A Double-Hurdle Model of Food Demand
With Endogenous Unit Values

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Abstract

This study develops a unique double-hurdle model of demand for composite food commodities which endogenizes unit values. The model structure allows us to account for the inability to observe such values for non-purchasing households and simultaneously adjusts for quality demand effects reflected in these unit values. Application to Mexican household food expenditure data shows the importance of controlling for the quality of composite goods. We find that poultry and pork expenditures depend on both quantity demanded and quality desired.

Key words: double-hurdle, unit value, household survey data, composite commodity, food demand, quality effects
Modeling the Household Food Purchase Process 
With Endogenous Unit Values

There are an increasing number of cross-sectional surveys of food purchase behavior, especially those associated with developing countries, where both quantity and expenditure data are collected. Division of observed expenditures by quantity (here referred to as unit-value) is often used as an estimate of a commodity’s price (Gould [1996, 1997]; Yen and Roe). Theil, Houthaker, Deaton (1987, 1988), Cox and Wohlgenant, Nelson and others have recognized that this method of calculating price reflects not only differences in market prices faced by each household but also in endogenously determined commodity quality. For example, observed differences in price paid for cheese across households may be reflecting not only local market conditions but also final product form. Households purchasing cheese in block form would be expected to pay a lower price than households purchasing cheese that is pre-sliced or shredded, ceteris paribus given increased manufacturer value-added.

As Nelson notes, the portion of product price determined by market forces is beyond the control of the consumer whereas the quality portion is endogenous to the purchase process. To assist in differentiating between these two forces, Nelson presents a review of the consumer purchase process from the perspective of both elementary goods \( x_i \) and composite commodities \( Q_j \) where an elementary good is relatively homogeneous while a composite commodity encompasses a set of elementary goods that vary according to some characteristic(s) such as flavor, fat content, packaging, or product form. (Nelson, p.1206). An example of an elementary good would be 2% milk purchased in a half gallon size package. In contrast the commodity category fluid milk would represent a composite commodity.

Dong, Shonkwiler and Capps adapt a two-equation model, originally formulated by Wales and Woodland in an analysis of labor supply, to account for selectivity bias in estimating a conditional commodity expenditure equation for a composite good while at the same time endogenizing its unit-value. The resulting two-equation model is an extension of the traditional Tobit model of censored quantity demands where an equation to explain determinants of unit value is simultaneously estimated along with a censored regression. We extend their framework by adopting a variant of Cragg’s double-hurdle model of consumption while endogenizing unit-
values. Under this revised framework and similar to previous double-hurdle models of the purchase process, two hurdles have to be overcome before positive purchases are observed.

A Model of Endogenous Unit Values

We can define the utility (U) maximization problem faced by a household as:

\[
\text{Max } U(x_1, x_2, \ldots, x_R ) \quad \text{s.t. } \sum_{i=1}^{R} p_i x_i = Y
\]

where \( p_i \) is the price of the \( i^{th} \) elementary good, \( R \), the total number of goods and \( Y \), income.

As an alternative, Nelson, using Hicks’ composite commodity theorem, shows that if we assume that within each composite commodity, the prices of all elementary goods vary proportionally, then:

\[
p_i = P_* p_i^* ; \quad i \in j \quad \text{and} \quad Q_j = \sum_{i \in j} p_i^* x_i
\]

where \( p_i^* \) is the base price of elementary good \( x_i \), which Thiel refers to as a quality indicator and \( P_* \) is the \( j^{th} \) composite good’s group specific price level proportionality factor. From (2), we can represent the consumer’s optimization problem in terms of composite goods as:

\[
\text{Max } U(Q_1, Q_2, \ldots, Q_s ) \quad \text{s.t. } \sum_{j=1}^{S} P_j Q_j = Y \Rightarrow Q_j = Q_j(P, Y)
\]

where \( P \) is an \( S \)-vector of composite commodity prices and \( S \) the number of commodities.

