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India Edible Oil Consumption: A Censored Incomplete Demand Approach

Suwen Pan, Samarendu Mohanty, and Mark Welch

A Censored Incomplete Demand System is applied to household expenditures for edible oil in India. The results show that edible peanut oil is still a luxury good in India, whereas expenditure elasticities for other edible oils are relatively low. The food habit, location, education of household heads, and other demographic variables have significant effects on the choice of edible oils.

Key Words: Censored Incomplete Demand System, India edible oil, unit value

JEL Classifications: C21, D1, Q11

India is the second largest importer of edible oil in the world, ranking just behind China. In 2002/2003, India accounted for 15% of global vegetable oil imports. Vegetable oil imports represented about 55% of India's edible oil consumption and about half the value of its total agricultural imports. A large population, steady economic growth, trade policy reforms in the early 1990s, and domestic programs that favored the production of cereals have contributed to the 10-fold increase in vegetable oil imports in the last decade. Despite being the world's second largest importer, Indian per capita edible oil consumption remains low relative to many other developing countries. For example, Indian per capita edible oil consumption was 11.2 kilograms in 2004/2005 compared to 15.8 kilograms in China and 16.3 kilograms in Indonesia (FAS). Similarly, U.S. and European Union per capita consumption in the same year were 29.6 and 18.8 kilograms, respectively.

Palm oil accounts for the majority of Indian vegetable oil imports because of its lower price, logistical advantages, contractual flexibility, and consumer acceptance (FAS). On average, the price of palm oil is 20–30% cheaper than other oils such as peanut and canola (FAPRI). However, in recent years, other edible oils have been slowly making inroads into the Indian market, partly because of a growing middle class population who are increasingly health conscious in their food habits. Domestic soy oil consumption has increased more than fivefold in the last decade, rising from 555 thousand metric tons (tmt) in 1994/1995 to 2,775 tmt in 2004/05 (FAS). Most of the increase in domestic demand has been met by rising imports rather than increased domestic production.

Given the impact of edible oils on the nutritional well-being of individuals, further understanding of edible oil demand behavior at more disaggregate levels would provide valuable information to aid implementation of sound public health and dietary recommendations. This understanding is especially important in a developing country like India where

S. Pan is a research scientist and S. Mohanty is a senior economist and the head of social sciences division at the International Rice Research Institute, Manila, Philippines; M. Welch is an Economist with Texas AgriLife Extension Service, Texas A&M University College Station, TX.

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nutritional deficiencies among its population are prevalent because of widespread poverty. Below average edible oil consumption is seen as one of the factors contributing to the inadequacy of energy and micronutrients in India. Hence, information about disaggregate edible oils demand behavior is essential in designing sound government-initiated nutritional programs to improve the status of malnourished households under the poverty line (Schneeman). Moreover, estimating disaggregate edible oil demand elasticities allows one to more accurately calculate implied nutrient elasticities that can consequently be used to design targeted public health and nutrition programs (Huang). Without this type of disaggregate information, public health and nutrition programs can be ineffective and can lead to the inefficient use of public resources.

To better analyze the Indian edible oil market, it is important to understand price and income responses of each vegetable oil along with the effects of demographic variables. Unfortunately, very few studies have focused on Indian edible oil demand analysis. Murty estimated the effects of changes in household size and changes in consumer tastes and preferences on total demand for edible oil and fats using National Sample Survey data (Murty). Similarly, Abdulai, Jain, and Sharma estimated expenditure and price elasticities for edible oils separately in rural and urban settings using household survey data. The results suggested inelastic expenditure elasticities for edible oils in both areas. However, these studies failed to provide own- and cross-price response and demographic effects for specific types of edible oils.

These studies also failed to address several important methodological issues before using survey data for modeling microeconomic relationships. These issues include the unit value problem (Cox and Wohlgenant; Crawford, Laisney, and Preston; Deaton; Dong, Gould and Kaiser); the validities of exogenous assumptions of expenditures and prices in demand analysis (Dhar, Chavas, and Gould); censored demand issues (Chen and Chen; Dong, Gould, and Kaiser; Perali and Chavas; Shonkwiler and Yen; Yen, Kan, and Su); and conformity to the basic properties of a demand system (Dong, Gould, and Kaiser; Yen, Lin, and Smallwood). Results are inconsistent and inefficient if these issues are not considered. For example, high-income consumers may choose better quality edible oils than low-income consumers. From the researcher's point of view, both types of consumers are observed purchasing edible oils, but at different prices. More importantly, each consumer is choosing its own price. Simply treating a unit value as if it were an exogenous price may yield biased and inconsistent estimates (Beatty). We used Deaton's method (Deaton), which is similar to Lewbel's proposal (Lewbel 1989), to deal with the unit value issue (Atella, Menon, and Perali). There are few applications of this method because expenditure surveys do not often include information about physical quantities.

The approach presented in this paper is to overcome these issues by applying the method of Shonkwiler and Yen to include the Lin-Quad incomplete demand system and simultaneously solve it accounting for the unit value problem. Through instrumental variable methods, we accounted for the potential endogeneity issues between food expenditure, unit values, and different edible oil consumption. The advantage of using the Linquad incomplete demand system is that it allows more flexibility and imposes less structure on underlying preferences consistent with the incomplete system than other demand systems such as the Almost Ideal Demand system. Specifically, adding up is not required in this demand system (Agnew). This approach is used in our analysis of Indian edible oil demand to provide estimates of own-price, cross-price, and expenditure elasticities and to analyze the effects of demographic characteristics on the demand for edible oil in India using household sample survey data.

The remainder of this paper is organized as follows: first, a discussion of economic issues and methodology is provided; second, the approach used to estimate Indian edible oil demand is discussed; and third, the results are reported and discussed.

