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Mexican Meat Demand at the Table Cut Level: Estimating a Censored Demand System in a Complex Survey

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Abstract

Demand elasticities at the table cut level are computed from a Mexican survey of household incomes and weekly expenditures, which is a stratified sample. A censored demand system is estimated incorporating stratification variables and it results in unbiased parameter and elasticity estimates, which can be interpreted as estimates of all Mexican meat-consuming households. Their standard errors are rigorously approximated by bootstrapping. Several indicators of heterogeneous meat-cut demands are found. Volumes traded differ among the table cuts of meats; the probability of buying a particular meat cut changes across meat cuts and geographical regions; and cases of substitutability and complementarity are identified within and across meat categories.

Keywords: stratified sampling, adult equivalent scales, censored demand system, two-step estimation, bootstrap standard errors, Mexican meat consumption, disaggregated elasticities

Introduction

The world meat market is experiencing increasing trends in consumption and trade. From 1997 to 2006, world meat consumption, exports and imports increased 26%, 48%, and 28% respectively (U.S. Department of Agriculture (USDA)). As world meat consumption and trade liberalization increase, it becomes very important for large meat exporters to appropriately understand foreign market characteristics, especially those derived from consumer demand functions. Mexico is a key meat market not only because of the large quantity it imports and its relatively low per capita meat consumption, but also because of its relatively high preference for edible meat offals.

The Mexican meat market is large and rapidly expanding. From 1997 to 2006, Mexico was the fourth largest meat-importing country of the world (after Russia, Japan and the U.S.) accounting for 8% of the total world meat import average of 13,195,000 MT (USDA). During the same period, Mexican meat imports increased by 147% (from 568,000 MT in 1997 to 1,405,000 MT in 2006) and represented the fastest growth among the leading importing countries (USDA). Given that the population growth during this period was 11% (International Monetary Fund (IMF)), this suggests that an increasing per capita Mexican demand may be driving this rapid growth.

Despite the size and rapid growth of the Mexican meat market, per capita meat consumption will likely continue increasing. Mexican per capita meat consumption remains low when compared to the equivalent levels in the U.S. and Canada. From 1997 to 2006, per capita meat consumption in Mexico averaged 60.78 kg/year, while it averaged 121.6 kg/year and 98.38 kg/year in U.S. and Canada respectively (consumption from USDA; population from IMF). Given Mexico's rapid import growth, this indicates potential for continuously increasing imports and highlights the importance of Mexico as a demand market for years to come.

Another key characteristic of the Mexican meat market is its high preference for edible meat offals. Mexican imports of edible meat offals are larger than imports of other meat cuts. For example, imports of edible bovine offals are larger than imports of bovine meat carcasses and half-carcasses, other cuts of bovine meat with bone-in, and ham, bacon, and similar products (Table 1). Similarly, edible swine offal imports are larger than imports of boneless swine meat, swine meat carcasses and half-carcasses, and ham, bacon, and similar swine meat products. Likewise, imports of other chicken cuts and edible offals are larger than whole chicken imports, and ham and similar chicken products. Mexico is a key destination for edible meat offals because its consumers place a higher value for these meat products (Dyck and Nelson 2003, 6).

To appropriately understand foreign meat consumption and international trade, a table cut analysis of meat is necessary (Dyck and Nelson 2003). A practical question for researchers, policy makers, and meat importers and exporters involves estimating the substitution pattern in meat demand at the table cut level. Previous studies on Mexican meat consumption (Henneberry and Mutondo 2009; Erdil 2006; Malaga, Pan, and Duch 2006; Dong, Gould, and Kaiser 2004; Gould et al. 2002; Gould and Villarreal 2002; Golan, Perloff, and Shen 2001; Sabates, Gould,

Table 1. Mexican Bovine, Swine and Chicken Meat Imports by Cut

	2002	2003	2004	2005	2006	2007	Average 2002-07
Mexican Bovine Meat Imports (1000 MT)							
Bovine meat carcasses and half-carcasses	4	2	0	0	0	0	1
Other bovine meat cuts with bone-in	15	15	0	1	5	9	7
Boneless bovine meat	230	251	210	235	266	277	245
Edible bovine offals	56	78	55	77	82	85	72
Ham, bacon, & similar bovine products	6	4	2	2	3	3	4
Total bovine meat	311	350	268	316	355	373	329
Mexican Swine Meat Imports (1000 MT)							
Swine meat carcasses and half-carcasses	17	23	23	19	19	15	19
Swine hams, shoulders & cuts thereof, with bone-in	101	171	226	210	220	219	191
Boneless swine meat	41	74	86	76	83	91	75
Edible swine offals	109	151	173	156	157	157	150
Ham, bacon, & similar swine products	21	37	43	45	48	51	41
Total swine meat	289	457	550	505	527	532	477
Mexican Chicken Imports (1000 MT)							
Whole chicken	1	4	0	11	33	13	10
Boneless chicken	78	125	163	165	182	177	148
Chicken legs & thighs	0	112	125	127	151	131	108
Other chicken cuts & offals	83	83	23	54	44	44	56
Ham & similar chicken products	13	5	0	0	0	0	3
Total chicken	163	321	311	355	410	410	322

Note: The series was computed from chapter 2 (meat and edible meat offal) of the Harmonized System. At the 8-digit level of disaggregation, bovine meat carcasses and half-carcasses include commodities 02011001 and 02021001. Other bovine meat cuts with bone-in include commodities 02012099 and 02022099. Boneless bovine meat includes commodities 02013001 and 02023001. Edible bovine offals include commodities 02061001, 02062101, 02062201 and 02062999. Ham, bacon, and similar bovine products include commodity 02102001 and half of commodity 02109999. Swine meat carcasses and half-carcasses include commodities 02031101 and 02032101. Swine hams, shoulder and cuts thereof, with bone-in include commodities 02031201 and 02032201. Boneless swine meat includes commodities 02031999 and 02032999. Edible swine offals include commodities 02063001, 02063099, 02064101, 02064901 and 02064999. Ham, bacon, and similar swine products include commodities 02090099, 02101101, 02101201, 02101999, and half of commodity 02109999. Whole chicken includes commodities 02071101 and 02071201. Boneless chicken includes commodities 02071301 and 02071401. Chicken legs and thighs include commodities 02071303 and 02071404. Other chicken cuts and offals include commodities 02071302, 02071399, 02071402, 02071403 and 02071499. Ham and similar chicken products include commodities 02090001 and 02109903. All years are calendar years (January to December) except for 2002, which was reported from April to December.

Source: Mexico's Secretariat of Economy, SIAVI Database, computed by authors.

and Villarreal 2001; Dong and Gould 2000; Garcia Vega and Garcia 2000; Heien, Jarvis, and 2001; Dong and Gould 2000; Garcia Vega and Garcia 2000; Heien, Jarvis, and Perali 1989) estimate meat demand at the aggregate level, sometimes within a more general demand system (i.e., including cereals, dairy, fats, fruits, vegetables, etc.).[1] However, estimation of meat demand elasticities using meat aggregates (i.e., beef, pork, and chicken) may be neither appropriate nor useful for Mexico if consumers' tastes and preferences vary across table cuts of meats. In the U.S., meat demand studies at the disaggregated level have provided additional insights about the nature of the demand for meat (see Taylor, Phaneuf, and Piggott 2008; Yen and Huang 2002; and Medina 2000).

Unlike previous studies, the objective of this paper is to estimate demand elasticities at the table cut level (i.e., beefsteak, ground beef, pork steak, ground pork, chicken legs, thighs and breast, fish, etc.) and calculate expenditure, Marshallian and Hicksian price elasticities, which at this level of disaggregation are currently unavailable for Mexico. To accomplish this objective, a censored demand system is estimated in two steps using a survey of Mexican household incomes and weekly expenditures, which is published by a Mexican governmental institution and was collected employing a stratified sampling methodology (see Cameron and Trivedi 2005, 853). The study not only analyzes Mexican meat demand elasticities for table cuts of meats but also uses a relatively recent secondary source of information. It provides a better understanding of the Mexican meat consumption and may be used to identify current and future trends in consumption and trade of specific meat cuts. U.S. meat exporters will find elasticities at this level of disaggregation very beneficial for assessing likely scenarios of price and income changes in Mexico.

In addition, the methodology used provides several advantages over previous studies. Parameter and elasticity estimates are not biased, not only because stratification variables are incorporated in the estimation procedure but also because a censored regression model is employed. Parameters and elasticities can also be interpreted as population estimates or viewed as census estimates because the study uses a stratified sample and cross-sectional survey data that is representative of the entire target population (i.e., Mexican meat-consuming households). The standard errors of parameter estimates are also rigorously approximated by bootstrapping because the data was obtained from a complex survey. In addition, the price imputation approach that is applied is also preferred over a simple average substitution approach. Finally, the study adjusts for household size by using scales to compute per adult-equivalent consumption, which is preferred

[1] Similar to Henneberry and Mutondo (2009), Malaga, Pan, and Duch (2006), Gould et al. (2002), Gould and Villarreal (2002), Golan, Perloff, and Shen (2001), and Dong and Gould (2000), this study assumes that meat and other food commodity groups are separable in the household utility function, and similar to Dong, Gould, and Kaiser (2004), Gould et al. (2002), and Golan, Perloff, and Shen (2001), this study assumes that beef, pork, and chicken are not separable from seafood. Studies on Mexican meat consumption have not formally tested whether commodities can be partitioned into groups so that preferences within groups are described independently of the quantities in other groups. In the literature, there is evidence that separability holds in U.S. meat purchases (Moschini, Moro, and Green 1994), but in Australia it is not clear (Alston and Chalfant 1987). If separability of Mexican meat purchases does not hold, the elasticity estimates in this study may be biased because the substitution pattern among the Mexican food commodities would be broader.

over ignoring or using a simple count or proportion of household members because less parameters are estimated.

Data

To estimate meat demand at the table cut level, this study uses data on Mexican household incomes and weekly expenditures obtained from the National Survey of Household Incomes and Expenditures (or ENIGH by its acronym in Spanish), which is a nationwide survey encompassing Mexico's 31 states and the Federal District. This cross-sectional data is published by a Mexican governmental institution (National Institute of Statistics, Geography, and Information Technology (or INEGI by its acronym in Spanish)) since 1977 (e.g., see Heien, Jarvis, and Perali 1989). This study uses the 2006 survey, which was conducted from August to November. During this period, direct interviews were given through a stratified sampling method and expenditures on food, drinks, cigarettes and public transportation were recorded for one week.

The analysis of ENIGH data implies the use of a stratified sampling methodology instead of a random sampling methodology. In stratified sampling, the population is divided into subgroups (strata), which are often of interest to the investigator, and a simple random sample is taken from each stratum. According to ENIGH–Methodological Synthesis (2006), ENIGH's sampling methods are probabilistic, multi-staged, stratified, and conglomerated. This implies that the sampling units are selected with a known probability from multiple stages, are obtained from dividing the population into groups with similar characteristics, and are made up from the observation units (i.e., household members). In ENIGH 2006, there is a nonresponse rate of 10.55% (ENIGH–Methodological Synthesis 2006, 33–34). From the 20,875 responding households, 16,909 reported consumption of at least one meat cut. Table 2 reports the number of observations (i.e., number of interviewed meat-consuming households), the sum of weights (number of households nationally represented by the interviewed meat-consuming households), and the average household size per stratum in ENIGH 2006. The weight variable is the number of households nationally represented by the interviewed household and it is corrected for the non-response by INEGI.

Table 2. Number of observations, sum of weights and average household Size per stratum

Strata	**No. of Obs.**	**Sum of Weights**	**Avg. hhsize**
Str1	7,285	11,473,327	3.99
Str2	3,942	3,241,161	4.13
Str3	1,574	2,837,679	4.52
Str4	4,108	4,554,086	4.28
Total	16,909	22,106,253	4.14

Note: Stratum 1 (Str1) consists of households who live in locations with a population of 100,000 people or more. Stratum 2 (Str2) consists of households who live in locations with a population between 15,000 and 99,999 people. Stratum 3 (Str3) consists of households who live in locations with a population between 2,500 and 14,999 people. Stratum 4 (Str4) consists of household who live in locations with a population of less than 2,500 people.
Source: ENIGH 2006 Database, computed by authors.