Since both \( P_j \) and \( Q_j \) are not observable, the demand for \( Q_j \) can not be estimated directly. However, expenditures on the \( j^{th} \) composite commodity \( (E_j) \) and resulting unit values, \( V_j \), are observed and can be related to expenditures on the associated elementary goods via the following:

\[
E_j = \sum_{i \in j} p_i x_i = \sum_{i \in j} P_j p_i^* x_i = P_j \sum_{i \in j} p_i^* x_i = P_j Q_j \Rightarrow V_j = \frac{P_j Q_j}{q_j}
\]

where \( q_j = \sum_{i \in j} x_i \), and is the observed physical quantity of composite commodity \( j \).

These unit values will not be exogenous given that they depend on the endogenously determined quality of each composite commodity. As shown by Nelson and by Dong, Shonkwiler and Capps, a quantity-weighted sum of elementary goods base prices can be used as a measure of average quality of a particular composite commodity \( (\psi_j) \). That is:

\[
\psi_j = \sum_{i \in j} \left( \frac{x_i}{q_j} \right) p_i^* = \frac{Q_j}{q_j}
\]
Combining (4) and (5) the relationship between unit value and quality is:

$$\ln V_j = \ln P_j + \ln \psi_j$$

where the first component of (6) is assumed constant within the jth composite commodity via (2).

Using a single commodity framework, Dong, Shonkwiler and Capps incorporate the above into a model originally formulated by Wales and Woodland to account for selectivity bias in estimating a conditional commodity expenditure equation for a composite good while at the same time endogenizing unit-value. Under their two-equation model, a unit value regression equation is formulated as is a conditional expenditure function where expenditure and unit-value equation error terms are assumed to be normally distributed and correlated via a full error covariance matrix. Under their formulation household expenditure on a particular commodity is represented as:

$$E = \begin{cases} \alpha X^E + \alpha_v \ln V + \mu_E & \text{if } \mu_E > -\alpha X^E - \alpha_v \ln V \\ 0, & \text{otherwise} \end{cases}$$

where $X^E$ is a vector of household characteristics, $\alpha$ and $\alpha_v$ are estimated coefficients and $\mu_E$ is expenditure error term. For non-purchasing households unit-values are not observed and the relationship in (6) can be represented as:

$$\ln V = \beta X^V + \mu_v \text{ if } \mu_E > -\alpha X^E - \alpha_v \ln V$$

where $X^V$ is a vector of household characteristics, $\beta$ a vector of estimated coefficients and $\mu_v$ an error term. From (6) the intercept term in (8) can be interpreted as a proxy for $\ln P$.

Combining (7) and (8), Dong, Shonkwiler and Capps assume the error terms are joint normal with mean vector 0 and covariance matrix

$$\begin{pmatrix} \sigma_{EE} & \sigma_{EV} \\ \sigma_{EV} & \sigma_{VV} \end{pmatrix}$$

where $\sigma_{jk}$ is the covariance of the jth and kth error terms.

Parameters of the expenditure and price equations in (7) and (8) are estimated within a single likelihood function encompassing all observations.

**The Discrete Purchase Process and Endogenous Unit Values**

The above discussion has implicitly assumed that all goods are contained in each consumer’s utility function. Given our use of household level data, we relax this assumption.
As such we adopt the double-hurdle model of consumer purchase behavior originally presented by Cragg, reviewed by Blundell and Meghir and recently applied to a variety of household-based analyses of consumer demand (Blaylock and Bisard, Jones, Yen and Su, Yen and Jones). Under this model, observing a zero-valued purchase outcome is not only considered a typical corner solution but also may be the result of the decision not to participate in the market. This implies that only market participants determine demand curve parameters.