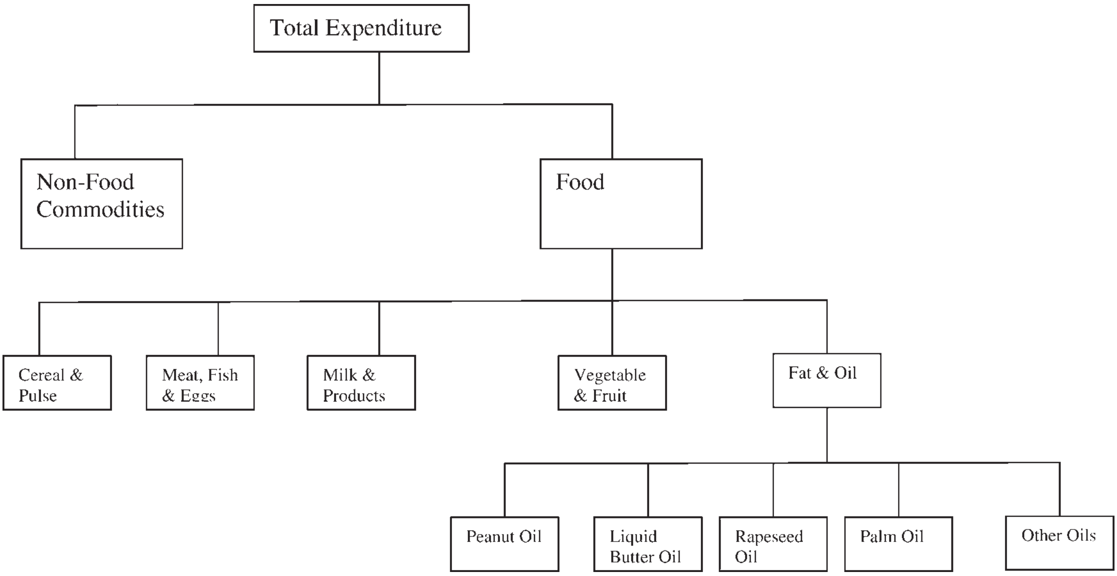

Figure 1. Household Utility Tree of Edible Oil Consumption in India

Economic Issues and Methodology

Economic Issues

Figure 1 provides the conceptual utility tree of edible oil consumption in India for a representative household. Food consumption is assumed to be weakly separable from nonfood consumption and oil consumption is assumed to be weakly separable from other food consumption. This procedure assumes that the consumer's utility maximization decision can be decomposed into three separate stages. In the first stage, total expenditure is allocated over food and nonfood. In the second stage, food expenditure is allocated over edible oils and other foods; and finally, edible oil expenditures are allocated among individual oils.

To estimate the demand system, we begin with the classical utility maximization framework. However, edible oil consumption may include zero expenditures when consumers either choose not to consume some type of edible oil or cannot afford to consume due to budget constraints. To formally model the case, following Kao, Lee, and Pit, let $U(x;\alpha)$ be a utility function with m commodities $x_1, \ldots, x_m$, where α represents unobserved preferences explained by demographic variables of the consumers.

The utility maximization model of the consumer is

$$(1) \qquad \max_x \{U(x;\alpha) : v'x = 1,\ x \geq 0\},$$

where $v = p/M$ is an m-dimensional vector of goods prices normalized by income M. Note that U is strictly increasing and strictly quasi-concave so as to guarantee a unique solution for the demand vector, x^*. Furthermore, assuming that U is continuously differentiable, the demand, x^*, can be characterized by the Kuhn-Tucker conditions.

Let $x^* = (0, \ldots, 0, x^*_{l+1}, \ldots, x^*_m)$ be a demand vector where the first l goods, with $l \geq 0$, are not consumed, and all remaining goods (indexed $l + 1$ through m) are consumed. The Kuhn-Tucker conditions for x^* are

$$(2) \qquad \frac{\partial U(x^*;\alpha)}{\partial x_i} - \lambda v \leq 0 \quad \text{for } i = 1, \ldots, l,$$

$$(3) \qquad \frac{\partial U(x^*;\alpha)}{\partial x_i} - \lambda v = 0 \quad \text{for } i = l + 1, \ldots, m,$$

where λ is the Lagrange multiplier corresponding to the budget constraints. Kuhn-Tucker conditions implicitly provide the demand estimation for different types of edible oils.

Methodology

Before we present the structure of the Incomplete Demand System, we first address the issue of censored survey data.[1] Let the system of equations with four limited dependent variables such as peanut oil, liquid butter oil, rapeseed oil, and palm oil be

$$(4)\quad y^*_{it} = f(\boldsymbol{X_{it}}, \beta_{it}) + \varepsilon_{it},$$

$$(5)\quad d^*_{it} = \boldsymbol{Z'_{it}}\alpha_{it} + v_{it},$$

$$(6)\quad d_{it} = \begin{cases} 1 & \text{if } d^*_{it} > 0 \\ 0 & \text{if } d^*_{it} \leq 0 \end{cases},$$

$$(7)\quad y_{it} = d_{it}y^*_{it}, \quad i = 1, 2, \ldots 4; t = 1, 2, \ldots, T,$$

where, for the *i*th equation and the *t*th observation, y_{it} and d_{it} are the corresponding unit price/expenditure and index for consuming a specific type of oil. $\boldsymbol{X_{it}}$ and $\boldsymbol{Z_{it}}$ are vectors of exogenous variables, β_i, α_i are conformable vectors of parameters, and ε_{it} and v_{it} are random errors. $\boldsymbol{X}$ includes income, urbanization, marriage status, age, and other household characteristics, and $\boldsymbol{Z}$ is a subset of the household characteristics included in $\boldsymbol{X}$. The selection mechanisms can be estimated by using individual Maximum Likelihood (ML) probit based on Shonkwiler and Yen. However, this procedure is not efficient (Chen and Chen; Tauchmann; Yen and Lin). The degree of the inefficiency, however, depends on the degree of the correlation among the error terms. To account for this issue, we adopted a multiprobit model that was easily calculated by *proc Qlim* in SAS. The estimated parameters are then used to calculate the cumulative density functions (CDFs) $\phi(\boldsymbol{Z'_{it}}\ \hat{\alpha})$ and probability density functions (PDFs) $\phi(\boldsymbol{Z'_{it}}\ \hat{\alpha})$, which are used to estimate the second step, such as a demand system and unit value system based on Shonkwiler and Yen.