Previous studies that use ENIGH data to estimate meat demand in Mexico (Malaga, Pan, and Duch 2006; Dong, Gould, and Kaiser 2004; Gould and Villarreal 2002; Gould et al. 2002; Golan, Perloff, and Shen 2001; Sabates, Gould, and Villarreal 2001; Dong and Gould 2000; Garcia Vega and Garcia 2000; Heien, Jarvis, and Perali 1989) do not take into account the issue of stratified sampling nor provide an explanation for excluding stratification variables. Ignoring stratification variables (e.g., weight and strata) results in parameter estimates that may be biased (not representative of the population) or that may not accurately identify differences among the subpopulations (Lohr 1999, 221–254). For example, not incorporating the variable weight into the analysis is equivalent to assigning a constant weight of 1,307.37 (i.e., 22,106,253/ 16,909) to each observation (Table 2); therefore, assuming each household member represents the same number of households nationally. A histogram of the weight variable from ENIGH 2006 shows this is not the case (Figure 1). Additionally, taking a random sample of 1,000 households from the 16,909 households and not incorporating the weight variable (e.g., see Golan, Perloff, and Shen 2001) will only produce a sample that is representative of the 16,909 households, assuming a constant weight, which is incorrect.

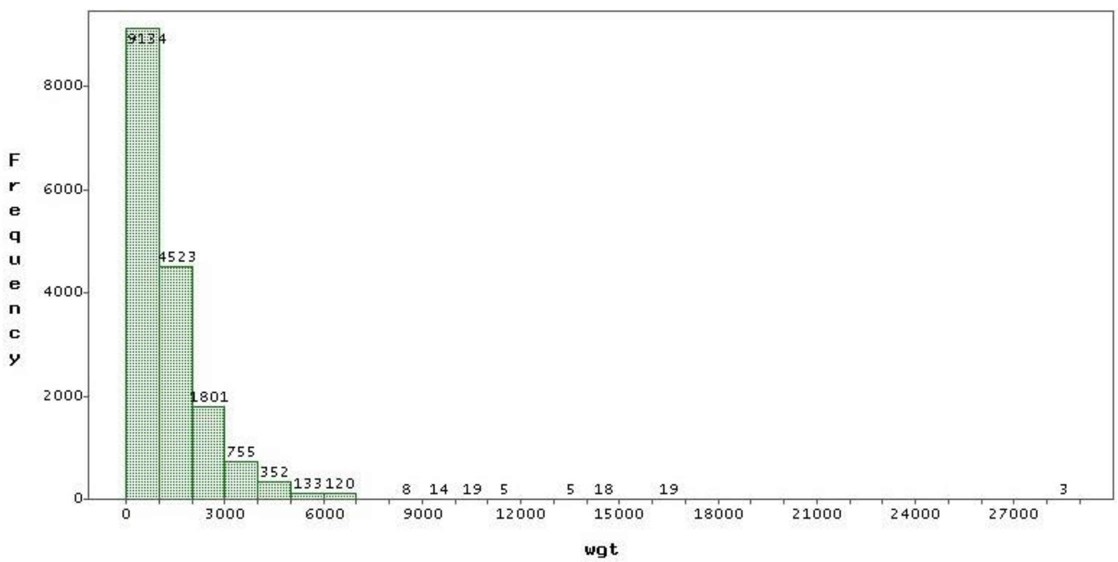

Figure 1. Histogram of the weight variable in ENIGH 2006
Source: ENIGH 2006 Database, computed by authors.

Furthermore, according to DuMouchel and Duncan's (1983) test, the use of stratification variables is necessary when using ENIGH 2006. In DuMouchel and Duncan's (1983) test, the null hypothesis favors the use of the unweighted estimator while the alternative hypothesis favors the use of the weighted estimator (DuMouchel and Duncan 1983, 539). DuMouchel and Duncan (1983, 538) recommend that the data passes this test before using the unweighted estimator over the weighted estimator.

The test is implemented by performing an F test for $\boldsymbol{\gamma} = \mathbf{0}$ in the following regression model estimated by ordinary least squares,

(1) $$\mathbf{Y} = \mathbf{X}\,\alpha + \mathbf{W}\,\mathbf{X}\,\boldsymbol{\gamma} + \boldsymbol{\varepsilon},$$

where **Y** is a ($n \times 1$) vector of observations in the dependent variable, **X** is a ($n \times p$) matrix of observations in the independent variables, **W** is a ($n \times n$) diagonal matrix whose i^{th} diagonal element is the sample weight w_i, $\boldsymbol{\alpha}$ and $\boldsymbol{\gamma}$ are ($p \times 1$) vector of parameters, $\boldsymbol{\varepsilon}$ is a ($n\times 1$) random error with $E(\boldsymbol{\varepsilon}) = \mathbf{0}$ and $var(\boldsymbol{\varepsilon}) = \boldsymbol{\sigma}^2\mathbf{I}_n$, and $\mathbf{Z} = \mathbf{W}\,\mathbf{X}$, where the columns of **Z** are further (perhaps unobserved) predictors that should have been included in the regression but were not.

Table 3 shows the *F* statistic from eighteen DuMouchel and Duncan's (1983) tests that were implemented (one test at a time) by using meat-cut quantities as dependent variables, and a constant, meat-cut prices, and regional and urbanization level dummy variables as independent variables. At the 0.05 significance level, sixteen out of eighteen tests reject the null hypothesis of using the unweighted estimator. Consequently, when working with ENIGH 2006, it is critical to treat the data as a stratified sample (instead of a simple random sample) and incorporate stratification variables into the analysis.

Table 3. DuMouchel and Duncan's (1983) Test Results

Equation	*F*	*p*-value
q_1	1.7907	0.0090
q_2	2.0893	0.0011
q_3	1.7377	0.0126
q_4	1.9422	0.0032
q_5	1.3806	0.0976
q_6	4.3003	<0.0001
q_7	3.0603	<0.0001
q_8	1.7962	0.0086
q_9	1.7718	0.0101
q_{10}	4.4449	<0.0001
q_{11}	1.6708	0.0191
q_{12}	8.3251	<0.0001
q_{13}	2.4402	0.0001
q_{14}	9.2035	<0.0001
q_{15}	7.3924	<0.0001
q_{16}	1.9762	0.0026
q_{17}	1.1127	0.3166
q_{18}	3.7224	<0.0001
Critical Values		
$F^*_{25;16,884}(0.01) = 1.77$		
$F^*_{25;16,884}(0.05) = 1.52$		

In addition, among Mexican meat demand studies, there are some such as Malaga, Pan, and Duch (2006) and Dong, Gould, and Kaiser (2004) that restrict their analysis to only strata 1 and 2 (i.e., households who live in locations with a population of 15,000 or more), which in ENIGH 2006 is equivalent to excluding 7,391,765 households of the target population (Table 2). The authors justify the decision of ignoring strata 3 and 4 (i.e., households who live in locations with a population of 14,999 or less) by the difficulty of assigning a dollar value (i.e., a price) to the meat produced at home; in other words, to avoid the problem of "valuation of home-produced goods" that was briefly mentioned by Dong, Gould, and Kaiser (2004, 1099). However, ENIGH does not record consumption of home-produced goods when the households do not make a living by selling home-produced goods (INEGI, personal communication).[2] Because this study is interested in obtaining demand parameters and elasticities that are unbiased and can be interpreted as population estimates (or viewed as census estimates), this study will not exclude any segment of the population.

Censored observations are another issue that arises when working with ENIGH 2006. Censored observations are common in consumer survey data and they occur when the values of observations are partially known. Because ENIGH records food consumption only when households make a purchase and because the collection period is only one week, expenditures on many meat cuts are censored. The values of these observations are partially known because meat-cut consumption is unknown, but information about the households such as income, number of adults, and education is known. Not adjusting for censoring may result in coefficient estimates markedly different (e.g., coefficient estimates shrunk toward zero) from those of a censored regression model (e.g., see Wooldridge 2006, 611).[3]

In ENIGH 2006, prices (unit values) are household specific because they are obtained by dividing the household expenditure on the product by its corresponding quantity. In this study, quantity consists of both meat consumed at home and away from home. Price and quantity are censored for the meat cuts that households did not buy during the week of interview (also known as item non-response). A censored price corresponds to a censored quantity as the result of one week of interview and the way in which ENIGH records food consumption.[4]

This study solves the problem of censored prices and adjusts for quality differences by adopting a regression imputation approach for each of the eighteen meat cuts considered. In particular, non-missing prices of each meat cut is regressed as a function of total income, dummy variables for the education level of the household decision maker, regional dummy variables, stratum dummy variables, the number of adult equivalents, a dummy variable for car, and a dummy variable for refrigerator.[5] This price imputation approach is preferred over a substitution of the miss-

[2] If a household consumes a home-produced good during the week of interview, the consumption is recorded (and therefore included in this study) only if the household makes a living by selling home-produced goods to the public. Unfortunately, once this consumption is recorded, there is not enough information in the survey to distinguish it from expenditures on goods not produced at home. There is not enough information in the survey to determine how many home produced goods were or were not recorded in each stratum.

[3] Because of censoring, how often Mexican households purchase meat cuts cannot be assessed other than during the week of interview. In general, 86% of the house-holds that purchased a specific meat cut did it once a week while 12% and 2% did it twice and three times a week. Households that purchased a specific meat cut four, five, six or seven times a week were found but were not common.

[4] A total of 59,782 meat purchases were reported (counting as different purchases any purchase of meat as well as purchases of the same meat cut by the same household in different places) by 16,909 of the total 20,875 responding households. Only 13 of the 59,782 purchases did not report both price and quantity, but yet reported household expenditure on the meat cut. Only 4,333 of the 59,782 purchases were for consumption away from home. Only 1,216 of the 16,909 meat-consuming households purchased at least one meat cut for consumption away from home.

[5] Each regression uses the SURVEYREG procedure and incorporates the variables strata and weight as documented in SAS Institute Inc. (2004, 4363–4418). Cox and Wohlgenant (1986, 912–913) explain a first-order missing regressor procedure which first regresses the deviation from the regional mean price as a function of household character-

ing price with the corresponding simple average of non-missing prices within each state and strata (e.g., Golan, Perloff, and Shen 2001, 545 and Dong, Shonkwiler, and Capps 1998, 1099).[6]

Table 4 reports the number of non-missing and missing observations, as well as the average prices in 2006 Mexican pesos per kilogram (pesos/kg) of the eighteen meat cuts considered in this study (generally grouped in five categories–beef, pork, processed meat, chicken, and seafood).[7]

Table 4. Number of non-missing and missing observations and average prices

p_i	Num. Non-Missing	Num. Missing	Before p_i Imputed		After p_i Imputed	
			Mean (Pesos/Kg)	Std. Err. of Mean	Mean (Pesos/Kg)	Std. Err. of Mean
Beef						
p_1	6,348	10,561	61.3642	0.2572	60.8785	0.1059
p_2	2,938	13,971	55.6279	0.4059	56.2014	0.0780
p_3	2,795	14,114	52.0036	0.6439	51.4183	0.1199
p_4	734	16,175	36.8413	1.0864	35.8138	0.1046
Pork						
p_5	892	16,017	50.3311	0.6043	50.3466	0.0417
p_6	1,506	15,403	47.0965	0.5020	46.9521	0.0519
p_7	366	16,543	48.6391	0.9688	47.9718	0.0515
p_8	2,168	14,741	46.8656	0.5416	46.7112	0.0816
Processed Beef & Pork						
p_9	3,175	13,734	50.7869	0.9072	51.2935	0.1824
p_{10}	4,156	12,753	50.5261	0.4528	48.7871	0.1385
p_{11}	2,384	14,525	31.2680	0.5327	31.4529	0.0849
p_{12}	2,626	14,283	72.5129	1.1257	73.8783	0.2174
Chicken						
p_{13}	5,057	11,852	35.2406	0.2458	34.6859	0.0969
p_{14}	5,716	11,193	28.5982	0.2876	28.1278	0.0953
p_{15}	760	16,149	22.4321	0.8949	24.8824	0.0924
Processed Chicken						
p_{16}	2,593	14,316	46.7430	0.5581	46.0728	0.1000
Seafood						
p_{17}	3,970	12,939	48.7240	0.5964	47.9096	0.1596
p_{18}	713	16,196	81.5472	2.2547	87.1642	0.1806

Note: p_i, i = 1, 2, …, 18, where 1 = beefsteak, 2 = ground beef, 3 = other beef, 4 = beef offal, 5 = pork steak, 6 = pork leg and shoulder, 7 = ground pork, 8 = other pork, 9 = chorizo, 10 = ham, bacon and similar products from beef and pork, 11 = beef and pork sausages, 12 = other processed beef and pork, 13 = chicken legs, thighs and breasts, 14 = whole chicken, 15 = chicken offal, 16 = chicken ham and similar products, 17 = fish, and 18 = shellfish. Average exchange rate in 2006 is U.S. $1 = 10.90 Pesos (Bank of Mexico).
Source: ENIGH 2006 Database, computed by authors.