It is assumed that for a given household the following preference relation, \( U^{**} \) exists:

\[
U^{**} = D_j U \left( Q_j, Q_{-j} \left| \sum_{j=1}^{S} P_j Q_j = Y \right. \right) + (1-D_j) U^* \left( Q_{-j} \left| \sum_{j=1}^{S} P_{-j} Q_{-j} = Y \right. \right)
\]

where \( U(.) \) and \( U^*(.) \) are the utility functions of potential market participants and non-participants of commodity \( j \) respectively, \( D_j = 1 \) if the household is a potential purchaser of commodity \( j \), the vector \( Q_{-j} \) represents all commodities except commodity \( Q_j \). If the household is not a market participant \( (D_j = 0) \), \( Q_j \) does not affect preferences. For market participants \( (D_j = 1) \), they solve the problem defined in (3) (Pudney, p.161).

Following Pudney, one can model the discrete participation decision using the familiar probit structure:

\[
D_j = \begin{cases} 
1, & \text{if } \Gamma = v X^\Gamma + \mu_F > 0, \\
0, & \text{otherwise}
\end{cases}
\]

where \( X^\Gamma \) is a vector of household characteristics, \( v \) estimated coefficients, and \( \mu_F \) an error term.

The endogenization of unit values can be accomplished by incorporating (10) with (7) and (8). The combined model structure can then be represented via the following:

**Observed Expenditures:** \( E = D E^* \)

**Participation Equation:** \( D = \begin{cases} 
1, & \text{if } \Gamma = v X^\Gamma + \mu_F > 0, \\
0, & \text{otherwise}
\end{cases} \)

**Expenditure Equation:** \( E^* = \begin{cases} 
\alpha X^E + \alpha_v \ln V + \mu_E \text{ if } \{ \mu_E > -\alpha X^E - \alpha_v \ln V \} \\
0, & \text{otherwise}
\end{cases} \)

**Unit Value Equation:** \( \ln V = \beta X^V + \mu_V \text{ if } \{ \mu_E > -\alpha X^E - \alpha_v \ln V \} \)
Under this model, two hurdles have to be overcome before positive expenditure values are observed: (i) be a potential consumer (\( \Gamma > 0 \)); and (ii) be an actual consumer (\( E^* > 0 \)).

**Derivation of the Likelihood Function**

Similar to the derivation of the likelihood function under the traditional double-hurdle model we segment the likelihood function into components associated with non-purchasing versus purchasing households. If we assume the three error terms \( \{ \mu_\Gamma, \mu_E, \mu_V \} \) are distributed trivariate normal with mean 0, and variance-covariance matrices as: 

\[
\Omega^D = 
\begin{bmatrix}
\sigma_{\Gamma \Gamma} & \sigma_{\Gamma E} & \sigma_{\Gamma V} \\
\sigma_{\Gamma E} & \sigma_{EE} & \sigma_{EV} \\
\sigma_{\Gamma V} & \sigma_{EV} & \sigma_{VV}
\end{bmatrix},
\]

the sample likelihood function (LF) for this model can be represented as:

(12) \[ \text{LF} = \prod_{0} \text{Prob}(E = 0) \prod_{0} \text{Prob}(E > 0) \Phi \left( E^*, \ln V, \Gamma \mid E > 0 \right) \]

where the first component is applied to nonpurchasing households and represents the probability of not purchasing. For purchasing households the contribution to the likelihood function is the probability of observing a purchase times the conditional joint probability density function of expenditures, the unit-value and the discrete participation decision.

In this model, the probability of a household not purchasing, \( \text{Prob}(E = 0) \), equals the probability of not being a market participant (i.e., \( \text{Prob}(D =0) \)) plus the probability of being a market participant but not purchasing (i.e., \( \text{Prob}(D =1 \text{ but } E^* \leq 0) \)). After substituting the unit value equation into the conditional expenditure equation, this probability can be represented as:

\[
\text{Prob} \left( E = 0 \right) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \Phi_3 \left( \mu_\Gamma, \mu_V, \mu_E \right) d\mu_\Gamma d\mu_V d\mu_E + \\
\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \{ \cdot \alpha X^E - \alpha V \beta X^V \} d\mu_\Gamma d\mu_V d\mu_E \\
\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \Phi_3 \left( \mu_\Gamma, \mu_V, \mu_E \right) d\mu_\Gamma d\mu_V d\mu_E + \\
\int_{-\infty}^{\infty} \{ \cdot \alpha X^E - \alpha V \beta X^V \} d\mu_\Gamma d\mu_V d\mu_E \\
= \int_{-\infty}^{\infty} \Phi \left( \mu_\Gamma \right) d\mu_\Gamma + \\
\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \Phi_2 \left( \mu_\Gamma, \mu_E \right) d\mu_\Gamma d\mu_E.
where \( \mu^*_E = \alpha_v \mu_v + \mu_E \), \( \phi(\mu) \) is the marginal pdf of \( \mu \), \( \phi_3(\cdot) \) is the joint pdf of \( \mu, \mu_v \), and \( \mu^*_E \).

\( \phi_2(\cdot) \) is the joint PDF of \( \mu \) and \( \mu^*_E \) with mean 0 and variance-covariance matrix:

\[
\Sigma = \begin{bmatrix}
\Sigma_{11} & \Sigma_{12} \\
\Sigma_{12} & \Sigma_{22}
\end{bmatrix}; \quad \Sigma_{11} = \sigma_{\Gamma \Gamma}; \quad \Sigma_{22} = \alpha_v^2 \sigma_{VV} + 2 \alpha_v \sigma_{EV} + \sigma_{EE}; \quad \text{and} \quad \Sigma_{12} = \alpha_v \sigma_{TV} + \sigma_{\Gamma E}
\]

The probability of not observing a purchase can be simplified to:

\[
\text{Prob}(E = 0) = \Phi\left(-\frac{u \Gamma + \mu}{\sqrt{\Sigma_{11}}}\right) + \Phi\left(-\frac{u \Gamma + \mu}{\sqrt{\Sigma_{22}}}\right) - \int_{-\infty}^{\infty} \int_{-\infty}^{0} \phi_2(\mu, \mu^*_E) \mu \mu^*_E d\mu d\mu^*_E
\]

where \( \Phi(\cdot) \) is the univariate standard normal distribution function.

The component of the likelihood function for consuming households can be transformed to the following as the Jacobian from \( (E^*, \ln V, \Gamma) \) to \( (\mu_E, \mu_V, \mu_D) \) is unity:

\[
(15) \quad f(E^*, \ln V, \Gamma | E > 0) = \frac{\phi^E_{\mu \mu\mu}(\mu_{\Gamma}, \mu_E, \mu_V)}{\text{Prob}(E > 0)}
\]

where:

\[
(16) \quad \phi^E_{\mu \mu\mu}(\mu_{\Gamma}, \mu_E, \mu_V) = \int_{-\infty}^{\infty} \phi(\mu_{\Gamma}, \mu_E, \mu_V) d\mu_{\Gamma} = \phi^E_{\mu \mu\mu}(\mu_E, \mu_V) \int_{-\infty}^{\infty} \phi_{\mu_{\Gamma} | \mu_{EV}}(\mu_{\Gamma} | \mu_{EV}) d\mu_{\Gamma}
\]

and \( \phi^E_{\mu \mu\mu}(\mu_E, \mu_V) \) is the joint pdf of \( \mu_E \) and \( \mu_V \) with mean 0 and covariance matrix

\[
\Omega_2 = \begin{bmatrix}
\sigma_{EE} & \sigma_{EV} \\
\sigma_{EV} & \sigma_{VV}
\end{bmatrix}; \quad \mu_{\Gamma | \mu_{EV}} = \Omega_{12} \Omega_{22}^{-1} \begin{bmatrix}
\mu_E \\
\mu_V
\end{bmatrix} \quad \text{and} \quad \sigma_{\Gamma | \mu_{EV}} = \Omega_1 - \Omega_{12} \Omega_{22}^{-1} \Omega_{12}';
\]

\( \Omega_1 = \sigma_{\Gamma \Gamma} \); and \( \Omega_{12} = \sigma_{\Gamma E} \sigma_{\Gamma V} \).