To estimate edible oil demand, we present three-stage budgeting. In the first stage, total expenditure is allocated over food and nonfood. In the second stage, food expenditure is allocated over edible oil and other food. In the third stage, edible oil expenditure is allocated over peanut oil, liquid butter oil, rapeseed oil, palm oil, and other oils. In this stage a household first decides whether to consume the specific type of oil and, if the decision is made to consume the oil, chooses the optimal quantity. For the first stage, a double-log function of total food expenditure $\boldsymbol{I_f}$ and total income $\boldsymbol{I}$ is estimated:

$$(8)\quad \ln(\boldsymbol{I_f}) = \tau_0 + \tau_1 \ln(\boldsymbol{I}) + \upsilon_1.$$

The expected food expenditure $\hat{\boldsymbol{I}}_{\boldsymbol{f}}$ is used in the second stage. Concurrently, the unit value problem must be addressed because it is obtained from the ratio of its associated expenditure to its associated quantity. There are at least two problems with using such unit value as representative of price: 1) price variation may be due to quality changes that are subject to consumers' choices and 2) truncation and missing regressor difficulties are encountered for those nonconsuming households (Crawford, Laisney, and Preston; Cox and Wohlgenant; Deaton; Dong, Gould, and Kaiser). As suggested by Dong, Shonkwiler, and Capps, unit value is an indicator of the quality that the household desires for the commodity of interest. It is impossible to derive consistent estimates of unit value equations independently from the participation equation because of selectivity and the simultaneity problem.[2] Assume for each *i* that

[1] The Shonkwiler and Yen method presumes a Tobit mechanism as a result of nonconsumption instead of budget constraints as one of the reviewers mentioned. To show this is the case, we checked the relationship between zero consumption and income quantiles (see Table A.1 for details). The results show that zero consumption is evenly distributed at different income levels and further implies that the methodology used is correct.

[2] Figure A.1 presents the estimated densities for the four unit values. Figures A.2 and A.3 present the relationship between the four unit values and income and total food expenditure. Based on those figures, one can see the unit values indeed have some relationships with income level and food expenditures. To see whether unit value is endogenous with expenditure, we use a variant of the Durbin-Wu-Hausman test. In an overwhelming majority of cases, exogeneity of unit value was rejected (p-value = 0.01).

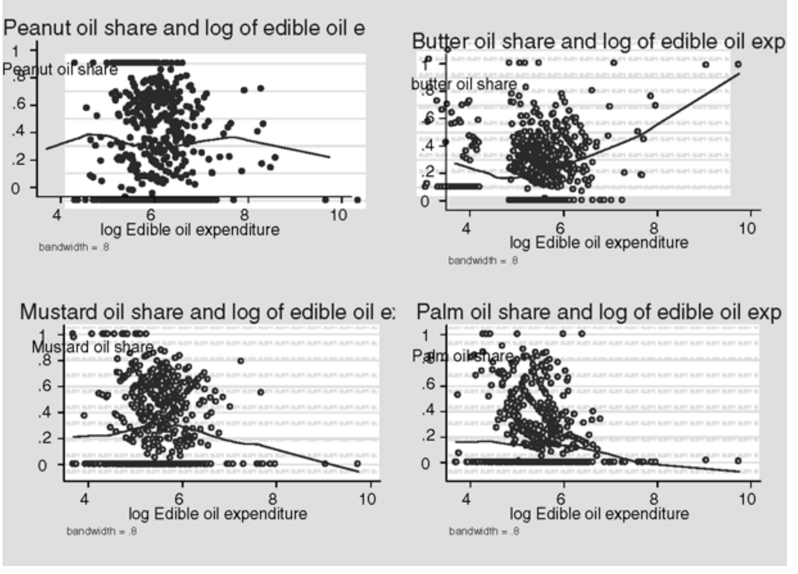

Figure A.1. Nonparametric Engle Curve

the error terms $[\varepsilon_{it}, v_{it}]$ are distributed as bivariate normal with $\text{cov}(\varepsilon_{it}, v_{it}) = \boldsymbol{\delta}_i$. Because we used the sample with actual unit value data to estimate the whole sample price, the following system is used to estimate the price equation and account for the sample selection problem:

$$(9) \quad P_{it} = \Phi(Z'_{it}\hat{\alpha}_i)\gamma(X_{it}\beta_i) + \delta_i\phi(Z'_{it}\hat{\alpha}_i) + \xi_{it},$$

where P_{it} is the unit value of four edible oils. The estimation of $\hat{P}_{it}$ based on the estimated parameters is used in the second and third stages; υ_1 is the error term assumed to be normally distributed. The estimated unit value is used as a representative of price accounting for the quality effects. To solve the identification issue, we use income instead of total expenditure in the equation.

For the second stage, a double-log function of total food expenditure and edible oil expenditure is chosen:

$$(10) \quad \ln(E_f) = \kappa_1 \ln(\hat{I}_f) + \kappa_2 \ln(PI_f) + \upsilon_2,$$

where PI_f and E_f are the aggregate edible oil price index and edible oil expenditure, $\hat{I}_f$ is household expected total food expenditure, and υ_2 is the error term assumed to be normally distributed. The κ's are parameters to be estimated. The price index PI_f is calculated based on the Stone Price Index:

$$(11) \quad \ln(PI_f) = \sum_{k=1}^{n} w_{ik} \ln(\hat{P}_{it}),$$

where $\hat{P}_{it}$ includes the prices of all four type of edible oils and w_{ik} is the relative share of edible oil in different households.