The mean before price imputation uses only non-missing observations to compute the average while mean after price imputation uses both non-missing observations and imputed (originally

istics, and then determines quality-adjusted missing prices. The simpler regression imputation procedure adopted here produced almost the same meat-cut price variability.

[6] If the latter procedure is adopted, using four strata and Mexico's 31 states plus the Federal District will only provide 128 different values for price imputation and using two strata will only provide 64 different values.

[7] Average prices also incorporate the variables strata and weight, and were computed using the SURVEYMEANS procedure (see SAS Institute Inc. 2004, 4313–4362).

missing) observations. The high number of censored observations is common when meat is analyzed at the disaggregate level (see Taylor, Phaneuf, and Piggott 2008) and even when meat is analyzed at the aggregated level (see Gould et al. 2002; Golan, Perloff, and Shen 2001; Sabates, Gould, and Villarreal 2001; Dong and Gould 2000; Dong, Shonkwiler, and Capps 1998; Heien, Jarvis, and Perali 1989).

Unlike some previous studies, this study solves the problem of censored quantities (which are treated as zeros) by using a censored regression model. The study incorporates estimation techniques from stratified sampling with the two-step estimation of a censored system of equations proposed by Shonkwiler and Yen (1999) and later illustrated by Su and Yen (2000). Additionally, estimating standard errors of parameter estimates in complex surveys is different and more difficult than estimating standard errors of parameter estimates in simple random samples. Because of the survey design, estimating them in the same manner is incorrect (Lohr 1999, 289–318 and 347–378).

For similar reasons, using the standard errors of parameter estimates obtained from weighted least squares (WLS) is also incorrect (Lohr 1999; Devaney and Fraker 1990; Kott 1990). Consequently, this study estimates standard errors of parameter estimates by using the nonparametric bootstrap procedure, which is both rigorous and practical (see Cameron and Trivedi 2005, 360 and SAS Institute Inc.). In general, the bootstrap is a resampling technique that can be used to estimate standard errors of parameter estimates when other techniques are inappropriate or not feasible.

A final issue incorporated into this study is that of using the number of adult equivalents rather than ignoring or using a simple count or proportion of household members (e.g., Malaga, Pan, and Duch 2006; Dong, Gould, and Kaiser 2004; Golan, Perloff, and Shen 2001). Adult equivalence scales are used to compute the number of adult equivalents per households by taking into account how much an individual household member of a given age and gender contributes to household expenditures or consumption of goods relative to a standard household member. Adult equivalents are computed so that the consumption of households are comparable. For instance, meat consumption in different households cannot be directly compared without computing per capita meat consumption because bigger households will naturally have a tendency to consume more meat than smaller households. To solve this issue, this study uses the National Research Council's recommendations of the different food energy allowances for males and/or females during the life cycle as reported by Tedford, Capps, and Havlicek (1986) to compute the number of adult equivalents and then the per capita meat consumption (i.e., per-adult-equivalent consumption).

Theoretical Framework

Shonkwiler and Yen's (1999) consistent censored demand system is used to estimate the meat demand parameters and compute Marshallian and Hicksian price elasticities as well as expenditure elasticities at the table cut level of disaggregation. Shonkwiler and Yen's (1999) censored demand model is preferred over Heien and Wessells' (1990) procedure because the latter is based on a set of unconditional mean expressions for the censored dependent variables which are inconsistent. In particular, "[a]s the censoring proportion increases, the [Heien and Wessells' (1990)] procedure produces significant parameter estimates in most cases but performs very poorly in that few 95% confidence intervals contain the true parameters" (Shonkwiler and Yen, 1999, 981).

Shonkwiler and Yen's (1999) two-step procedure, which is explained in more detail below, does not incorporate the theoretical restrictions of adding-up, homogeneity, and symmetry.[8] However, the model is designed to take into account censored observations, which is critical when analyzing Mexican meat demand at the disaggregated level. Furthermore, Shonkwiler and Yen's (1999) censored demand system is very flexible and practical, which allows for incorporating estimation techniques used in stratified sampling theory.

For an arbitrary observation t, $t = 1, 2, \ldots, T$, from the i^{th} equation, $i = 1, 2, \ldots, M$, the censored system of equations with limited dependent variables is written as follows:

$$(2)\qquad \begin{aligned} y_i &= d_i\, y_i^*, \\ y_i^* &= \mathbf{x}_i' \,\boldsymbol{\beta}_i + \varepsilon_i, \\ d_i &= \begin{cases} 1 \text{ if } d_i^* > 0, \\ 0 \text{ if } d_i^* \leq 0, \end{cases} \\ d_i^* &= \mathbf{z}_i' \,\boldsymbol{\alpha}_i + v_i; \end{aligned}$$

where y_i and d_i are (1×1) observed dependent variables, y_i^* and d_i^* are (1×1) corresponding latent or unobserved variables, $\mathbf{z}_i' = (1 \;\; z_{i2} \ldots z_{iK_1})$ and $\mathbf{x}_i' = (1 \;\; x_{i2} \ldots x_{iK_2})$ are $(1 \times K_1)$ and $(1 \times K_2)$ vector of explanatory variables respectively, $\boldsymbol{\alpha}_i = (\alpha_{i1} \;\; \alpha_{i2} \ldots \alpha_{iK_1})'$ and $\boldsymbol{\beta}_i = (\beta_{i1} \;\; \beta_{i2} \ldots \beta_{iK_2})'$ are $(K_1 \times 1)$ and $(K_2 \times 2)$ vector of parameters respectively, and ε_i and v_i are (1×1) random errors.

Shonkwiler and Yen (1999) explain that if it is assumed that for each i the error terms $(\varepsilon_i \; v_i)'$ are distributed as bivariate normal with $\text{Cov}(\varepsilon_i, v_i) = \delta_i$; then, the mean of y_i is

$$(3)\qquad \text{E}(y_i|\mathbf{x}_i, \mathbf{z}_i) = \Phi(\mathbf{z}_i' \,\boldsymbol{\alpha}_i)\, \mathbf{x}_i' \,\boldsymbol{\beta}_i + \delta_i \,\phi(\mathbf{z}_i' \,\boldsymbol{\alpha}_i).$$

Then, using equation (3), the system in equation (2) can be written as

$$(4)\qquad y_i = \Phi(\mathbf{z}_i' \,\boldsymbol{\alpha}_i)\, \mathbf{x}_i' \,\boldsymbol{\beta}_i + \delta_i \,\phi(\mathbf{z}_i'\boldsymbol{\alpha}_i) + \xi_i, \quad i = 1, \ldots, M,$$

where $\xi_i = y_i - \text{E}(y_i|\mathbf{x}_i, \mathbf{z}_i)$ and $\text{E}(\xi_i) = 0$.

[8] The adding-up restriction is not imposed because the left-hand side of the system of equations consists of meat-cut quantities, not shares (see equation (4)). However, the adding up is imposed when computing the Marshallian and Hicksian price elasticities as well as expenditure elasticities (see equations (8) and (9)). Since the adding-up restriction is not imposed and the system of equations compensate for censoring by incorporating the probability of consuming meat cut i (i.e., the standard normal cumulative distribution function appropriately evaluated) and the standard normal probability density function (appropriately evaluated), the homogeneity and symmetry conditions cannot be imposed. In fact, the parameter estimates reported by Su and Yen (2000) and Shonkwiler and Yen (1999) reflect that these restrictions were not imposed.

Shonkwiler and Yen (1999) suggest the following two-step procedure for the system in equation (4): (i) obtain maximum-likelihood probit estimates $\hat{\boldsymbol{\alpha}}_i$ of $\boldsymbol{\alpha}_i$ for $i = 1, 2, \ldots, M$ using the binary dependent variable $d_i = 1$ if $y_i > 0$ and $d_i = 0$ otherwise; (ii) calculate $\Phi(\mathbf{z}_i' \hat{\boldsymbol{\alpha}}_i)$ and $\phi(\mathbf{z}_i' \hat{\boldsymbol{\alpha}}_i)$ and estimate $\boldsymbol{\beta}_1, \boldsymbol{\beta}_2, \ldots, \boldsymbol{\beta}_M, \delta_1, \delta_2, \ldots, \delta_M$ in the system

$$(5) \qquad y_i = \Phi(\mathbf{z}_i' \boldsymbol{\alpha}_i)\, \mathbf{x}_i' \boldsymbol{\beta}_i + \delta_i\, \phi(\mathbf{z}_i' \boldsymbol{\alpha}_i) + \xi_i, \quad i = 1, \ldots, M,$$

by maximum likelihood (ML) or seemingly unrelated regression (SUR) procedure,[9] where

$$(6) \qquad \xi_i = \varepsilon_i + [\,\Phi(\mathbf{z}_i' \boldsymbol{\alpha}_i) - \boldsymbol{\Phi}(\mathbf{z}_i' \hat{\boldsymbol{\alpha}}_i)]\, \mathbf{x}_i' \boldsymbol{\beta}_i + \delta_i\, [\phi(\mathbf{z}_i' \boldsymbol{\alpha}_i) - \phi(\mathbf{z}_i' \hat{\boldsymbol{\alpha}}_i)].$$

The differentiation of the mean of y_i, equation (3), with respect to a common variable in $\mathbf{x}_i$ and $\mathbf{z}_i$, say $x_{ij} = z_{ij}$, gives

$$(7) \qquad \frac{\partial \mathrm{E}(y_i|\mathbf{x}_i, \mathbf{z}_i)}{\partial x_{ij}} = \Phi(\mathbf{z}_i' \boldsymbol{\alpha}_i)\, \beta_{ij} + \mathbf{x}_i' \boldsymbol{\beta}_i\, \phi(\mathbf{z}_i' \boldsymbol{\alpha}_i)\, \alpha_{ij} - \delta_i\, (\mathbf{z}_i' \boldsymbol{\alpha}_i)\, \phi(\mathbf{z}_i' \boldsymbol{\alpha}_i)\, \alpha_{ij}.$$

Following, Su and Yen (2000), the elasticities are derived from equation (7). For example, the elasticities of commodity i with respect to price p_j, total meat expenditure m, and demographic variable r_l are (e.g., see Yen, Kan, and Su 2002)

$$(8) \qquad e_{ij} = \frac{\partial \mathrm{E}(y_i|\mathbf{x}_i, \mathbf{z}_i)}{\partial p_j} \frac{p_j}{\mathrm{E}(y_i|\mathbf{x}_i, \mathbf{z}_i)},$$
$$e_i = \frac{\partial \mathrm{E}(y_i|\mathbf{x}_i, \mathbf{z}_i)}{\partial m} \frac{m}{\mathrm{E}(y_i|\mathbf{x}_i, \mathbf{z}_i)},$$
$$e_{il} = \frac{\partial \mathrm{E}(y_i|\mathbf{x}_i, \mathbf{z}_i)}{\partial r_j} \frac{r_l}{\mathrm{E}(y_i|\mathbf{x}_i, \mathbf{z}_i)}.$$

These elasticities can be evaluated using parameter estimates and sample means of explanatory variables. Since ENIGH is a stratified sample, means of explanatory variables are computed incorporating the variables strata and weight.[10] The elasticity of commodity i with respect to demographic variable r_l is "not strictly defined... [but] allows convenient assessment of the significance of corresponding variables in a complex functional relationship" (Su and Yen 2000, 736). Finally, the compensated or Hicksian elasticities of commodity i with respect to price p_j can be obtained from Slutsky equation in elasticity form. That is,

$$(9) \qquad e_{ij}^c = e_{ij} + e_i \frac{p_j \mathrm{E}(y_j|\mathbf{x}_j, \mathbf{z}_j)}{m}.$$

[9] See Zellner (1962).
[10] See SAS Institute Inc. (2004, 4313–4362).