**Application of the Model to Mexican Food Demand**

We apply the dependent version of the above model using the likelihood function in (12) to an analysis of Mexican household food purchases. In particular, we apply our model to
household purchases of pork and poultry products. The household survey data used was obtained from the 1994 *Encuesta Nacional de Ingreso y Gastos del Hogar* [ENIGH] (Household Income and Expenditure National Survey) collected by the Instituto Nacional de Estadística, Geografía e Informática (INEGI) between August-November, 1994. This is a nation-wide survey where surveyed households maintain a weekly diary of expenditures on a detailed set of food and non-food items. Our sample consisted of approximately 11,800 households. Table 1 provides an overview of the exogenous variables used in the analysis.

The structure of Mexican poultry and pork demand is characterized using parameter estimates obtained from the maximization of (12). The GAUSS software system was used to obtain parameter estimates. We assumed \( \sigma_{ug} \), the variance of the error term in the participation equation to be 1 as has typically been assumed in previous applications of similar models (Blaylock and Bilsard, 1992, 1993). Heteroskedasticity was accounted for by modeling the standard deviation of expenditure equation as a function of income and family size. The income and household size standard deviation coefficients were statistically significant for both commodities.

Since the double-hurdle model used in this study nests the single hurdle approach used by Dong, Shonkwiler and Capps we conducted a likelihood ratio test to determine if the additional explanatory power of our approach is statistically greater than that observed under the earlier specification. The resulting \( \chi^2 \) statistic shows that the double hurdle model dominates the single hurdle approach. The household characteristics included in the analysis appear to explain a significant portion of both the discrete and continuous portions of the purchase process. Over 69% of the estimated coefficients were statistically significant in the poultry equation and more than 43% in the pork equation. As hypothesized we found household income had a positive impact on both poultry and pork unit values while household size resulted in lower unit values. Both variables have positive estimated coefficients in the conditional expenditure equations. In contrast they differ in signs when comparing the market participation equation. For poultry, HHINC generated a positive coefficient while HHSIZE generated a negative coefficient. The opposite pattern was observed for these variables with respect to pork.

There appears to be significant regional variation in market prices (and therefore unit
values) given a large number of statistically significant regional dummy variables. Household composition was also found not to impact the market participation decisions as evidenced by non of the 5 composition-related variables being statistically significant in either equation. Composition did have an impact on conditional expenditures however. With the variable PER25_44 used as a base, statistically significant positive coefficients for the variables PER45_65 and PERGT65 were obtained in the poultry expenditure equation while significant and negative PERLT5 and PER5_15 coefficients were obtained in the pork equation.

Occupation was found to impact the poultry market participation decision. Using AGRICUL households as the base, four of the five occupation dummy variables were found to have positive and statistically significant coefficients while none were significant in the conditional expenditures equation. Market participation in terms of pork purchases did not appear to be impacted as none of the occupation-related dummy variables was statistically significant. This is similar to the results obtained by Heien, Jarvis and Perali based on 1977 data.

Expenditure, quantity and probability elasticities are also evaluated at the mean levels of the exogenous variables (Table 2). The first column contains the elasticity of the endogenously determined unit values to changes in income and household size. Both sets showed a relatively inelastic impact on unit values to variable changes. The next 7 columns of this table provide the impact on poultry and pork expenditures of changes in Unit Values, HHINC and HHSIZE. The first 3 of these are based on the assumption of a given unit value. Similar to the McDonald and Moffitt’s Tobit decomposition, we add the impacts of exogenous variable changes on the probability of observing an expenditure and conditional expenditures to obtain an estimate of the total impacts. The next 3 columns of elasticities recalculate the income and household size elasticities without the assumption of a given unit value.