For the third stage, the LinQuad model, developed by LaFrance (1985, 1998; LaFrance and Hanemann; LaFrance et al.), is used. The model has been applied to microlevel data (Fang and Beghin) to estimate Chinese edible oil demand. Popular flexible functional form demand systems do not contain higher-order expenditure terms to capture nonlinearities in the utility effects that have been found to be significant on individual household data (Lyssiotou, Pashardes, and Stengos). A number of studies (Banks, Blundell, and Lewbel; Lyssiotou, Pashardes, and Stengos) have suggested including quadratic functions of income or expenditures in the demand system. Parametric empirical tests of demand system rank include Banks, Blundell, and Lewbel, Hausman, Newey, and Powell, Lyssioto and Pashardes, and Nicol. Nonparametric rank tests are proposed and implemented by Lewbel (1991), Banks, Blundell, and Lewbel, and Donald. Nonparametric kernel regressions for the nonparametric Engle curves of our four edible oil consumptions may be found in the Appendix (Figure A.1). The results indicate

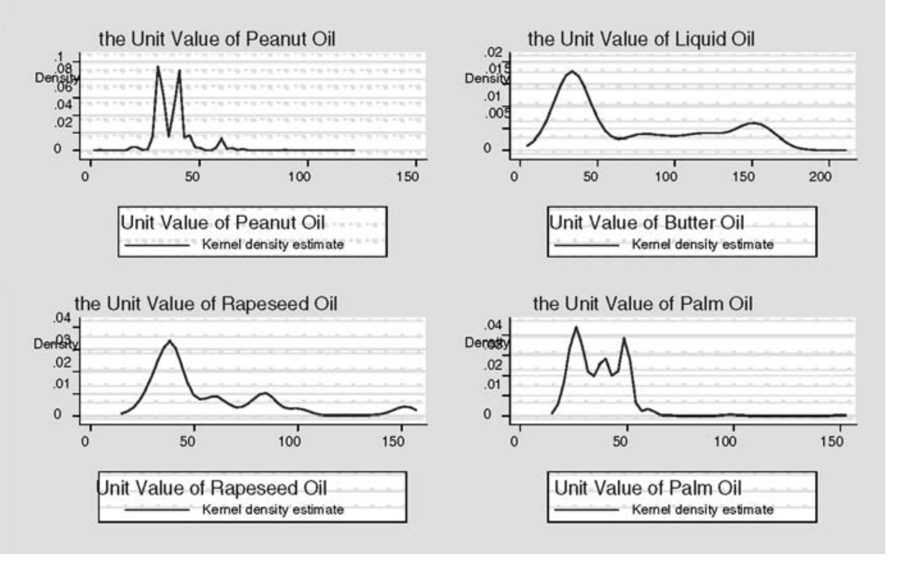

Figure A.2. Empirical Density Function of the Unit Values

nonlinear behavior at least in peanut, butter, and mustard oils. The need for higher-order terms in the Engle curve relationship is also evident from the likelihood ratio test of rank two versus one (with $\chi_4^2 = 13.96$) and rank three versus two (with $\chi_4^2 = 1.14$).

To estimate the demand system based on censored data, we extend the Schonkwiler and Yen method in the demand estimation due to the large number of zero consumption households. The final system of demand to be estimated is as follows:

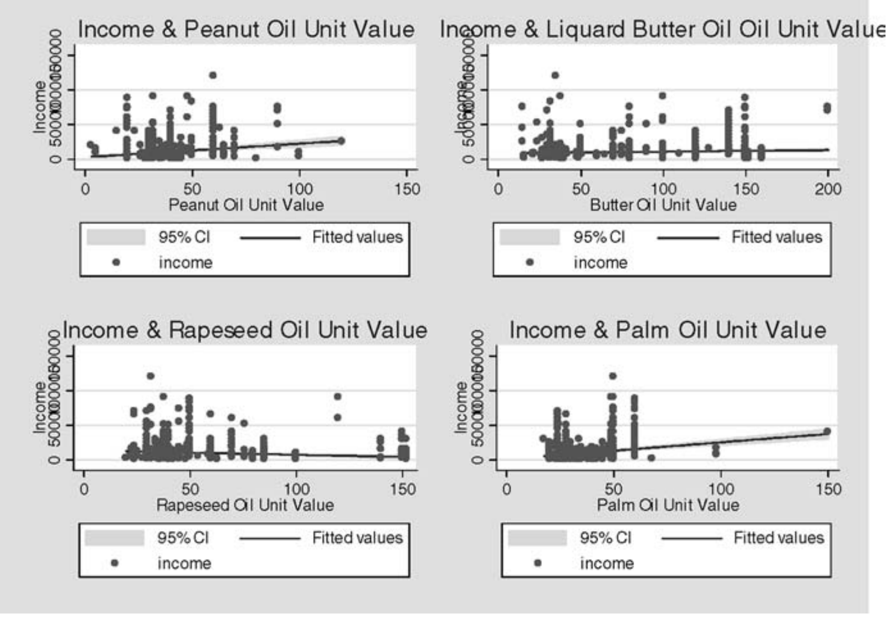

Figure A.3. Effects of Income on the Unit Value

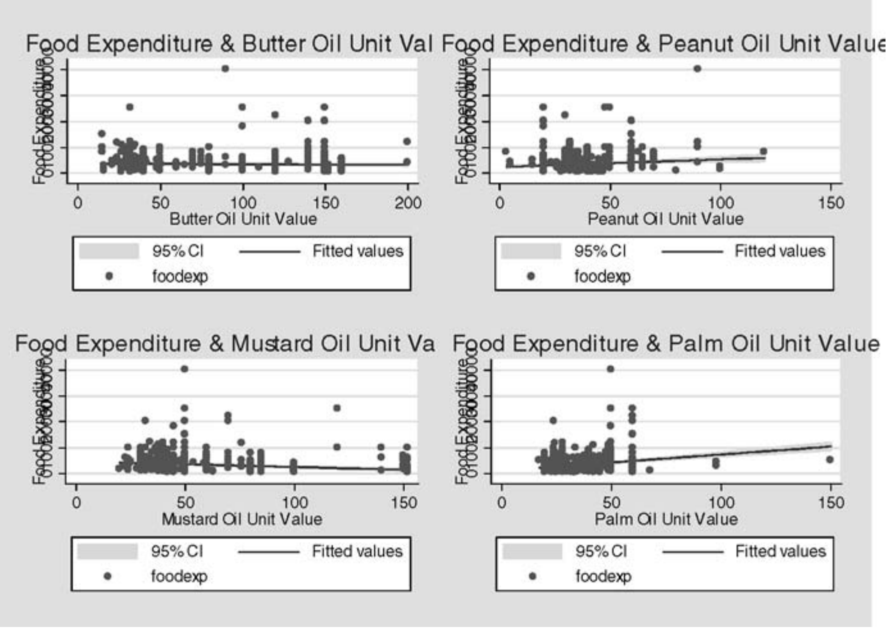

Figure A.4. Unit Value and Total Food Expenditures

$$
\begin{aligned}
e_i = {} & \Phi(Z'_{it}\hat{\alpha}_i)\Big\{P_i\Big\{\alpha_i + A_iR \\
& + B_iP + \gamma_i[\hat{\kappa}_o - P'\alpha - P'AR - 0.5P'BP] \\
& + \pi_i[\hat{\kappa}_o - P'\alpha - P'AR - 0.5P'BP]^2\Big\}\Big\} \\
& + \tau_i\phi(Z'_{it}\hat{\alpha}_i) + u_i,
\end{aligned}
$$

where $i = 1, \ldots, 4$ representing the four types of edible oils, $\boldsymbol{e_i}$'s are expenditures for specific edible oils, $\boldsymbol{P} = \{\boldsymbol{P_1}, \ldots, \boldsymbol{P_n}\}$ are the prices for each edible oil, and B_i and A_i are the corresponding rows of matrices A and B. $\pi_i \ldots \hat{\kappa}_o$ is the total edible oil expenditure, R represents exogenous variables, and u is the error term assumed to be distributed $N(0, \boldsymbol{\Sigma})$. The theoretical demand restriction, homogeneous of degree zero in prices and total edible oil expenditures, is provided by deflating all prices and expenditures by a total edible oil price index. The adding up condition is not a problem for the incomplete demand system because the expenditure in a small group is smaller than total edible oil expenditure. Symmetry of the Slutsky substitution term is imposed by letting $B_{ij} = B_{ji}$ (LaFrance 1998).

By Shepherd's lemma, demands for different edible oils, X_i, are derived as

$$
\begin{aligned}
X_i = {} & \Phi(Z'_{it}\hat{\alpha}_i)\Big\{\Big\{\alpha_i + A_iR + B_iP \\
& + \gamma_i[\hat{\kappa}_o - P'\alpha - P'AR - 0.5P'BP] \\
& + \pi_i[\hat{\kappa}_o - P'\alpha - P'AR - 0.5P'BP]^2\Big\}\Big\} \\
& + \Phi(Z'_{it}\hat{\alpha}_i)\Big\{P_{it}(B_i + \gamma_i[-AR - BP] \\
& + 2\pi_i[-\alpha - AR - BP] \\
& \times [\hat{\kappa}_0 - P'\alpha - P'AR - 0.5P'BP]\Big\}.
\end{aligned}
$$

Because of the complexity of the model structure, the marginal effects of discrete variables have to be computed as the finite changes in the mean level resulting from a change in value of these variables from zero to one. The uncompensated own- and cross-price elasticities, η_{ii} and η_{ij}, associated with Equation (9) and with symmetry imposed are

$$
\begin{aligned}
\eta_{ii} = {} & \Phi(Z'_{it}\hat{\alpha}_i)[\beta_{ii} - \gamma_i(\alpha_i + A_iR + B_iP) \\
& + 2\pi_i(\bar{\kappa}_o - P\alpha - P'AR - 0.5P'BP) \\
& \times (\alpha_i + A_iR + B_iP)]P_i/x_i
\end{aligned}
$$

and

$$
\begin{aligned}
\eta_{ij} = {} & \Phi(Z'_{it}\hat{\alpha}_i)\Big[\beta_{ij} - \gamma_i(\alpha_j + A_jR + B_jP) \\
& + 2\pi_i(\bar{\kappa}_o - P\alpha - P'AR - 0.5P'BP) \\
& \times (\alpha_j + A_jR + B_jP)\Big]P_j/x_i.
\end{aligned}
$$

Table 1. Variable Description (Sample size: 1,192)

Variable Name	Description	Mean	Std. Error
AGE	Age of head of household	44.22	0.34
RUBN	If RUBN = 1, then household is in rural; otherwise urban	0.34	0.01
EDU	Number of years of schooling	13.48	0.04
SNTHERN	If SNTHERN = 1, then household is Muslim, otherwise not	0.15	0.01
NORTH	If NORTH = 1, household is living in north of India; otherwise is in south	0.50	0.01
SEX	If SEX = 1, then head of household is male; otherwise is female	0.96	0.01
MARRIED	If MARRIED = 1, then household head is married; otherwise single	0.98	0.004
FDHABIT	If FDHABIT = 1, then household is vegetarian; otherwise not	0.42	0.01
TOTALEXP	Per capita total expenditure per month ($)	6,466.32	157.71
INCOME	Per capita income per month ($)	10,928.48	643.31
FOODEXP	Per capita food expenditure per month ($)	3,543.59	82.47
FDPRICE	Aggregated food price ($)	16.52	4.16
EDOILEXP	Per capita edible oil expenditure per month ($)	263.87	16.87
GOILEXP	Per capita peanut oil expenditure per month ($)	82.88	3.79
GHEEEXP	Per capita liquid butter oil expenditure per month ($)	74.21	1.42
MOILEXP	Per capita rapeseed oil expenditure per month ($)	72.98	2.84
POILEXP	Per capita palm oil expenditure per month ($)	33.80	1.73

The expenditure elasticities, ε_i, are

$$\varepsilon_i = \Phi(Z'_{it}\hat{\alpha}_i)[\gamma_i y + 2\pi_i(\bar{\kappa}_o - P\alpha - P'AR - 0.5P'BP)] \div x_i.$$

Standard errors of elasticities have been calculated by the Delta method.