Empirical Results

The univariate maximum-likelihood probit parameters α_i, $i = 1, 2, \ldots, M$ are estimated by multiplying the contribution of each observation to the likelihood function by the value of the weight variable.[11] Table 5 reports the parameter estimates from the first five equations as well as their corresponding bootstrap standard errors.[12] The variable *m* stands for total meat expenditure, and the binary variables *NE*, *NW*, *CW*, *C* and *urban* stands for the Northeast, Northwest, Central-west, and Central regions, and the urban sector.[13] Note that the excluded dummy variables from each equation are the Southeast region (SE) and the rural sector (rural). From a total of 450 parameters estimated in the first step (25 parameters estimated at a time for 18 equations), 204, 157, and 137 parameters are statistically different from zero at the 0.20, 0.10, and 0.05 significance levels respectively.[14] Considering only parameter estimates corresponding to binary variables, from a total of 90 parameters estimated, 68, 59, and 51 are statistically different from zero at the 0.20, 0.10, and 0.05 significance levels respectively.[15] These significant determinants of the probability of consuming meat cut *i* are reported in Table 5 (see Appendix).

Moreover, the partial effect of continuous variable z_{ik} (e.g., $p_1, \ldots, p_{18}$ or m) on the probability of buying meat cut *i*, which is given by $\phi(\mathbf{z}_i' \boldsymbol{\alpha}_i)\, \alpha_{ik}$, can be estimated from Tables 4 and 5.[16] For example, an increase of one peso/kg in the price of pork leg and shoulder decreases the probability of consuming beefsteak by 0.0035, other things held constant. Similarly, the partial effect of binary variable z_{ik} (e.g., *NE*, *NW*, *CW*, *C*, *urban*) changing from 0 to 1 on the probability of buying meat cut *i* is given by $\Phi(\alpha_{i1} + \alpha_{i2}z_{i2} + \ldots + \alpha_{i(k-1)}z_{i(k-1)} + \alpha_{ik}(1) + \alpha_{i(k+1)}z_{i(k+1)} + \ldots + \alpha_{iK_1}z_{iK_1}) - \Phi(\alpha_{i1} + \alpha_{i2}z_{i2} + \ldots + \alpha_{i(k-1)}z_{i(k-1)} + \alpha_{i(k+1)}z_{i(k+1)} + \ldots + \alpha_{iK_1}z_{iK_1})$. For instance, the

[11] See SAS Institute Inc. (2004, 3754).

[12] The parameter estimates as well as their corresponding bootstrap standard errors for the other thirteen equations are available from the authors upon request.

[13] The Northeast region (NE) of Mexico consists of the states of Chihuahua, Cohahuila de Zara-goza, Durango, Nuevo León, and Tamaulipas. The Northwest region (NW) of Mexico consists of the states of Baja California, Sonora, Baja California Sur, and Sinaloa. The Central-West (CW) region of Mexico consists of the states of Zacatecas, Nayarit, Aguascalientes, San Luis Potosí, Jalisco, Guanajuato, Querétaro Arteaga, Colima, and Michoacán de Ocampo. The Central region (C) of Mexico consists of the states of Hidalgo, Estado de México, Tlaxcala, Morelos, and Puebla, and Distrito Federal. Finally, the Southeast region (SE) of Mexico consists of the states of Veracruz de Ignacio de la Llave, Yucatán, Quintana Roo, Campeche, Tabasco, Guerrero, Oaxaca, and Chiapas. These are the major geographical regions of Mexico used by Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA). Similarly, SAGARPA defines the urban sector as stratum 1 and stratum 2 while it defines the rural sector as stratum 3 and stratum 4.

[14] Given that the survey is complex, this study estimates standard errors of parameter estimates using the bootstrap procedure. A researcher, who naively estimates standard errors treating the survey as a simple random sample and uses Wald Chi-Square statistic from SAS default procedure to determine the statistical significance of the parameter estimates, would report that out of 450 parameters estimated in the first step, 439 are statistically different from zero at the 0.01 significance level. Devaney and Fraker (1990) and Kott (1990) explicitly caution about the limitations of standard regression packages when applied to complex surveys.

[15] As a goodness-of-fit measure, the overall percent of correctly predicted observations from the eighteen probit models are 69.11%, 82.42%, 81.93%, 95.65%, 94.71%, 91.06%, 97.84%, 87.04%, 81.21%, 75.32%, 85.87%, 84.46%, 73.03%, 68.04%, 95.50%, 84.55%, 76.46%, and 95.74% respectively.

[16] Average total meat expenditure is 33.0374 pesos per capita per week. The standard error of average total meat expenditure is 0.3450.

probability of consuming whole chicken in the Northeast region is about 0.3163 lower than the Southeast region, holding everything else constant.

Table 6 (see Appendix) reports the regional probabilities of buying meat cut *i* during the week of interview, $P(d_i = 1|\mathbf{z}_i)$. For some meat cuts the difference among the regional probabilities is about 1.5 times greater. For example, the probability of buying beefsteak in the Central-West region (0.4923) is about 1.5 times greater than the Northwest region (0.3202). Likewise for the probability of buying other beef in the Northeast (0.2352) and the Southeast (0.1555) regions, and the probability of buying chorizo in the Northeast (0.2283) and Southeast (0.1535) regions. In some cases the difference among the regional probabilities is larger (about 7 or 11 times greater). Probability comparisons can also be made across meat cuts in a single region or across both meat cuts and regions. The results suggest that Mexican meat-cut demands are heterogeneous.

In the second step, the estimation of the system of censored demand equations is based on the full system of $M = 18$ equations because the parametric restriction of adding-up is not imposed in the model (see also Yen, Kan, and Su 2002, 1801). Given that in stratified samples the weighted estimator is consistent (Wooldridge 2001, 464), all observations are weighted by the weight variable prior to estimation. However, "[if we] use weights, w_i, in the weighted least squares estimation, [we] will obtain the same point estimates...; however, in complex surveys, the standard errors and hypothesis tests the software provides will be incorrect and should be ignored" (Lohr 1999, 355). Consequently, standard errors of parameter estimates in this study are estimated using the bootstrap procedure. Table 7 (see Appendix) presents the SUR parameter estimates for the first five equations as well as their corresponding bootstrap standard errors from the system of eighteen equations.[17] From a total of 468 parameter estimated in the second step, 200, 128, and 67 parameters are statistically different from zero at the 0.20, 0.10, and 0.05 significance levels respectively.[18]

Tables 8 and 9 (see Appendix) respectively report the Marshallian and Hicksian price elasticities. The expected negative sign is obtained for all Marshallian and Hicksian own-price elasticities. In addition, there are as many positive price elasticities (160 Marshallians and 178 Hicksians) as there are negatives (164 Marshallians and 146 Hicksians). Positive cross-price elasticities suggest cases of substitute meat cuts while negatives suggest cases of complement meat cuts. Moreover, the signs of the Marshallian (Table 8) and Hicksian (Table 9) price elasticities are the same in all but 18 cases. In general, further cases of (gross and net) substitutability and complementarity are identified within and across the traditional categories (i.e., beef, pork, chicken, and fish). For example, within categories, cases of substitutability are found in Mexico. Ground beef is a (gross and net) substitute of beefsteak (and vice versa). Chicken ham and similar products are (gross and net) substitutes of ham, bacon and similar products from beef and

[17] The parameter estimates from the second step estimation as well as their corresponding bootstrap standard errors for the other thirteen equations are available from the authors upon request.

[18] If the standard errors of parameter estimates are calculated by treating the survey as a simple random sample and the statistical significance of the parameter estimates is determined by using the *t* statistic from SAS default procedure, then from a total of 468 parameter estimated in the second step, 314, 352, 372, and 393 are statistically different from zero at the 0.01, 0.05, 0.10, and 0.20 significance levels respectively.

pork (and vice versa). Within categories, cases of complementarity are also found in Mexico. Other beef cuts (i.e., excluding beefsteak, ground beef, and beef offal) are (gross and net) complements of beefsteak (and vice versa). Pork leg and shoulder is a (gross and net) complement of pork steak (and vice versa). Across categories, cases of substitutability are found in Mexico. Pork steak is a (gross and net) substitute of beefsteak (and vice versa). Chicken offal is a (gross and net) substitute of beef offal (and vice versa). Across categories, cases of complementarity are also found in Mexico. Fish is a (gross and net) complement of whole chicken (but not vice versa).

Elasticity estimates at the table-cut level of disaggregation are currently not available for Mexico. Only an indirect comparison with previous Mexican elasticity estimates at aggregate level (see Table 10 in Appendix) or a direct comparison with U.S. elasticity estimates at the disaggregated level are possible. However, model functional forms, sample sizes, and time period under consideration (among other things) influence elasticity estimates to differ from one study to another. For example, the Marshallian beef-beef elasticity in past studies ranges from –1.4300 in Malaga, Pan, and Duch (2006) to –0.4610 in Erdil (2006). In this study, there are sixteen Marshallian beef-beef elasticity estimates ($\hat{e}_{ij}$, $i, j = 1, 2, 3, 4$). The own-price elasticity estimates from the beef cuts ($\hat{e}_{ij}$, $i, j = 1, 2, 3, 4$, $i = j$) range from −4.8186 for beef offal to −1.0270 for beefsteak while the cross-price elasticity estimates from the beef cuts ($\hat{e}_{ij}$, $i, j = 1, 2, 3, 4$, $i \neq j$) range from −1.8100 between offal and beefsteak to 0.4889 between offal and ground beef (Table 8). The Marshallian pork-pork elasticity estimates in past studies range from –1.5100 in Malaga, Pan, and Duch (2006) to 0.0270 in Dong and Gould (2000). The sixteen Marshallian pork-pork elasticity estimates in this study consist of the own-price elasticity estimates ($\hat{e}_{ij}$, $i, j = 5, 6, 7, 8$, $i = j$), which range from −15.9428 for ground pork to −4.4711 for pork steak, and the cross-price elasticity estimates ($\hat{e}_{ij}$, $i, j = 5, 6, 7, 8$, $i \neq j$), which range from −1.9708 between other pork and ground pork to 1.6971 between the quantity consumed of other pork and the price of pork leg and shoulder. The Marshallian processed meat-processed meat elasticity estimates in past studies range from –0.7830 in Golan, Perloff, and Shen (2001) to −0.7755 in Dong, Gould, and Kaiser (2004). In this study, the own-price elasticity estimates from the processed beef and pork cuts ($\hat{e}_{ij}$, $i, j = 9, 10, 11, 12$, $i = j$) range from −3.1156 for other processed beef and pork to −0.7832 for ham and bacon while the cross-price elasticity estimates from these cuts ($\hat{e}_{ij}$, $i, j = 9, 10, 11, 12$, $i \neq j$) range from − 0.6150 between the quantity consumed of chorizo and the price of ham and bacon to 0.2719 between quantity consumed of ham and bacon and the price of sausages. The Marshallian chicken-chicken elasticity estimates in past studies ranges from −1.4300 in Malaga, Pan, and Duch (2006) to −0.1300 in Dong and Gould (2000). In this study, the own-price elasticity estimates from the chicken cuts ($\hat{e}_{ij}$, $i, j = 13, 14, 15, 16$, $i = j$) range from −9.1730 for offal to −1.2640 for whole chicken while the cross-price elasticities from the chicken cuts ($\hat{e}_{ij}$, $i, j = 13, 14, 15, 16$, $i \neq j$) range from −0.2035 between offal and whole chicken to 1.1161 between offal and chicken ham. The Marshallian own-price elasticity for fish and shellfish range from −2.1500 in Golan, Perloff, and Shen (2001) to –0.6348 in Dong, Gould, and Kaiser (2004). In this study, the own-price elasticity estimate for fish is −0.9825 and for shellfish is −7.5997 while the cross-price elasticity estimates are 0.6658 between fish and shellfish and −0.0001 between shellfish and fish.