As shown in equation (6), unit values are composed of two parts: exogenous price and endogenous quality. This implies that a change of unit value is the sum of the change in price and quality. For instance, a negative change in poultry’s price due to lower costs of raising chicken may be offset by a positive change in the purchased poultry products (high quality cuts) due to relatively higher income in the household, consequently a positive change in the unit value can be observed. Therefore a positive demand elasticity with respect to the unit value may not necessarily
imply the commodity is a Giffen good.

The last two columns of Table 2 provide estimates of both the unit value, household income and household size impacts on quantity demanded. In contrast to Heien, Jarvis and Perali’s analysis of “meat” purchases we find relatively income inelastic poultry and pork demand. We also find relatively inelastic unit value demand elasticities.

**Summary and Conclusions**

We have presented a method which allows for an analysis of not only whether or not to purchase a particular commodity and the amount to purchase but also the endogenous choice of quality of the product consumed where quality can be defined in terms of such variables as level of processing, product form, packaging, and/or nutrient content. We have applied this analysis to Mexican household demand for poultry and pork products. Our model can be expanded in a number of areas both from a methodological and analysis perspective.

First, from a methodological standpoint we need to expand the analysis from a single commodity to a demand systems framework. Although there have been recent advances made in the analysis of demand systems in the presence of significant censoring of commodity demands, estimation of such models continues to represent an area of research that is numerically intensive (Yen and Roe, Gould, 1996). Adding to this, the problem of endogenizing unit-values, significantly increases the complexity of the estimation process. A second area of extension is with respect to the use of the quality measure applied here to adjust the quantity purchased. In this application we have limited our analysis to unit values which represents a quality adjusted market price. How can we use this quality measure to adjust the physical quantity purchased to a “quality adjusted” quantity? This is important to examine the impacts of changes in incomes and market prices on commodity demand.

Our application to Mexican food demand shows the importance of controlling for the quality of composite goods typically used in demand analyses. For example, we found that as household size increases, there is a positive impact on conditional expenditures while at the same time there is a negative impact on product “quality”. The net impact on quantity demanded will depend on the relative strength of these two forces.
Table 1. Values of Exogenous Variables Used in the Econometric Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Equation</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Household Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HHINC</td>
<td>Quarterly household income (peso)</td>
<td>V, E, D</td>
<td>6,037</td>
<td>5,958</td>
</tr>
<tr>
<td>REFRIG</td>
<td>Household owns a refrigerator/freezer (0/1)</td>
<td>E,D</td>
<td>0.635</td>
<td>-----</td>
</tr>
<tr>
<td>HHSIZE</td>
<td>Number of household members (#)</td>
<td>V,E,D</td>
<td>4.65</td>
<td>2.33</td>
</tr>
<tr>
<td>METRO_1</td>
<td>Reside in major metropolitan area (0/1)</td>
<td>V</td>
<td>0.387</td>
<td>-----</td>
</tr>
<tr>
<td>METRO_2</td>
<td>Reside in area with more than 100,000 (0/1)</td>
<td>V</td>
<td>0.135</td>
<td>-----</td>
</tr>
<tr>
<td>METRO_3</td>
<td>Reside in area with population of 15,000-99,999 (0/1)</td>
<td>V</td>
<td>0.092</td>
<td>-----</td>
</tr>
<tr>
<td>METRO_4</td>
<td>Reside in area with population of 2,500-15,000 (0/1)</td>
<td>V</td>
<td>0.147</td>
<td>-----</td>
</tr>
<tr>
<td>METRO_5</td>
<td>Reside in area with population less than 2,500 (0/1)</td>
<td>V</td>
<td>0.239</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO_ED</td>
<td>Have not attended a formal school (0/1)</td>
<td>V,D</td>
<td>0.165</td>
<td>-----</td>
</tr>
<tr>
<td>SOME_ED</td>
<td>Have some education but did not complete primary (0/1)</td>
<td>V,D</td>
<td>0.269</td>
<td>-----</td>
</tr>
<tr>
<td>PRIME_ED</td>
<td>Have a minimum of a primary education (0/1)</td>
<td>V,D</td>
<td>0.256</td>
<td>-----</td>
</tr>
<tr>
<td>SEC_ED</td>
<td>Have completed secondary education (0/1)</td>
<td>V,D</td>
<td>0.152</td>
<td>-----</td>
</tr>
<tr>
<td>ADV_ED</td>
<td>Have post-secondary education (0/1)</td>
<td>V,D</td>
<td>0.158</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Occupation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROFTECH</td>
<td>Professional, technical (0/1)</td>
<td>D,E</td>
<td>0.070</td>
<td>-----</td>
</tr>
<tr>
<td>MERCHANT</td>
<td>Merchant, salesperson (0/1)</td>
<td>D,E</td>
<td>0.119</td>
<td>-----</td>
</tr>
<tr>
<td>SERVICES</td>
<td>Personal services (0/1)</td>
<td>D,E</td>
<td>0.152</td>
<td>-----</td>
</tr>
<tr>
<td>MANGADM</td>
<td>Manager, administrator (0/1)</td>
<td>D,E</td>
<td>0.089</td>
<td>-----</td>
</tr>
<tr>
<td>NONAGWK</td>
<td>Non-agricultural laborer (0/1)</td>
<td>D,E</td>
<td>0.363</td>
<td>-----</td>
</tr>
<tr>
<td>AGRICUL</td>
<td>Agricultural worker (0/1)</td>
<td>D,E</td>
<td>0.207</td>
<td>-----</td>
</tr>
</tbody>
</table>

