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Modeling Household Preferences for Cereals and Meats in Mexico

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Abstract

Using 2008 household data and a two-step censored model, this article analyzes separability among preferences of the major food groups in Mexico. The main objective of the present paper was to determine if beans and potatoes are not separable from meats and cereals, respectively. Results indicate that beans belong to the protein source demand system and potatoes are not separable from cereals. Another major finding is that corn income elasticity very close to one might indicate a sensitive situation for low income households that consider this cereal their major source of calories.

Keywords: separability, preferences, Mexico, demand, censored.

Introduction

There are nearly 112 million people in Mexico who make up 28.2 million households. Cereals and meats are the most important food groups consumed in Mexico. Corn is the major cereal consumed with per capita consumption exceeding 100 kilograms per year. The main meats consumed by Mexican households are chicken, pork, and beef, but about 15% of chicken, 31% of pork and 14% of beef consumed are imported. In 2010, 97% of imported chicken, 88% of imported pork and 83% of imported beef were from the United States (Secretary of Economy, SIAVI). It is very important for the Mexican Agricultural Industry, policy makers and Mexico's major trading partners to understand Mexican preferences across cereals and meats.

As household cross-sectional data are more available, interest to conduct econometric analysis of consumer demand with economic and demographic effects increases. However, the use of micro survey data presents a major estimation issue. This type of data is censored because it contains a large amount of zero expenditure on several commodities, situation that generates missing prices. Another important consideration while conducting demand analysis is the decision of what goods to include in each food group. When estimating demand systems, researchers often aggregate products by characteristics or nutritional attributes but it is not always clear how to group commodities with different characteristics. For example, should beans be included in the meat group? Should potatoes be included as a starch along with other cereals? The consumption of potatoes has grown in significant amounts during the recent years and its use as starch makes potatoes comparable with cereals. Also, beans are the major source of proteins for low income families. For these families, meats are substituted with beans. Is this sufficient support to include potatoes with cereals and beans with meats for food demand analysis? In 1936, Hicks and Leontief introduced the idea of separability among preferences through the *composite commodity theorem* to construct commodity groups for empirical analysis. In 1994, Moschini et al. provided empirical evidence to show differences in cross-elasticities when weak separability is rejected.

The data set used in this study is the 2008 National Survey of Income and Expenditure for Household (ENIGH) in Mexico. This cross-sectional data is a rich sample with demographic effects, but it is censored. To overcome this issue, this study uses a two-step estimation of a censored demand system proposed by Shonkwiler and Yen in 1999. The main objectives of this study are to estimate demand elasticities among cereals and meats in Mexico and to test the validity of weak separability regarding whether beans are part of the meat group and whether potatoes should be part of a demand system of cereals.

Model Specification

This study uses a non-linear approximation of the AIDS model as follows:

$$w_{ih} = \rho_{i0} + \sum_{k=1}^{K} \rho_{ik}\, d_{kh} + \sum_{j=1}^{n} \gamma_{ih} \ln(p_{ih}) + \beta_i \ln[\frac{x_h}{a(p_h)}] + u_{ih} \quad (1)$$

where w_{ih} is the budget share of the i^{th} good purchased by household h, ρ_{i0}, ρ_{ik}, γ_{ih} and β_i are the parameters to be estimated, d_{kh} are the k^{th} demographic variables, $\ln(p_{ih})$ is the log of the price of the i^{rh} good, x_h is the total expenditure, and $a(p_h)$ is a price index which is defined as:

$$\ln a(p_h) = \alpha_0 + \sum_{j=1}^{n} \delta_{jh} \ln(p_{jh}) + 0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln(p_{ih}) \ln(p_{jh}) \quad (2)$$

In 1999, Blundell and Robin suggested a reduced form function for $\ln(x_h)$ to address the correlation issue between the error term u_{ih} and the log expenditure variable $\ln(x_h)$ as follows:

$$\ln(x_h) = \sum_{k=1}^{K} \rho_{ik}\, d_{kh} + \sum_{j=1}^{n} \delta_{ih} \ln(p_{ih}) + \omega \ln(x_h) + v_h \quad (3)$$

where v_h are computed residuals to be added into the non linear AIDS model. Adding-up restriction, homogeneity and slutsky symmetry (properties of demand) can be imposed as:

$$\sum_{i}^{n} \rho_{i0} = 1, \sum_{i}^{n} \rho_{ik} = 0, \sum_{i=1}^{n} \gamma_{ij} = 0, \sum_{i}^{n} \beta_i = 0, \text{and} \sum_{i}^{n} \lambda_i = 0 \quad (4)$$

$$\sum_{i=1}^{n} \gamma_{ij} = 0 \text{ for any } j \quad (5)$$

$$\gamma_{ij} = \gamma_{ji} \text{ for all } i \text{ and } j \quad (6)$$

Weak separability imposes restrictions on the degree of substitutability between goods from different groups and allows the use of total expenditure of the goods in the system, instead of total income. Moschini, et al. (1994) defined non-homothetic asymmetric weak separability as:

$$\sigma_{if} * e_m = \sigma_{im} * e_f \quad (i) \in I_g, (m, f) \in I_s, \text{and } g \neq s \quad (7)$$

where σ's are the Allen-Usawa elasticities, e is the expenditure elasticity, good i belongs to group I_g, good m and f belong to group I_s, and g and s are different groups of commodities.

Data and Procedure

The 2008 National Survey of Income and Expenditure for Mexican Households is a micro survey conducted by the National Institute of Statistics and Geography (INEGI) every two years. Households report quantity purchased and total expenditure on different byproducts during one week. The present study calculated a weighted average price of the each product to account for the relative importance of quantity of each byproduct on the price of a good. The number of households included in the cereals and meat models were 27,846 and 25,769, respectively. The group of cereals included corn, wheat, rice, other cereals, and potatoes, and the one for meats comprised beef, pork, chicken, processed meats, fish and beans. Data contains zero expenditure for corn, wheat, rice, other cereals and potatoes for 12%, 13%, 68%, 78%, and 53% of households, respectively. Also 44%, 75%, 44%, 34%, 87%, and 47% of households reported zero expenditure on beef, pork, chicken, processed meats, fish and beans, respectively. Missing prices, a consequence of censored data, were generated using Markov Chain Monte Carlo (MCMC) approach (MI procedure in SAS) with log of prices to avoid negative prices.

The demographic factors included were: size of the household, strata (1:more than 99,999 inhabitants; 2:from 15,000 to 99,999 inhabitants; 3:from 2,500 to 14,999 inhabitants; and 4:less than 2,499 inhabitants), regions (CR: Central Region; COR: Central Occidental Region; NWR: Northwest Region; NER: Northeast Region; and SR: South Region), poverty levels (1:very low; 2:low; 3:medium; 4:high; and 5:very high), and age and gender of the head of the household.

The first step of Shonkwiler and Yen (1999) is a multivariate probit regression (PROC QLIM in SAS) to estimate household's probability of purchasing a commodity. In this regression, the cdf denoted by $\Phi(\boldsymbol{z}_i'\boldsymbol{\tau}_i)$ and the standard normal probability density function (pdf) represented by $\phi(\boldsymbol{z}_i'\boldsymbol{\tau}_i)$ are calculated to generate the following model in the second step using the Full Information Maximum Likelihood in Proc Model (SAS):

$$w_{ih} = \Phi(\boldsymbol{z}_i'\boldsymbol{\tau}_i) \cdot \left[\alpha_{ih} + \sum_{j=1}^{n} \gamma_{ij} \ln(p_{ih}) + \beta_i \ln[\tfrac{x_h}{a(p_h)}] + \kappa_i \hat{v}_h \right] + \varphi_i \cdot \phi(\boldsymbol{z}_i'\boldsymbol{\tau}_i) + \zeta_{ih} \quad (8)$$

As Pudney (1989) suggested, each model used n-1 equations in order for adding up restriction to hold. The residual goods were rice for cereals and pork for meats. To calculate Marshallian, Hicksian, expenditure, income and demographic elasticities the following formulas were used:

$$e_{ij}^{m} = w_i^{-1}\{\gamma_{ij} - \beta_i[\alpha_j + \textstyle\sum_k^n \gamma_{jk}\ln(p_k)]\} \cdot \Phi_i - \delta_{ij} \quad (9)$$

$$e_{ij}^{h} = e_{ij}^{m} + w_i e_i \quad (10)$$

$$e_i = 1 + w_i^{-1} \cdot \beta_i \cdot \Phi_i \quad (11)$$

$$e_{M(i)} = e_i e_M \quad (12)$$

$$e_{im}^{d} = w_i^{-1}\{[\rho_{im} - \textstyle\sum_k^n \gamma_{jk}\ln(p_k)] \cdot \beta_i\} \cdot d_m \Phi_i \quad (13)$$