These elasticity estimates have a wider range of values and identify further cases of gross substitutability and complementarity within the traditional categories (i.e., beef, pork, chicken, and fish). In general, the own-price elasticities had the largest magnitudes, which is common in demand studies at the differentiated level (see Chidmi and Lopez 2007 and Nevo 2001). It suggests that Mexican consumers are very price sensitive with respect to the consumptions and changes in the own prices of these commodities. Own-price elasticities with large magnitudes result from the fact that in the model Mexican consumers can substitute a beef cut with another beef cut, a pork cut with another pork cut, and so on, which allows the consumers to be more price sensitive. In other words, the own-price elasticities of aggregated meat categories (i.e., beef, pork, and chicken) tend to be more inelastic because consumers are given less potential substitutes, not only across meat categories but most importantly within a meat category. Consequently, consumers might be more reluctant to substitute an aggregated meat category. On the other hand, when disaggregated commodities are considered, there are more potential substitutes. In this study, there are more potential substitutes across and within categories. Consequently, consumers have more choices (especially within a meat category); therefore, own-price elasticities tend to have large magnitudes.

Few studies have reported U.S. elasticity estimates at the disaggregated level. A comparison of this study's findings with U.S. estimates may also provide additional insight about the nature of the Mexican demand for meat at the table cut level. Yen and Huang (2002, 329) reported own- and cross-price conditional elasticity estimates for four beef cuts (steak, roast, ground beef, other beef) and one aggregated meat category (other meat). The Marshallian beefsteak-beefsteak elasticity estimate of −1.0270 in this study (Table 8) is close to the estimate of −1.1100 reported by Yen and Huang (2002, 329). This indicates that U.S. and Mexican beefsteak consumers may respond similarly to changes in the beefsteak price. Unlike Yen and Huang (2002, 329), the Marshallian own-price elasticity estimates for ground beef and other beef in this study are elastic while the Yen and Huang's (2002, 239) estimates are inelastic. This is not surprising because Yen and Huang (2002) only considered five meat products while this study considered eighteen.

Medina (2000) also studied the U.S. demand for meat at the table cut level. Medina (2000, 123) reported Hicksian own- and cross-price elasticity estimates for nine meat products (roast, steak, other beef, ground beef, chicken, turkey, other poultry, pork, and fish) under four income groups ($0-$24,999; $25,000-$49,999; $50,000-$74,999; and over $75,000). Provided that the average total income of the meat-consuming households in Mexico is 36,384 pesos per month or U.S. $3,338,[19] selective Hicksian elasticity comparisons can also be made with the $25,000-$49,999 household income group reported in Medina (2000, 123). In general and as expected, this study's Hicksian elasticity estimates (Table 9) are more elastic than Medina's (2000, 123) estimates because it considers more table cuts of meats. Interestingly, most of the time, the cases of net substitutability and complementarity among the meat cuts were the same. For example, in both studies net substitutes (Table 9) include beefsteak and ground beef (and vice versa), beefsteak and whole chicken (and vice versa), beefsteak and fish (and vice versa). Similarly, in both

[19] The average total income estimate of the 16,909 meat-consuming households is 36,384 pesos per month or U.S. $3,338 with a standard error of average total income of 484.70 pesos per month or U.S. $44.47. The average total income estimate of the 20,875 responding households is $35,955 pesos or U.S. $3,298.62 per month with a standard error of the average total income of 444.35 pesos or U.S. $40.77 per month.

studies net complements include beefsteak and other beef (and vice versa), and other beef and fish (but not vice versa). In the case of the Marshallian eslasticity estimates (Table 8), this study's findings and Yen and Huang (2002) also found ground beef and beefsteak to be gross substitutes (but not vice versa), and other beef and beefsteak to be gross complements (but not vice versa).

Figure 2 presents the expenditure elasticity estimates. All of them have the expected positive sign and are statistically different from zero at the 0.05 significance level (except for ground beef), which means all the meat cuts are "normal" products and that consumption of all meat cuts are expected to increase as the economy grows. Additionally, since all the expenditure elasticities are less than one, none of the meat cuts is considered a "luxury" commodity. The expenditure elasticities range from 0.1846 for ground pork to 0.9733 for beefsteak. In addition, most pork-cut elasticities have a lower value (therefore more "necessary" goods in terms of their tastes and preferences) than most beef-cut elasticities and chicken-cut elasticities, except for processed-meat-cut expenditure elasticities (i.e., chorizo; ham, bacon and similar products from beef and pork; beef and pork sausages; other processed beef and pork; and chicken ham and similar products).

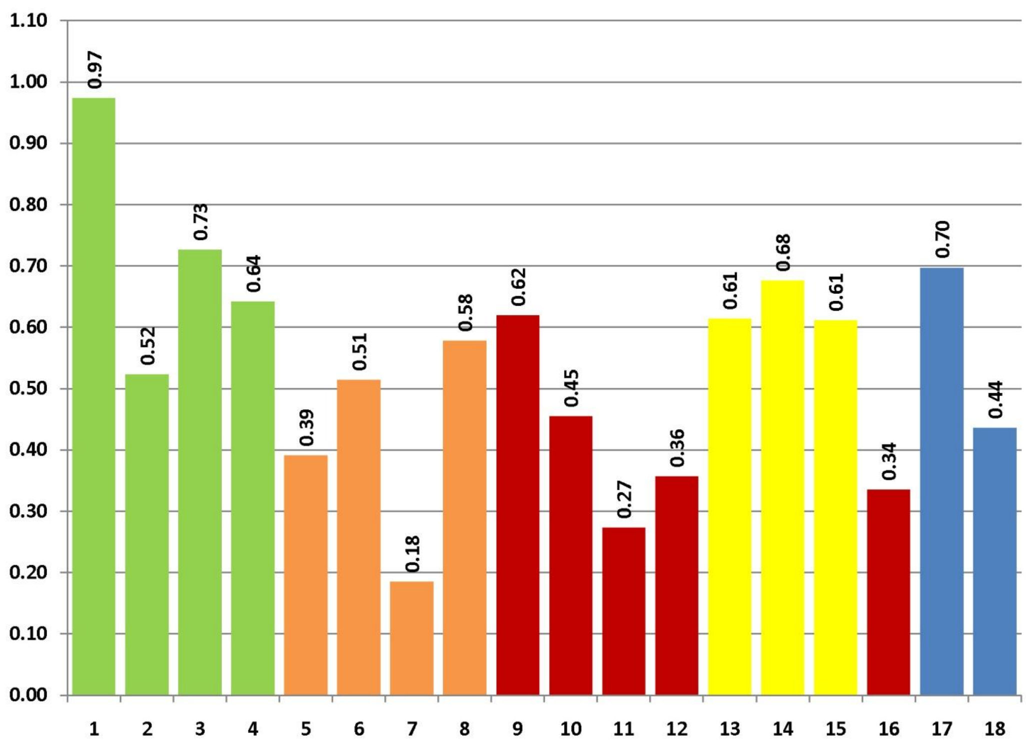

Figure 2. Expenditure Elasticities

Note: Bars depict $\hat{e}_i$, $i = 1, 2, \ldots, 18$, where 1 = beefsteak, 2 = ground beef, 3 = other beef, 4 = beef offal, 5 = pork steak, 6 = pork leg and shoulder, 7 = ground pork, 8 = other pork, 9 = chorizo, 10 = ham, bacon and similar products from beef and pork, 11 = beef and pork sausages, 12 = other processed beef and pork, 13 = chicken legs, thighs and breasts, 14 = whole chicken, 15 = chicken offal, 16 = chicken ham and similar products, 17 = fish, and 18 = shellfish. All expenditure elasticities are statistically different from zero at the 0.05 significance level except for ground pork. Significance levels were estimated with the bootstrap procedure at 1,000 resamples.

In past studies (Table 11), the beef expenditure elasticity estimates ranges from 0.1040 in Gould and Villarreal (2002) to 1.3059 in Dong, Gould, and Kaiser (2004). In this study (Figure 2), the expenditure elasticity estimates from the beef cuts range from 0.5228 for ground beef to 0.9733 for beefsteak. In past studies the pork expenditure elasticity estimates range from 0.1000 in Gould and Villarreal (2002) to 1.1728 in Dong, Gould, and Kaiser (2004) while in this study the expenditure elasticity estimates from pork cuts range from 0.1846 for ground pork to 0.5776 for other pork. Similarly, in past studies the processed meat expenditure elasticity estimates range from 0.5420 in Golan, Perloff, and Shen (2001) to 1.1512 in Dong, Gould, and Kaiser (2004) while in this study the expenditure elasticity estimates from processed beef and pork cuts range from 0.2728 for beef and pork sausages to 0.6190 for chorizo. Likewise, in past studies the fish (or seafood) expenditure elasticity estimates range from 1.1554 in Dong, Gould, and Kaiser (2004) to 1.2470 in Golan, Perloff, and Shen (2001) while in this study the shellfish elasticity estimate is 0.4361 and the fish elasticity estimate 0.6970. These results indicate that most expenditure elasticity estimates in this study fall within the range from past studies.

Yen and Huang (2002, 329) also reported conditional meat expenditure elasticity estimates for some table cuts of beef in the U.S. The Mexican beefsteak, other beef, and ground beef expenditure elasticity estimates of 0.9733, 0.7260, and 0.5228 from this study (Figure 2) follow the same respective descending order than the U.S. steak, other beef, and ground beef expenditure elasticity estimates of 1.1850, 1.0400, and 0.9780 reported by Yen and Huang (2002, 329). This means that in both the U.S. and Mexico beefsteak is the "most luxurious" beef cut while other beef is the "most necessary" beef cut.

Conclusions

Mexico is an important market for meat exporters because it is one of the leading meat importing countries in the world with a relatively high preference for meat offal and growing per capita meat consumption. Several of our findings suggest that Mexican meat consumption is more appropriately analyzed when considering table cuts of meats rather than meat aggregates. Volumes traded differ among the table cuts of meats; the probability of buying a particular meat cut changes across meat cuts and regions; and there are cases of (gross and net) substitutability and complementarity within and across the traditional meat categories (i.e., beef, pork, chicken, and seafood). Interestingly, the U.S. and Mexican beefsteak consumers seem to respond similarly to changes in the beefsteak price. The Marshallian own-price beef elasticity estimates (except for beefsteak) from this study seem to be more elastic than U.S. estimates. Interestingly, the several cases of (gross and net) substitutability and complementarity seem be the same in both the U.S. and Mexico. However, the substitution and complementarity patterns need to be further investigated as more studies on disaggregated elasticities are conducted in the U.S. and Mexico.

Our results also indicate that consumption on all meat cuts is expected to increase as the Mexican economy grows. In addition, all Mexican meat cuts are considered "normal" commodities but pork cuts appeared to have the most inelastic expenditure elasticities (except for processed meat cuts). Interestingly, in both the U.S. and Mexico beefsteak seems to be the "most luxurious" beef cut while other beef seems to be the "most necessary" beef cut. Similar comparisons between the U.S. and Mexico for pork and chicken cuts could be conducted if the meat demand studies in the U.S. would disaggregate these meat cuts. Unfortunately, few studies on the U.S. meat demand and no study on Mexican meat demand have conducted an analysis at the table cut level of disaggregation.