(Continued)
Table 1. Values of Exogenous Variables Used in the Econometric Model (continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Equation</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Household Composition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PERLT5</td>
<td>Percent of Household Members Less Than 5 Years Old (%)</td>
<td>D,E</td>
<td>10.8</td>
<td>15.1</td>
</tr>
<tr>
<td>PER6_15</td>
<td>Percent of Household Members Between 6 and 15 Years Old (%)</td>
<td>D,E</td>
<td>22.2</td>
<td>21.9</td>
</tr>
<tr>
<td>PER16_24</td>
<td>Percent of Household Members Between 16 and 24 Years Old (%)</td>
<td>D,E</td>
<td>18.1</td>
<td>22.0</td>
</tr>
<tr>
<td>PER25_44</td>
<td>Percent of Household Members Between 25 and 44 Years Old (%)</td>
<td>D,E</td>
<td>27.1</td>
<td>23.0</td>
</tr>
<tr>
<td>PER45_65</td>
<td>Percent of Household Members Between 45 and 65 Years Old (%)</td>
<td>D,E</td>
<td>15.3</td>
<td>24.4</td>
</tr>
<tr>
<td>PERGT65</td>
<td>Percent of Household Members Older than 65 Years Old (%)</td>
<td>D,E</td>
<td>6.5</td>
<td>19.8</td>
</tr>
<tr>
<td><strong>Region of Residence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REGION_1</td>
<td>Baja California, Baja California Sur, Nayarit, Sinaloa, Sonora (0/1)</td>
<td>V,D</td>
<td>0.087</td>
<td>-----</td>
</tr>
<tr>
<td>REGION_2</td>
<td>Chihuahua, Durango, San Luis Potosi, Tamaulipas, Zacatecas (0/1)</td>
<td>V,D</td>
<td>0.108</td>
<td>-----</td>
</tr>
<tr>
<td>REGION_3</td>
<td>Coahuila, Nuevo Leon, Tabasco (0/1)</td>
<td>V,D</td>
<td>0.090</td>
<td>-----</td>
</tr>
<tr>
<td>REGION_4</td>
<td>Veracruz (0/1)</td>
<td>V,D</td>
<td>0.079</td>
<td>-----</td>
</tr>
<tr>
<td>REGION_5</td>
<td>Aguas Calientes, Colima, Jalisco, Michoacan (0/1)</td>
<td>V,D</td>
<td>0.137</td>
<td>-----</td>
</tr>
<tr>
<td>REGION_6</td>
<td>Guanajuato, Hidalgo, Queretaro (0/1)</td>
<td>V,D</td>
<td>0.073</td>
<td>-----</td>
</tr>
<tr>
<td>REGION_7</td>
<td>Campeche, Chiapas, Quintana Roo, Yucatan (0/1)</td>
<td>V,D</td>
<td>0.064</td>
<td>-----</td>
</tr>
<tr>
<td>REGION_8</td>
<td>Oaxaca, Puebla, Tlaxcala (0/1)</td>
<td>V,D</td>
<td>0.084</td>
<td>-----</td>
</tr>
<tr>
<td>REGION_9</td>
<td>Guerrero, Estado de Mexico, Morelos (0/1)</td>
<td>V,D</td>
<td>0.171</td>
<td>-----</td>
</tr>
<tr>
<td>REGION_10</td>
<td>Distrito Federal (0/1)</td>
<td>V,D</td>
<td>0.106</td>
<td>-----</td>
</tr>
</tbody>
</table>