To derive the compensated price elasticities $\left(\eta_{ij}^c\right)$, we rely on Slutsky's equation

$$(17) \quad \eta_{ij}^c = \eta_{ij} + \varepsilon_i w_j.$$

Estimation Procedure

As Dong, Shonkwiler, and Capps suggested, unit values may be simultaneously determined with the expenditure decision (Figure A.2, A.3, A.4); therefore the coefficient of the unit value equation is estimated with the expenditure Equation (9). To achieve asymptotically consistent and efficient estimators, we first created an instrumental variable from estimating the expected food expenditure based on Equation (5). The expected value of the price index based on Equation (8) is used to estimate the expected expenditure of edible oil in Equation (7), and then the expected expenditure is included in Equation (9). A Seemingly Unrelated Regression (SUR) is adopted to solve the unit value Equations (6) and the demand system (9).

Data

Data used in this analysis were obtained from a survey administered by the National Institute of Extension Management, Hyderabad, India. The survey was collected from August 2000 to August 2001. A stratified sampling technique was used to select households in urban and rural areas of Secunderab, Adilabad, and Hyderabad in the southern state of Andhra Pradesh and in the urban and rural areas of Mirzapur and Allahabad in the northern state of Uttar Pradesh. Overall, a total of 1,192 observations were included in the analysis. The items included in the survey were household consumption quantity, total expenditure data on various commodities, and demographic characteristics for each sampled household.

Table 1 provides a description of the variables used in the estimation. In the sample

34% of the households lived in rural areas, and 42% were vegetarians. Based on the data, urban per capita income was 2.26 times that of those living in rural areas, per capita food expenditure was 70% higher for urban households compared to rural food expenditures, and urban per capita edible oil expenditures were 31% higher than rural edible oil expenditures. The data also suggest significant variations in the edible oil consumption patterns among urban and rural populations. Rural per capita edible peanut oil consumption was found to be 28% higher than urban, whereas urban per capita liquid butter oil, rapeseed oil, and palm oil consumption was 52%, 54%, and 102% higher than rural per capita consumption, respectively. Overall, per capita edible oil consumption in urban areas was 7.01 kilograms as compared to 5.9 kilograms for rural persons. Of the 1,192 households, only six households (0.5%) consume all four types of edible oils included in the survey, whereas more than 75% of the households consume two or more types of edible oils (Table A.1).[3]

Results and Discussions

Multiple probit estimates for the four types of edible oils are presented in the Appendix (Table A.2). Most of the variables included are significant at the 10% level. The correlation among four types of oils is supported by significant error correlation coefficients for the multivariate probit model by *t*-tests. Households in rural areas are less likely to consume liquid butter oil and more likely to consume palm oil than those in urban areas. The results also indicate the preference of the northern population for peanut oil. Although it might be expected that wealthier persons might be more aware of the health benefits of peanut oil relative to the other edible oils, income appears to play a positive role in determining the consumption of liquid butter oil, but a negative role in rapeseed oil and palm oil. The reason may be due to the price effects from butter oil, important in developing countries because they are more constrained by income. Religion and food habits play important roles in the choice of edible oil consumption. Religion is significant in the choice of rapeseed oil consumption. The positive coefficient implies that Muslims are more likely to use rapeseed oil than others. Vegetarians are more likely to use liquid butter oil and rapeseed oil than peanut oil and palm oil, which may be partly due to protein considerations for vegetarians. Our results are contrary to U.S. studies that show education plays an insignificant role in the consumption of butter (Yen, Kan, and Su). Our results indicate that education is significantly and positively correlated to the consumption of liquid butter oil.

The results of unit value estimation and the parameters of the Quadratic LinQuad model are presented in the Appendix (Tables A.3 and A.4). In assessing the parameter estimates, most of them are statistically significant at 10%. Estimates for the covariance parameters (PDFs) are significant in all of the equations. The results show that it is important to accommodate zero observations in the price/quality estimation. The results are consistent with the first step estimation. All types of unit value for edible oil exhibit a significant income influence with a positive sign in the peanut oil and a negative sign in liquid butter oil, rapeseed oil, and palm oil. Significant impact from urbanization and location (north/south) are indicated for all four types. Education has significant positive effects on peanut oil quality selection and negative effects on the other three types. Religion and food habits also have significant effects on the price and quality of edible oils.

In estimating the first- and second-stage demands, the double-log expenditure system is estimated in shares because this specification is less likely to involve heteroskedasticity than would an expenditure specification (Fan, Wailes, and Cramer; Pollak and Wales). The elasticities are reported in Table 2. Own-price for edible oil is −0.69. Expenditure elasticities

[3] Although the survey asked whether the household consumes other edible oils, only five households answered yes. To simplify our estimation, we ignore this category and assume they consume only from the four categories discussed.