Unlike previous studies on the U.S. and Mexico meat demands, this study reports demand elasticities for eighteen table cuts of meats. The study is also unique in that it uses a relatively recent survey of households' incomes and weekly expenditures and it incorporates stratification variables into the analysis. Not treating the data as a stratified sample results in parameter estimates that may not only be biased (not be representative of the population) but also have incorrect standard errors. Given that the study employs cross-sectional survey data that is representative of the entire target population (i.e., Mexican meat-consuming households) and applies estimation techniques from stratified sampling theory, the elasticities reported can be interpreted as census estimates. Finally, data issues, such as censored observations and the number of adult equivalents, are incorporated into the analysis as well. This study has also the advantage of using a consistent two-step estimation procedure of a censored demand system. Since the data used in the study is not a simple random sample but a stratified one, the study incorporates estimation techniques from stratified sampling theory. For instance, it incorporates stratification variables (strata and weight) in preliminary data preparation, in each of the two-step estimation procedure, and in computing standard errors.

Furthermore, this study also has the advantage of having used data at the household level, which provides additional insights about the nature of the demand for meat. By analyzing individual households with micro-data, microeconomic models enable better estimation of demand parameters and improvement of forecasts over those using macro-data, which assumes aggregate household behavior is the outcome of the decision of a representative household. Consequently, the demand elasticity estimates reported in this study might be more precise than the aggregated estimates reported in previous studies. More importantly, the study may be used to perform a forecast and simulation analysis of Mexican meat consumption at the table cut level. That is, the study may be helpful in identifying current and future trends and growth rates in consumption and imports of specific table cuts of meats in Mexico.

References

Alston, J., and J. Chalfant. 1987. "Weak Separability and a Test for the Specification of Income in Demand Models with an Application to the Demand for Meat in Australia." Australian Journal of Agricultural Economics 31(31):1–15.

Bank of Mexico. 2008. "Exchange Rate to Pay Obligations in U.S. Dollars Within the Mexican Republic." Available http://www.banxico.org.mx/PortalesEspecializados/tiposCambio/ TiposCambio.html [Accessed August 2008].

Cameron, A.C., and P.K. Trivedi. 2005. Microeconometrics: Methods and Applications. Cambridge: Cambridge University Press.

Chidmi, B., and R.A. Lopez. 2007. "Brand-Supermarket Demand Breakfast Cereals and Retail Competition." American Journal of Agricultural Economics 89(2):324–337.

Cox, T.L., and M.K. Wohlgenant. 1986. "Prices and Quality Effects in Cross-Sectional Demand Analysis." American Journal of Agricultural Economics 68(4):908–919.

Devaney, B., and T. Fraker. 1990. "The Effect of Food Stamps on Food Expenditures: Reply." American Journal of Agricultural Economics 72(1):732–733.

Dong, D., and B.W. Gould. 2000. "Quality Versus Quantity in Mexican Poultry and Pork Purchases." Agribusiness 16(3):333–355.

Dong, D., J.S. Shonkwiler, and O. Capps. 1998. "Estimation of Demand Functions Using Cross-Sectional Household Data: The Problem Revisited." American Journal of Agricultural Economics 80(3):466–473.

Dong, D., B.W. Gould, and H.M. Kaiser. 2004. "Food Demand in Mexico: An Application of the Amemiya-Tobin Approach to the Estimation of a Censored Food System." American Journal of Agricultural Economics 86(4):1094–1107.

DuMouchel, W.H., and G.J. Duncan. 1983. "Using Sample Survey Weights in Multiple Regression Analyses of Stratified Samples." Journal of the American Statistical Association 78(383):535–543.

Dyck, J.H., and K.E. Nelson. 2003. Structure of the Global Markets for Meat. Washington, D.C.: U.S. Department of Agriculture, Economic Research Service, Market and Trade Economics Division, Agriculture Information Bulletin No. 785.

National Survey of Household Incomes and Expenditures (ENIGH). Aguascalientes, Mexico: National Institute of Statistics, Geography, and Information Technology (INEGI). Available at http://www.inegi.gob.mx.

National Survey of Household Incomes and Expenditures (ENIGH) – Methodological Synthesis. 2006. Aguascalientes, Mexico: National Institute of Statistics, Geography, and Information Technology (INEGI). Available at http://www.inegi.gob.mx.

Erdil, E. 2006. "Demand Systems for Agricultural Products in OECD Countries." Applied Economics Letters 13(3):163–169.

Garcia Vega, J.J., and M.C. Garcia. 2006. "The Role of Economic and Demographic Variables in Mexican Food Consumption." Journal of Food Distribution Research 31(1):24–31.

Golan, A., J.M. Perloff, and Z. Shen. 2001. "Estimating a Demand System with Non Negativity Constraints: Mexican Meat Demand." Review of Economics and Statistics 83(3):541–550.

Gould, B.W., and H.J. Villarreal. 2002. "Adult Equivalence Scales and Food Expenditures: An Application to Mexican Beef and Pork Purchases." Applied Economics 34(9):1075–1088.

Gould, B.W., Y. Lee, D. Dong, and H.J. Villarreal. 2002. "Household Size and Composition Impacts on Meat Demand in Mexico: A Censored Demand System Approach." Paper presented at the American Agricultural Economics Association Annual Meeting, Long Beach, CA, July 28-31, 2002.

Kott, P.S. 1990. "The Effects of Food Stamps on Food Expenditures: Comment." American Journal of Agricultural Economics 72(3):731.

Heien, D., L.S. Jarvis, and F. Perali. 1989. "Food Consumption in Mexico: Demographic and Economic Effects." *Food Policy Journal* 14(2):167–179.

Heien, D., and C.R. Wessells. 1990. "Demand Systems Estimation with Microdata: A Censored Regression Approach." *Journ*al of Business & Economic Statistics 8(3):365–371.

Henneberry, S.R., and J.E. Mutondo. 2009. "Agricultural Trade among NAFTA Countries: A Case Study of U.S. Meat Exports." Review of Agricultural Economics 31(3):424-445.

National Institute of Statistics, Geography, and Information Technology (INEGI). 2008. Personal Communication. INEGI−Customer Service. Available at: http://www.inegi.org.mx/lib/buzon.asp?s=inegi.

International Monetary Fund (IMF) − International Financial Statistics (IFS) Database. Available at http://www.imfstatistics.org/imf/ [Accessed December 2008].

Lohr, S.L. 1999. "Sampling: Design and Analysis." New York: Duxbury Press.

Malaga, J.E., S. Pan, and T. Duch-Carvallo. 2006. "Mexican Meat Demand: Did NAFTA Cause Consumer Behavior Change?" Paper presented at the Western Agricultural Economics Association Annual Meeting, Anchorage, AK, June 28–30, 2006.

Medina, S. 2000. "Household Demand for Meats Using Expenditure Allocation Models." Ph.D. dissertation, Department of Food and Resource Economics, University of Florida.

Mexico's Secretariat of Economy – System of Tariff Information via Internet (SIAVI). Available at http://www.economia.gob.mx/?P=5400 [Accessed October 2008].

Moschini, G., D. Moro, and R. Green. 1994. "Maintaining and Testing Separability in Demand Systems." American Journal of Agricultural Economics 76(1):61–73.

Nevo, A. 2001. "Measuring Market Power in the Ready-to-Eat Cereal Industry." Econometrica 69(2):307–342.

Sabates, R., and B.W. Gould, and H. Villarreal. 2001. "Household Composition and Food Expenditures: A Cross-Country Comparison." Food Policy 26(6):571–586.

SAS Institute Inc. – Sample 24982: Jacknife and Bootstrap Analyses. Available at http://support.sas.com/kb/24/982.html [Accessed July, 2008].

SAS Institute Inc. 2004. SAS/STAT 9.1 User's Guide. Gary, NC: SAS Institute Inc.

Shonkwiler, J.S., and S.T. Yen. 1999."Two-Step Estimation of a Censored System of Equations." American Journal of Agricultural Economics 81(4):972–982.

Su, S.J., and S.T. Yen. 2000. "A Censored System of Cigarette and Alcohol Consumption." Applied Economics 32(6):729–737.

Taylor, M., D. Phaneuf, and N. Piggott. 2008. "Does Food Safety Information Affect Consumers' Decision to Purchase Meat and Poultry? Evidence from U.S. Household Level Data." Paper presented at the Western Agricultural Economics Association Annual Meeting, Big Sky, MT, June 23–24, 2008.

Tedford, J.R., O. Capps, and J. Havlicek. 1986. "Adult Equivalent Scales Once More: A Developmental Approach." American Journal of Agricultural Economics 68(2):322–333.

United States Department of Agriculture. 2007. (USDA) – Economic Research Service (ERS), Production, Supply and Distribution (PSD) Database. Online. Available at http://www.fas.usda.gov/psdonline/psdQuery.aspx [Accessed March 2007].

Wooldridge, J.M.. 2001. "Asymptotic Properties of Weighted M-Estimators for Standard Stratified Samples." Econometric Theory 17(2):451–470.

Wooldridge, J.M. 2006. Introductory Econometrics: A Modern Approach, 3rd ed. New York: Thomson South-Western.

Yen, S.T., and C.L. Huang. 2002. "Cross-Sectional Estimation of U.S. Demand for Beef Products: A Censored System Approach." Journal of Agricultural and Resource Economics 27(2):320–334.

Yen, S.T., K. Kan, and S.J. Su. 2002. "Household Demand for Fats and Oils: Two-Step Estimation of a Censored Demand System." Applied Economics 34(14):1799–1806.

Zellner, A. 1962. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." Journal of the American Statistical Association 57(298):348–368.

Appendix

Table 5. ML Parameter Estimates from Univariate Probit Regressions (Step 1)

Var.	Beefsteak Param. Est.	Beefsteak Bootstr. Std. Err.	Ground Beef Param. Est.	Ground Beef Bootstr. Std. Err.	Other Beef Param. Est.	Other Beef Bootstr. Std. Err.	Beef Offal Param. Est.	Beef Offal Bootstr. Std. Err.	Pork Steak Param. Est.	Pork Steak Bootstr. Std. Err.
cont.	-0.6046	0.5169	-0.7441†	0.4906	-0.2887	0.5569	-0.6048	0.6586	0.4161	0.7201
p_1	-0.0011	0.0016	0.0047*	0.0017	-0.0047*	0.0018	-0.0005	0.0026	-0.0016	0.0020
p_2	0.0012	0.0023	-0.0012	0.0033	-0.0063*	0.0025	-0.0019	0.0033	-0.0038	0.0032
p_3	-0.0010	0.0019	-0.0000	0.0018	-0.0005	0.0022	-0.0008	0.0032	0.0017	0.0025
p_4	-0.0028	0.0029	-0.0036	0.0035	0.0064‡	0.0036	0.0007	0.0060	-0.0067†	0.0043
p_5	0.0101‡	0.0058	-0.0007	0.0040	0.0057†	0.0039	-0.0079†	0.0062	0.0026	0.0073
p_6	-0.0091*	0.0031	-0.0032	0.0034	-0.0069*	0.0034	0.0016	0.0037	-0.0060	0.0050
p_7	0.0084	0.0066	0.0082	0.0062	0.0003	0.0083	0.0028	0.0083	-0.0046	0.0100
p_8	0.0030†	0.0021	-0.0019	0.0021	-0.0055*	0.0028	-0.0001	0.0045	-0.0007	0.0029
p_9	0.0011	0.0010	0.0002	0.0010	-0.0014†	0.0009	-0.0065*	0.0029	0.0003	0.0013
p_{10}	0.0012	0.0013	0.0015	0.0013	0.0011	0.0012	-0.0007	0.0023	-0.0067*	0.0023
p_{11}	0.0007	0.0025	0.0007	0.0027	-0.0070*	0.0026	-0.0020	0.0037	0.0031	0.0040
p_{12}	-0.0008	0.0009	-0.0021†	0.0014	0.0003	0.0008	-0.0030†	0.0020	-0.0024†	0.0017
p_{13}	-0.0011	0.0019	-0.0024	0.0019	-0.0007	0.0020	0.0005	0.0026	-0.0046†	0.0033
p_{14}	-0.0002	0.0021	0.0001	0.0029	0.0015	0.0022	-0.0018	0.0041	-0.0048	0.0037
p_{15}	0.0029	0.0034	0.0057	0.0039	0.0064	0.0045	0.0012	0.0048	0.0047	0.0043
p_{16}	-0.0057*	0.0019	-0.0057*	0.0021	-0.0016	0.0018	0.0005	0.0028	-0.0037†	0.0027
p_{17}	0.0000	0.0011	0.0009	0.0011	0.0006	0.0012	-0.0040‡	0.0021	0.0007	0.0011
p_{18}	-0.0092*	0.0020	-0.0128*	0.0020	-0.0062*	0.0018	-0.0016	0.0024	-0.0061*	0.0028
m	0.0112*	0.0027	0.0085*	0.0006	0.0097*	0.0006	0.0037*	0.0009	0.0045*	0.0007
NE	-0.2030‡	0.0998	-0.1764†	0.1256	0.2429*	0.1046	-0.0361	0.1626	-1.1071*	0.1617
NW	0.0207	0.1259	1.1140*	0.1447	0.6158*	0.1393	0.0177	0.2380	-1.3065*	0.2121
CW	0.3399*	0.1007	0.1291	0.1031	0.2278*	0.0925	-0.3667*	0.1408	-0.4446*	0.1182
C	0.1808‡	0.0967	0.2106‡	0.1051	0.2959*	0.1058	0.0590	0.1413	-0.1934†	0.1313
urban	0.4952*	0.0590	0.5259*	0.0601	0.1378*	0.0589	0.1952*	0.0902	0.3051*	0.0826

Note: Number of bootstrap resamples = 1,000. Bootstrap significance levels of 0.05, 0.10 and 0.20 are indicated by asterisks (*), double daggers (‡) and daggers (†) respectively.