Note: The means are weighted means using weights supplied in the ENIGH data set. “V, E, and D” identifies whether this variable is used as an exogenous variable in the unit-value (V), conditional expenditure (E) and/or discrete purchase regression (D).
Table 2. Comparison of Various Elasticities Obtained From the Dependent Model Specification

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit Value</th>
<th>Expenditure</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Conditional on Unit value</td>
<td>Unconditional on Unit value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$E(V)^a$ $E(V</td>
<td>E&gt;0)^b$ $E(V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prob$(E&gt;0</td>
<td>V)$ $E(E</td>
</tr>
</tbody>
</table>

**Poultry**

| Unit Value | $E(V)^a$ | $E(V|E>0)^b$ | $E(V|E<0)^c$ | $E(V)^d$ | $E(V|E>0)^e$ | $E(V|E<0)^f$ | $E(V)^g$ | $E(V|E>0)^h$ | $E(V|E<0)^i$ |
|------------|----------|---------------|---------------|----------|---------------|---------------|----------|---------------|---------------|
| HHINC      | 0.104    | 0.069         | 0.137         | 0.206    | 0.102         | 0.151         | 0.253    | 0.047         | 0.033         |
| HHSIZE     | -0.035   | 0.254         | 0.319         | 0.573    | 0.230         | 0.298         | 0.528    | -0.045        | 0.354         |

**Pork**

| Unit Value | $E(V)^a$ | $E(V|E>0)^b$ | $E(V|E<0)^c$ | $E(V)^d$ | $E(V|E>0)^e$ | $E(V|E<0)^f$ | $E(V)^g$ | $E(V|E>0)^h$ | $E(V|E<0)^i$ |
|------------|----------|---------------|---------------|----------|---------------|---------------|----------|---------------|---------------|
| HHINC      | 0.082    | 0.252         | 0.051         | 0.303    | 0.311         | 0.075         | 0.386    | 0.083         | -0.031        |
| HHSIZE     | -0.121   | 0.291         | 0.235         | 0.526    | 0.246         | 0.211         | 0.457    | -0.069        | 0.356         |

a. Elasticity of unit value obtained from equation (23);  b. Conditional elasticity of positive purchase probability given unit value obtained from equation (20);  c. Conditional elasticity of positive expenditures given unit value obtained from equation (18);  d. Conditional elasticity of expenditure given unit value obtained from equation (19);  e. Unconditional elasticity of positive purchase probability obtained from equation (14);  f. Unconditional elasticity of positive expenditure obtained from equation (22);  g. Unconditional elasticity of expenditure obtained from equation (22).
References