Table 2. Elasticities for the First and Second Stages of Demand Analysis

	Income		Expenditure		Price	
	Elasticity	Std. Error	Elasticity	Std. Error	Elasticity	Std. Error
First stage						
Food	0.57*	(0.02)			−0.59*	(0.02)
Second stage						
Edible oil	0.42*	(0.006)	0.64*	(0.04)	−0.69*	(0.05)

* signifies significant at 10%.

are all less than one, meaning that these goods are considered to be necessity items in the household. Conditional elasticity of edible food expenditure is 0.64, and unconditional income elasticity is 0.42, which is much less than food income elasticities.

Elasticities of the price and expenditure variables are provided in Table 3. All elasticities are calculated at the sample means of variables based on Equations (11)–(14). Income elasticities are calculated based on three-stage estimation. The income elasticity of peanut oil exceeds that of the other edible oils for households in India. All elasticities of total edible oil expenditures are positive and significant with that of peanut oil being higher than unity.

The own-price elasticity of peanut oil is negative, and the absolute value of cross-price elasticity between liquid butter oil and peanut oil is greater than unity. Except for the significance of cross-price elasticities between liquid butter oil and peanut oil, all of the other cross-price elasticities are statistically insignificant. The results imply that the edible oil with the most price-sensitive demand is peanut edible oil and that liquid butter oil is a complementary product to peanut oil. This relationship may be explained by the income effects and consumption behavior of households in India. Most do not use butter oil as cooking oil.

The marginal effects of demographic variables on the different edible oils are presented in Table 4. Comparing these marginal effects, location and food habits (rural, living in the north of India, and/or having a vegetarian

Table 3. Uncompensated and Compensated Price, Expenditure, and Income Elasticities

	Peanut Oil		Liquid Butter Oil		Rapeseed Oil		Palm Oil	
Variables	Elast.	Std. Error	Elast.	Std. Error	Elast.	Std. Error	Elast	Std. Error
Uncompensated price elasticties								
Peanut oil price	−1.27*	(0.41)	−1.14*	(0.27)	0.08	(0.06)	0.020	(0.02)
Liquid butter oil price	−0.66*	(0.20)	−0.58*	(0.24)	0.02	(0.07)	0.07	(0.05)
Rapeseed oil price	0.06	(0.06)	0.05	(0.05)	−0.28*	(0.05)	0.02	(0.02)
Palm oil price	0.06	(0.05)	0.01	(0.01)	0.07	(0.07)	−0.75*	(0.33)
Compensated price elasticties								
Peanut oil price	−0.93*	(0.41)	−0.83*	(0.28)	0.39	(0.26)	0.16	(0.16)
Liquid butter oil price	−0.56*	(0.21)	−0.49*	(0.25)	0.11	(0.08)	0.11	(0.05)
Rapeseed oil price	0.11	(0.07)	0.11	(0.06)	−0.22*	(0.06)	0.07	(0.02)
Palm oil price	0.28	(0.09)	0.21	(0.06)	0.26	(0.07)	−0.65*	(0.04)
EDOILEXP	1.11*	(0.18)	0.38*	(0.10)	0.17*	(0.05)	0.71*	(0.21)
Income	0.40*	(0.19)	0.12*	(0.07)	0.06*	(0.03)	0.25*	(0.14)

Note: Elasticities are based on unit value instead of the real price.
* is significant at 10% level.

Table 4. Marginal Effects of Demographic Variables on Edible Oil Demand

	Peanut Oil		Butter Oil		Rapeseed Oil		Palm Oil	
Variables	M.E.	Std. Error	M.E.	Std. Error	M.E.	Std. Error	M.E.	Std. Error
AGE	0.06	(0.07)	−0.64*	(0.07)	−0.17*	(0.02)	0.16*	(0.03)
RURAL	−2.17*	(0.14)	−1.79*	(0.14)	−1.09*	(0.20)	0.81*	(0.20)
SNTHERN	−3.30*	(0.14)	−0.02	(0.12)	4.85*	(0.14)	0.03	(0.14)
EDU	0.68*	(0.23)	0.72*	(0.14)	−0.47*	(0.13)	−0.32*	(0.12)
NORTH	7.63*	(1.92)	3.70*	(1.19)	1.59	(1.85)	3.97*	(1.39)
FDHABIT	−7.33*	(1.41)	−8.39*	(1.92)	−4.85*	(1.41)	3.71*	(1.94)

Note: Only AGE and EDU are continuous variables.
* is significant at 10% level.

diet), religion, and education all have significant effects on edible oil choices. The elasticity of education with respect to peanut, butter, rapeseed, and palm edible oils is 0.11, 0.13, −0.08, and −0.13, respectively.

Summary and Conclusions

The LinQuid incomplete demand system and Shonkwiler and Yen approach were used to develop a more efficient demand analysis based on censored household survey data. The unit value problem has been simultaneously estimated with a censored incomplete demand system. The model was estimated using iterative 3SLS. The use of this technique allows us to deal with a large demand system, which is impractical under traditional methods.

The procedure is used to estimate demand parameters for Indian households with special emphasis on the edible oil commodity group. The results show that peanut edible oil has the greatest income and expenditure elasticities in India, whereas expenditure elasticities for other oils are relatively low. The variables shown to have the strongest significant effects on the choice of edible oils include the location of the household and food habits.

The disaggregate edible oil elasticity estimates from this article can be used in various analytical procedures (i.e., simulation models) to evaluate the welfare effects of domestic food policies, international trade policies, and nutritional or public health programs. Quantification of the welfare impacts of domestic food policies would be more meaningful if disaggregate elasticity estimates (of different edible oil items) are used in simulation models. Disaggregate demand elasticities are also important in analyzing effects of trade policies. For example, the domestic own-price elasticities of edible oil demand can be combined with import share data to calculate import demand elasticities (Brester). Reliable estimates of disaggregate import demand elasticities can then be utilized to simulate the impact of trade liberalization policies on specific edible oil commodities. Because India imports a number of edible oil commodities to augment any shortfall in domestic supply, the disaggregate edible oil elasticity information gleaned from our analysis may be of value in the development of trade policies.