Table 6. Probability of Consuming Meat Cut i by Region

Table entries estimate $P(d_i = 1|\mathbf{z}_i)$.

	NE	*NW*	*CW*	*C*	*SE*	Mexico	Min.	Max.
$P(d_1 = 1\|\mathbf{z}_1)$	0.3621	0.3202	0.4923	0.4126	0.3386	0.3977	0.3202	0.4923
$P(d_2 = 1\|\mathbf{z}_2)$	0.1590	0.3928	0.1596	0.1457	0.1159	0.1757	0.1159	0.3928
$P(d_3 = 1\|\mathbf{z}_3)$	0.2352	0.2348	0.1630	0.1601	0.1555	0.1753	0.1555	0.2352
$P(d_4 = 1\|\mathbf{z}_4)$	0.0535	0.0392	0.0257	0.0560	0.0538	0.0463	0.0257	0.0560
$P(d_5 = 1\|\mathbf{z}_5)$	0.0173	0.0076	0.0418	0.0541	0.0819	0.0487	0.0076	0.0819
$P(d_6 = 1\|\mathbf{z}_6)$	0.0391	0.0549	0.0869	0.0615	0.1109	0.0758	0.0391	0.1109
$P(d_7 = 1\|\mathbf{z}_7)$	0.0100	0.0076	0.0181	0.0256	0.0309	0.0216	0.0076	0.0309
$P(d_8 = 1\|\mathbf{z}_8)$	0.0625	0.0682	0.1371	0.1807	0.1318	0.1360	0.0625	0.1807
$P(d_9 = 1\|\mathbf{z}_9)$	0.2283	0.1989	0.2056	0.1882	0.1535	0.1887	0.1535	0.2283
$P(d_{10} = 1\|\mathbf{z}_{10})$	0.2131	0.1935	0.2710	0.3690	0.1477	0.2620	0.1477	0.3690
$P(d_{11} = 1\|\mathbf{z}_{11})$	0.1520	0.2385	0.1534	0.1572	0.0745	0.1480	0.0745	0.2385
$P(d_{12} = 1\|\mathbf{z}_{12})$	0.1437	0.0804	0.1350	0.2233	0.1503	0.1621	0.0804	0.2233
$P(d_{13} = 1\|\mathbf{z}_{13})$	0.3034	0.2600	0.2016	0.5468	0.2906	0.3552	0.2016	0.5468
$P(d_{14} = 1\|\mathbf{z}_{14})$	0.1997	0.1696	0.3597	0.2481	0.4859	0.3128	0.1696	0.4859
$P(d_{15} = 1\|\mathbf{z}_{15})$	0.0128	0.0277	0.0247	0.0855	0.0613	0.0532	0.0128	0.0855
$P(d_{16} = 1\|\mathbf{z}_{16})$	0.2921	0.2189	0.1520	0.1052	0.1217	0.1487	0.1052	0.2921
$P(d_{17} = 1\|\mathbf{z}_{17})$	0.2784	0.2008	0.2437	0.2394	0.2629	0.2436	0.2008	0.2784
$P(d_{18} = 1\|\mathbf{z}_{18})$	0.0694	0.0102	0.0476	0.0209	0.0670	0.0396	0.0102	0.0694

Note: i = 1, 2, …, 18, where 1 = beefsteak, 2 = ground beef, 3 = other beef, 4 = beef offal, 5 = pork steak, 6 = pork leg and shoulder, 7 = ground pork, 8 = other pork, 9 = chorizo, 10 = ham, bacon and similar products from beef and pork, 11 = beef and pork sausages, 12 = other processed beef and pork, 13 = chicken legs, thighs and breasts, 14 = whole chicken, 15 = chicken offal, 16 = chicken ham and similar products, 17 = fish, and 18 = shellfish.

Table 7. SUR Parameter Estimates from System of Equations (Step 2)

Variable	Beefsteak ($i=1$)		Ground Beef ($i=2$)		Other Beef ($i=3$)		Beef Offal ($i=4$)		Pork Steak ($i=5$)	
	Param. Est.	Bootstr. Std. Err.	Param. Est.	Bootstr. Std. Err.	Param. Est.	Bootstr. Std. Err.	Param. Est.	Bootstr. Std. Err.	Param. Est.	Bootstr. Std. Err.
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)$	1.6951*	0.3939	0.6607	0.4387	2.0916*	0.7051	13.0161	16.0844	1.5472†	0.8903
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_1$	-0.0038*	0.0015	-0.0002	0.0007	-0.0038*	0.0022	-0.0057	0.0080	0.0051†	0.0040
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_2$	0.0000	0.0008	-0.0130*	0.0046	0.0053*	0.0031	0.0176	0.0230	0.0022	0.0069
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_3$	-0.0016*	0.0007	-0.0005	0.0006	-0.0109*	0.0040	0.0035	0.0090	-0.0019	0.0028
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_4$	0.0008	0.0013	0.0006	0.0016	-0.0019	0.0026	-0.0497*	0.0168	0.0075	0.0115
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_5$	-0.0067*	0.0024	0.0022†	0.0023	0.0044†	0.0050	0.0504	0.0884	-0.0235*	0.0105
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_6$	0.0050*	0.0021	0.0030‡	0.0016	0.0009	0.0044	-0.0061	0.0183	0.0027	0.0108
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_7$	-0.0072*	0.0021	-0.0011	0.0027	-0.0236*	0.0080	-0.0320	0.0333	-0.0017	0.0090
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_8$	-0.0020*	0.0007	0.0014	0.0011	-0.0036	0.0034	-0.0006	0.0036	0.0045‡	0.0025
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_9$	-0.0007*	0.0003	-0.0002	0.0002	0.0021	0.0022	0.0528	0.0738	-0.0024‡	0.0014
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_{10}$	-0.0009‡	0.0004	-0.0003	0.0004	-0.0003	0.0009	0.0035	0.0077	0.0062	0.0115
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_{11}$	-0.0007	0.0007	-0.0009	0.0007	0.0070*	0.0030	0.0208	0.0238	-0.0035	0.0055
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_{12}$	0.0005	0.0004	0.0007	0.0006	-0.0008†	0.0007	0.0192	0.0345	0.0028	0.0043
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_{13}$	-0.0014*	0.0008	0.0009	0.0011	-0.0025‡	0.0017	-0.0097†	0.0069	0.0052	0.0080
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_{14}$	-0.0002	0.0005	0.0017	0.0022	-0.0008	0.0011	0.0085	0.0202	0.0021	0.0087
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_{15}$	-0.0018†	0.0010	-0.0011	0.0009	-0.0006	0.0027	-0.0026	0.0171	-0.0043	0.0071
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_{16}$	0.0032*	0.0011	0.0014	0.0011	0.0019†	0.0014	-0.0053	0.0066	0.0090	0.0069
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_{17}$	-0.0002	0.0007	-0.0007‡	0.0004	-0.0016†	0.0010	0.0206	0.0455	-0.0009	0.0013
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,p_{18}$	0.0049*	0.0016	0.0021	0.0017	0.0014	0.0021	0.0162	0.0179	0.0058	0.0103
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,m$	-0.0003	0.0018	0.0005	0.0009	0.0010	0.0020	-0.0215	0.0410	-0.0033	0.0072
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,NE$	0.1933*	0.0552	0.1172*	0.0624	0.1733‡	0.1201	-0.2618	0.4762	0.9236	1.9232
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,NW$	0.0432	0.0487	-0.0280	0.1539	-0.0402	0.1721	-1.1865*	0.4623	1.4056	2.2352
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,CW$	-0.0888	0.0734	-0.0384	0.0437	-0.0149	0.0911	2.0145	4.2729	0.5291	0.7748
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,C$	-0.0698	0.0504	0.0683†	0.0541	0.1229	0.1251	-0.9158	0.7403	0.1874	0.3540
$\Phi(\mathbf{z}_i'\hat{\alpha}_i)\,urban$	-0.2890*	0.0938	-0.1448†	0.0895	-0.0609	0.0614	-1.4360	2.2463	-0.2713	0.5124
$\phi(\mathbf{z}_i'\hat{\alpha}_i)$	-0.8134*	0.2837	-0.1105	0.1768	-0.3410	0.3433	-8.2907	13.4497	-1.1200	1.9879

Note: Number of bootstrap resamples = 1,000. Bootstrap significance levels of 0.05, 0.10 and 0.20 are indicated by asterisks (*), double daggers (‡) and daggers (†) respectively.