where δ_{ij} is the Kronecker delta (1 if $i=j$ and 0 otherwise), w_i is the average budget share per commodity, e_M is the estimated parameter of household income in the reduced equation, d_m is equal to one for binary variables or the mean of the variable otherwise. To avoid over rejection, a size corrected Likelihood Ratio statistic (Italianer, 1985 and Moschini, et al.,1994) was used:

$$LR_c = \left[-2\left(\ln L(\tilde{\theta}) - \ln L(\hat{\theta})\right)\right]\left[MN - \tfrac{1}{2}(P_{\hat{\theta}} + P_{\tilde{\theta}}) - \tfrac{1}{2}N(N+1)\right] \xrightarrow{d} X_J^2 \quad (13)$$

where $\ln L(\tilde{\theta})$ is the restricted log likelihood value, $\ln L(\hat{\theta})$ is the unrestricted log likelihood, M is the number of equations, N is the total number of observations, $P_{\hat{\theta}}$ and $P_{\tilde{\theta}}$ are the number of parameters of the unrestricted and restricted model respectively, and J are the restrictions to test.

Results and Conclusions

Multivariate probit results in Table 1 and Table 2 show consumers' view of corn, rice, other cereals, and potatoes as having a lower nutritional value than wheat. But, consumers give the same nutritional value to all protein source products. Parameter estimates for the pdf (φ) in Table 3 show the importance of censoring treatment in these models. Non linear AIDS model's outcome (Table 3) shows that overall both demographic and economic factors have significant effect on the quantity demanded for all the goods included in each system. Homogeneity and symmetry restrictions (Table 4) from the neoclassical demand theory show that these properties do not hold for the demand system of cereals which encompasses some theoretical implications for smaller data sets. The major objective was to test whether beans and potatoes belong to the demand systems of meats and cereals, respectively. Empirical evidence suggests the inclusion of these two commodities in their respective food group. This major result entails that further research in Mexico on food demand systems for cereals and meats might not ignore the effect of potatoes and beans on demand for cereals and meats, respectively.

Table 5 and 6 show own and cross price elasticities for both models. Own price elasticities from the two models indicate that all commodities are price elastic implying that an increase on its own price will reduce the demand for each good. Income elasticities show that all goods are normal in the two models, but beef and fish are considered normal luxury commodities. This finding is consistent to the situation in Mexico. As households move to a higher level of income, they purchase more beef. Additionally, Mexican households do not consider fish as a part of their essential diet. Compensated price elasticities show that all commodities in the model for cereals are net substitutes, except for rice, which shows a net complementary relationship with corn. Consequently, demand for most of the cereals is positively related to an increase of other commodities price. On the other hand, uncompensated cross price elasticities for meats demonstrate that Mexicans substitute beef, pork and chicken with beans, which was the main driving force to include beans into the analysis of food demand for animal protein source products. Income effect offsets most of substitution effect among commodities in both models.

Demographic variable effects on the demand for cereals and meats show the impact of hetereogeneity across households in the demand for these food groups. These results are very important for the Mexican Industry and major trading partners of Mexico, because it shows how quantity demanded will change across regions and type of households. For instance, rural areas consume more corn, wheat, other cereals, beans and pork than urban areas. COR, NER and SR have a higher propensity to consume corn than CR, while NWR consumes less corn than CR. CR consumes more rice and chicken but less beans and fish than the rest of the country. Moreover, the lower the poverty level, the greater consumption of corn, beef, chicken and processed meats. However, low income families consume less wheat, rice, other cereals, potatoes, beans and fish than high income families. Another major finding is that corn income elasticity (very close to one) suggests that this commodity is very close to becoming a luxury good for Mexican households. Corn in Mexico is principally a food grain rather than a feed grain. Corn plays a central role among Mexican population as a critical component of the cultural heritage and identity of the Mexicans and as a food staple. Do results imply a major food security issue? Mexico has already lost its self-sufficiency in white corn because its domestic use has steadily outpaced its production. If corn becomes a luxury good in Mexico, low income families will not be able to afford their main source of calories, leaving a country in a cultural and political sensitive situation.

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