.031)	(0.035)	(0.098)
η_{i4}	0.425*	0.387*	0.633*	-3.183*
	(0.104)	(0.110)	(0.123)	(0.347)
η_{iI}	1.699*	0.305*	0.290*	1.513*
	(0.106)	(0.112)	(0.124)	(0.352)

1 = beef, 2 = pork, 3 = chicken, 4 = lamb. η_{ij}'s denote Marshallian elasticities. η_{iI} denotes the i^{th} good's income (expenditure) elasticity. Estimates of η_{i4} were obtained from the homogeneity restriction. Numbers in parentheses are asymptotic standard errors. * denotes significance at the .05 level, based on asymptotic t-ratios.

Table 2: Parameter Estimates for the Double-Log Models: Real Income Constant

Parameter	Beef	Pork	Chicken	Lamb
α_i	-5.896*	2.078*	0.908	-7.418*
	(0.797)	(0.658)	(0.701)	(2.130)
η_{i1}^*	0.005	0.204*	-0.050	2.007*
	(0.106)	(0.087)	(0.093)	(0.283)
η_{i2}^*	0.556*	-0.772*	0.275*	0.714*
	(0.061)	(0.051)	(0.054)	(0.164)
η_{i3}^*	0.025	0.226*	-0.785*	0.616*
	(0.052)	(0.043)	(0.046)	(0.140)
η_{i4}^*	-0.585*	0.342*	0.561*	-3.336*
	(0.142)	(0.118)	(0.125)	(0.381)
η_{iI}	2.027*	0.387*	0.412*	1.822*
	(0.162)	(0.134)	(0.143)	(0.434)

1 = beef, 2 = pork, 3 = chicken, 4 = lamb. η_{ij}^*'s denote compensated elasticities. η_{iI} denotes the i^{th} good's income (expenditure) elasticity. Estimates of η_{i4}^* were obtained from the homogeneity restriction. Numbers in parentheses are asymptotic standard errors. * denotes significance at the .05 level, based on asymptotic t-ratios.

rameter Estimates for the Compound Models

neter	Beef	Pork	Chicken	Lamb
	1.607*	1.616*	1.167*	1.026*
	(0.037)	(0.057)	(0.007)	(0.001)
	1.228*	1.785*	0.579*	0.128*
	(0.180)	(0.098)	(0.019)	(0.008)
	0.301*	-0.366*	-0.084*	-0.012*
	(0.012)	(0.024)	(0.002)	(0.002)
	-0.221*	0.372*	-0.064*	-0.010*
	(0.019)	(0.041)	(0.003)	(0.001)
	-0.103*	-0.089*	0.143*	-0.002*
	(0.006)	(0.013)	(0.006)	(0.001)
	-0.611*	-0.732*	-0.184*	-0.027*
	(0.062)	(0.044)	(0.005)	(0.002)

icken, 4 = lamb. Numbers in parentheses are asymptotic standard
nce at the .05 level, based on asymptotic t-ratios.