Table 8. Marshallian Price Elasticities

i\j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	-1.0270*	0.1874†	-0.4383*	-0.1690	0.1565	-0.3042†	-0.1590	0.0375	0.0174	-0.0030	-0.0186	-0.0346	-0.2778*	-0.0361	0.0325	-0.1666†	-0.0394	-0.6354*
2	0.3941*	-3.4594*	-0.1164	-0.1068	0.4419	0.3923	0.3808	0.1548	-0.0236	0.0619	-0.0916	-0.0081	0.0032	0.2245	0.1064‡	-0.1294	-0.0950	-0.9724*
3	-1.2609*	0.2100	-1.7451*	0.2404	1.2346*	-0.5032	-3.3987*	-1.0235*	0.1885	0.0609	0.2369	-0.1490	-0.3109*	0.0158	0.2704	0.1163	-0.1758	-0.6919*
4	-1.8100*	0.4889	-0.3440	-4.8186*	-1.3840	0.8117†	-1.5508	-0.2194	0.6108	-0.2380	0.5040	-0.7262‡	-0.6557‡	-0.4232†	0.4998	-0.2088	-1.3958*	1.1782
5	0.7866	-0.7295†	0.0720	-0.2287	-4.4711*	-1.1063	-1.6662†	0.7246†	-0.4432†	-0.5834‡	0.0896	-0.1335	-0.1423	-0.5410†	0.2138†	0.8314*	0.0147	-0.9145†
6	-1.2086*	-0.5236	0.0135	0.4876†	-0.7959	-4.8375†	0.9168	0.3153	-0.1748	-0.3171	0.0492	0.5835*	0.1087	-0.4584†	0.0094	0.1924	0.1516	0.3673
7	-2.4904*	-0.5660	0.2482†	0.1254	-1.9010	-0.8229	-15.9428‡	-0.2945	0.1764	-0.0677	0.6991‡	-1.4896*	-0.2333	-0.5569†	-0.3212	-0.6395	-0.4851†	-0.6696
8	-0.1314	0.4929	0.3194	0.3868†	1.4251‡	1.6971*	-1.9708†	-8.3019*	0.6219	0.0730	0.5472	-0.4080	-0.2200	-0.3565†	0.0529	-0.8650†	-0.2177	0.4907
9	0.1705	-0.0911	0.1114	-0.0318	0.9794‡	-0.3901	0.0174	-0.1277	-1.2275*	-0.6150	-0.0932	-0.3774*	-0.1623	-0.2235†	-0.3070*	-0.3966†	-0.0510	0.0536
10	0.2400†	-0.7629*	0.4232*	-0.2591	0.1586	0.1704	-1.3375*	0.1069	0.0478†	-0.7832*	0.2719‡	0.2156	0.0995	0.1305‡	-0.4764*	0.2149	0.0845‡	0.4884
11	-0.3879*	-0.1636	0.1905*	-0.5674‡	1.0437*	-0.8304‡	0.4634†	0.6703*	0.0787‡	-0.0091	-1.8406†	-0.1287‡	-0.0014	-0.1101	-0.2771	0.3034	0.2344*	0.6494
12	0.1538	-0.7593†	0.0713	-1.2194*	-2.2317*	0.0021	0.5628	-0.3655	0.1009	-0.6053*	0.0806	-3.1156*	0.5946*	-0.0236	-0.6132*	0.2790‡	0.0330	0.3075
13	-0.2773‡	0.0030	0.0300	-0.4099*	0.2920	0.3180†	0.6752*	-0.0566	0.0603	0.1820*	-0.0051	0.1125	-1.2841*	-0.1555*	-0.0368	0.1865‡	0.0551†	0.0615
14	0.3895†	-0.3419†	-0.2401	-0.1481‡	-0.0380	0.0698	-0.2241	0.0332	-0.0866	-0.2281†	-0.1014	0.0320	0.0290	-1.2640*	0.1768†	-0.0120	-0.7013*	-0.0068
15	0.0033	0.2217	0.0484	0.3276	0.7168	0.4577	-1.7283	0.1402	-2.0678	-2.6776	1.0031	0.2440	-0.1783	-0.2035	-9.1730*	1.1161†	-0.4770	-0.0833
16	-0.0592	0.2251	0.0547	0.1362	2.1079*	0.2196	-1.7323*	0.6956†	0.0533	0.1333	0.2558†	0.0448	0.2076†	0.0365	0.1239	-1.2713*	0.0404	0.1742
17	-0.0347	-0.1137	0.0638	-0.1373	0.9090*	-0.6018†	-1.6105‡	0.1549	-0.0718	0.2375†	0.1125	0.0456	-0.0525	0.1371	0.2298‡	0.1382	-0.9825*	0.6658*
18	-1.0742‡	0.5885†	-0.6597*	0.1389	0.8832	0.3021	0.2106	-0.5493	0.0255	0.2046	0.4451†	0.0774	-0.1591	-0.0278	0.1831	1.1353‡	-0.0001	-7.5997*

Table 9. Hicksian Price Elasticities

i\j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	-0.8317*	0.2510‡	-0.3507*	-0.1528	0.1727	-0.2745	-0.1534	0.0933	0.0527†	0.0471	0.0054	0.0143	-0.1292‡	0.0772	0.0506	-0.1248	0.0591	-0.6028*
2	0.4990*	-3.4253*	-0.0693	-0.0981	0.4506	0.4083	0.3838	0.1848	-0.0046	0.0888	-0.0787	0.0182	0.0830	0.2853†	0.1161‡	-0.1069	-0.0421	-0.9549*
3	-1.1152*	0.2574	-1.6797*	0.2525	1.2467*	-0.4810	-3.3945*	-0.9820*	0.2148	0.0983	0.2549†	-0.1125	-0.2001†	0.1003†	0.2839	0.1475	-0.1023	-0.6676‡
4	-1.6814*	0.5308	-0.2862	-4.8079*	-1.3733	0.8313†	-1.5471	-0.1827	0.6341	-0.2050	0.5199	-0.6940‡	-0.5577†	-0.3486	0.5117	-0.1812	-1.3309*	1.1997
5	0.8650	-0.7040†	0.1072	-0.2222	-4.4646*	-1.0944	-1.6640†	0.7470†	-0.4291†	-0.5633‡	0.0993	-0.1139	-0.0827	-0.4956†	0.2210†	0.8482*	0.0542	-0.9014
6	-1.1054*	-0.4900	0.0598	0.4962†	-0.7873	-4.8218†	0.9197	0.3448	-0.1562	-0.2907	0.0619	0.6093*	0.1872	-0.3985†	0.0190	0.2144	0.2036†	0.3845
7	-2.4533*	-0.5540	0.2649†	0.1284	-1.8980	-0.8173	-15.9417‡	-0.2839	0.1831	-0.0582	0.7037‡	-1.4803*	-0.2051	-0.5354†	-0.3177	-0.6316	-0.4664†	-0.6634
8	-0.0155	0.5306†	0.3714	0.3964†	1.4347‡	1.7147*	-1.9675†	-8.2689*	0.6428	0.1027	0.5615	-0.3790	-0.1318	-0.2892	0.0636	-0.8402†	-0.1592	0.5101
9	0.2947†	-0.0507	0.1672	-0.0215	0.9897‡	-0.3712	0.0210	-0.0922	-1.2050*	-0.5832	-0.0779	-0.3463‡	-0.0678	-0.1515	-0.2955*	-0.3701†	0.0116	0.0743
10	0.3313*	-0.7333*	0.4641*	-0.2516	0.1662	0.1843	-1.3349*	0.1329	0.0643‡	-0.7598*	0.2831*	0.2385	0.1688‡	0.1835*	-0.4679*	0.2344†	0.1305*	0.5036†
11	-0.3331‡	-0.1458	0.2151*	-0.5628‡	1.0483*	-0.8221‡	0.4655†	0.6859*	0.0886*	0.0049	-1.8339†	-0.1150‡	0.0403	-0.0783	-0.2720	0.3151	0.2621*	0.6585
12	0.2254	-0.7360†	0.1034	-1.2135*	-2.2258*	0.0130	0.5649	-0.3451	0.1138	-0.5869‡	0.0894	-3.0977*	0.6491*	0.0179	-0.6066*	0.2944‡	0.0691	0.3194
13	-0.1541	0.0431	0.0852	-0.3996*	0.3023	0.3368†	0.6788*	-0.0214	0.0825†	0.2136*	0.0101	0.1434	-1.1904*	-0.0840‡	-0.0254	0.2129*	0.1173*	0.0821
14	0.5252*	-0.2978†	-0.1793	-0.1368†	-0.0267	0.0905	-0.2202	0.0720	-0.0621	-0.1933	-0.0847	0.0659	0.1323†	-1.1853*	0.1894†	0.0170	-0.6328*	0.0158
15	0.1260	0.2615	0.1034	0.3378	0.7270	0.4764	-1.7247	0.1752	-2.0457	-2.6461	1.0182	0.2747	-0.0850	-0.1323	-9.1617*	1.1423†	-0.4151	-0.0629
16	0.0082	0.2470	0.0849	0.1417	2.1135*	0.2299	-1.7304*	0.7149†	0.0655	0.1506	0.2641†	0.0617	0.2588‡	0.0755	0.1301	-1.2569*	0.0743	0.1854
17	0.1051	-0.0683	0.1265	-0.1257	0.9207*	-0.5805†	-1.6065‡	0.1949	-0.0465	0.2733‡	0.1298	0.0806	0.0539	0.2182	0.2427*	0.1681	-0.9119*	0.6891*
18	-0.9867†	0.6169†	-0.6204*	0.1462	0.8904	0.3154	0.2131	-0.5244	0.0413	0.2271	0.4559†	0.0993	-0.0925	0.0230	0.1912	1.1540‡	0.0440	-7.5851*

Note: *i*, *j* = 1, 2, …, 18, where 1 = beefsteak, 2 = ground beef, 3 = other beef, 4 = beef offal, 5 = pork steak, 6 = pork leg and shoulder, 7 = ground pork, 8 = other pork, 9 = chorizo, 10 = ham, bacon and similar products from beef and pork, 11 = beef and pork sausages, 12 = other processed beef and pork, 13 = chicken legs, thighs and breasts, 14 = whole chicken, 15 = chicken offal, 16 = chicken ham and similar products, 17 = fish, and 18 = shellfish. Number of bootstrap resamples = 1,000. Bootstrap significance levels of 0.05, 0.10 and 0.20 are indicated by asterisks (*), double daggers (‡) and daggers (†) respectively.

Table 10. Marshallian Beef-Price, Pork-Price, and Chicken-Price Elasticities in Mexican Meat Demand Studies

	Model	Period	Beef-Beef	Beef-Pork	Beef-Chicken	Beef-Fish
Henneberry and Mutondo (2009)[a]	SAIDS	1995-2005	-1.0330	0.1030	-0.1550	NA
Erdil (2006)[b]	AIDS	1961-1999	-0.4610	NA	NA	NA
Malaga, Pan, and Duch (2006)[c]	Censored QUAIDS	2004	-1.4300	0.0300	0.2700	NA
Dong, Gould, and Kaiser (2004)[d]	Censored AIDS	1998	-0.6276	-0.1014	0.0680	-0.0452
Golan, Perloff, and Shen (2001)[e]	Censored AIDS	1992	-1.0800	NA	NA	NA

	Model	Period	Pork-Beef	Pork-Pork	Pork-Chicken	Pork-Fish
Henneberry and Mutondo (2009)[a]	SAIDS	1995-2005	0.0490	-0.9230	-0.2280	NA
Erdil (2006)[b]	AIDS	1961-1999	NA	-0.0180	NA	NA
Malaga, Pan, and Duch (2006)[c]	Censored QUAIDS	2004	0.1000	-1.5100	0.2600	NA
Dong, Gould, and Kaiser (2004)[d]	Censored AIDS	1998	-0.3670	-0.1322	-0.1056	-0.0507
Golan, Perloff, and Shen (2001)[e]	Censored AIDS	1992	NA	-0.5600	NA	NA
Dong and Gould (2000)[f]	Double-Hurdle	1992	NA	0.0270	NA	NA

	Model	Period	Chick-Beef	Chick-Pork	Chick-Chick	Chick-Fish
Henneberry and Mutondo (2009)[a]	SAIDS	1995-2005	-0.1410	-0.3380	-0.6540	NA
Erdil (2006)[b]	AIDS	1961-1999	NA	NA	-0.2200	NA
Malaga, Pan, and Duch (2006)[c]	Censored QUAIDS	2004	0.5300	0.1200	-1.4300	NA
Dong, Gould, and Kaiser (2004)[d]	Censored AIDS	1998	0.1064	-0.0274	-0.8251	-0.0818
Golan, Perloff, and Shen (2001)[e]	Censored AIDS	1992	NA	NA	-0.6400	NA
Dong and Gould (2000)[f]	Double-Hurdle	1992	NA	NA	-0.1300	NA

[a] Henneberry and Mutondo (2009) used a source-differentiated almost ideal demand system to estimate meat demand in the U.S., Canada, and Mexico. They reported elasticities for beef, pork, and poultry.
[b] Erdil (2006) did not explain whether Marshallian or Hicksian own-price elasticity. He also reported own-price elasticity of ovine meat.
[c] Malaga, Pan, and Duch (2006) also estimated censored LA/AIDS and QUAIDS models for the years 1992, 1994, 1996, 1998, 2002.
[d] Dong, Gould, and Kaiser (2004) extended the Amemiya-Tobin approach to demand systems estimation using an AIDS specification. They reported simulated Marshallian price elasticities of beef, pork, poultry, processed meat and seafood.
[e] Golan, Perloff, and Shen (2001) used a generalized maximum entropy (GME) approach to estimate a nonlinear version of the AIDS with nonnegativity constraints. They reported elasticities for beef, pork, chicken, processed meat, and fish.
[f] Dong and Gould (2000) provided estimates of unit value impacts on quantity demanded of poultry and pork.