Additionally, nutritional and public health programs may be enhanced with disaggregate edible oil demand elasticity information from this study. These demand elasticities can be used to derive the implied relationship between nutrient availability and changes in food prices and income—the so-called nutrient elasticities (Huang; Pinstrup-Andersen, de Londono, and Hoover). In conjunction with disaggregate elasticities associated with other food groups (e.g., meats, dairy), a comprehensive set of nutrient elasticities can be calculated to help guide the design of nutritional and public health programs for meeting minimum dietary requirements. Furthermore, the disaggregate elasticities calculated for the different edible oil commodities can be used to improve edible oil consumption forecasting in

India—an area in which empirical studies are nascent. More accurate disaggregate forecasts would enable policy makers to be more proactive in setting and designing nutritional programs.

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APPENDIX

Table A.1. Frequency of Zero Consumption by Quintile of Income Distribution

Quintile of Income	No Peanut Oil Consumption	No Butter Oil Consumption	No Mustard Oil Consumption	No Palm Oil Consumption
10%	25.77	24.69	25.31	26.26
25%	31.74	22.41	24.78	24.84
50%	21.06	18.88	20.14	19.66
75%	17.08	18.05	16.04	18.50
No. observations	586	482	561	773

Table A.2. Multivariate Probit Model

	Peanut Oil		Liquid Butter Oil		Rapeseed Oil		Palm Oil	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
Intercept	2.03*	(0.23)	−1.47*	(0.17)	−2.04*	(0.23)	−0.82*	(0.16)
RUBN	−0.21	(0.14)	−0.39*	(0.10)	0.13	(0.13)	0.26*	(0.10)
NORTH	2.82*	(0.13)	−1.31*	(0.10)	−2.70*	(0.13)	−0.20*	(0.09)
SNTHERN	−0.03	(0.16)	−0.07	(0.12)	0.25*	(0.15)	−0.13	(0.12)
EDU	−0.01	(0.01)	0.02*	(0.01)	−0.01	(0.01)	0.01	(0.01)
FDHABIT	−0.24*	(0.13)	0.28*	(0.11)	0.43*	(0.13)	−0.26*	(0.10)
Log(INCOME)	0.06	(0.07)	0.36*	(0.06)	−0.37*	(0.07)	−0.23*	(0.05)
Error Correlation Matrix								
Peanut oil	1		−0.03	(0.07)	−0.42*	(0.07)	−0.02	(0.07)
Liquid butter oil			1		−0.29*	(0.07)	−0.43*	(0.05)
Rapeseed oil					1		0.08	(0.07)
Palm oil							1	

* is significant at 10% level.

Table A.3. Parameter Estimation of Unit Value Equations

	Peanut Oil		Liquid Butter Oil		Rapeseed Oil		Palm Oil	
Variable	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
Intercept	35.40*	(2.26)	114.04*	(60.22)	44.71*	(15.24)	31.44*	(9.72)
RUBN*CDF	3.63*	(1.92)	−12.00*	(1.26)	5.22*	(2.07)	3.55*	(1.76)
NORTH*CDF	10.07*	(4.77)	−79.31*	(26.84)	−6.98*	(0.60)	−21.51*	(3.29)
SNTHERN*CDF	1.76*	(0.60)	−6.49	(6.17)	2.07*	(0.63)	−1.35	(4.09)
EDU*CDF	0.05*	(0.01)	−0.15*	(0.05)	−0.09*	(0.02)	−0.62*	(0.04)
FDHABIT*CDF	0.42*	(0.03)	−4.36*	(1.74)	−0.85*	(0.10)	3.78*	(0.55)
Log(INCOME) *CDF	1.78*	(0.18)	−0.33*	(0.09)	−2.14*	(1.27)	−2.61*	(0.21)
PDF	5.08*	(1.47)	6.46*	(3.73)	6.01*	(2.76)	7.44*	(1.53)

* is significant at 10% level.

Table A.4. Parameter Estimation of the Quadratic LinQuad Model

	Peanut Oil		Liquid Butter Oil		Rapeseed Oil		Palm Oil	
Variable	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
α	0.13	(0.03)	−0.03*	(0.004)	−0.12*	(0.01)	0.06*	(0.01)
A_1	0.009	(0.02)	−0.16*	(0.02)	−0.17*	(0.02)	0.31*	(0.02)
A_2	−0.0001	(0.0002)	0.002*	(0.0002)	0.002*	(0.0003)	−0.003*	(0.0003)
A_3	0.53*	(0.21)	−0.74*	(0.18)	0.65*	(0.23)	−0.43	(0.33)
A_4	0.04*	(0.02)	0.04*	(0.02)	−0.06*	(0.02)	−0.09*	(0.03)
A_5	0.36*	(0.21)	−1.29*	(0.23)	0.21	(0.27)	0.70*	(0.28)
A_6	1.78*	(0.45)	2.09*	(0.33)	5.20*	(0.46)	−5.44*	(0.31)
A_7	−1.14*	(0.20)	−0.43*	(0.17)	0.09*	(0.20)	1.46*	(0.21)
B_1	−0.0016*	(0.0003)						
B_2	0.011*	(0.0011)	−0.0015*	(0.0021)				
B_3	0.0003	(0.0002)	0.00006	(0.0001)	−0.001*	(0.0001)		
B_4	0.0003	(0.0003)	0.00004	(0.0001)	0.0001	(0.0002)	−0.0026*	(0.0004)
γ	0.678*	(0.002)	0.844*	(0.026)	0.49*	(0.030)	−0.27*	(0.03)
π	−0.04*	(0.001)	0.04*	(0.0001)	−0.03*	(0.007)	0.02*	(0.003)
τ	66.21*	(17.46)	34.21*	(7.99)	88.16*	(2.25)	23.88*	(3.63)
Log-likelihood	9,342							

Note: See Equation (9) for parameter explanation.
* is significant at 10% level.