The Structure of U.S. Red Meat and Livestock Imports

Authors

Dwi Susanto
Department of Agricultural Economics, Texas A&M University
2124 TAMU
College Station, Texas 77843-2124
Email: dsusanto@ag.tamu.edu

C. Parr Rosson
Department of Agricultural Economics, Texas A&M University
2124 TAMU
College Station, Texas 77843-2124
Email: CPR@ag.tamu.edu

Shida Henneberry
Professor, Department of Agricultural Economics
Oklahoma State University
424 Ag Hall
Stillwater, OK 74078
E-mail: srh@okstate.edu

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Abstract

The Flexible nonlinear almost ideal demand systems are estimated for U.S. import demand for red meat and livestock (live cattle and hogs). Included in the model are domestic consumption on beef, pork, and chicken. The results reveal that fresh beef and live cattle are own price elastic; while other products are much more inelastic. Imported fresh beef is much more superior to imported frozen beef. Sheep, cattle, hogs, and chicken fall in superior good category. In all cases, the cross price elasticities of imported products with respect to prices of domestic products outweigh the cross price elasticities of domestic products with respect to prices of imported products, suggesting that consumers are more responsive to domestic prices than imported prices. Furthermore, BSE significantly affects imports of cattle, fresh beef, and hogs.

1. Introduction

U.S. imports of red Meat and livestock have steadily increased in recent years. Between 1996 and 2006, imports of red meat increased from 2.76 to 4.26 billion pounds and imports of hogs increased from 2.78 million head to 8.76 million head. U.S. imports of live cattle have experienced similar pattern, where imports increased from 1.97 million head in 1996 to 2.6 million head in 2002[1]. Although, the total share of meat imports is currently only about ten percent of total US meat consumption in volume, it is expected that imports continue to grow in the future. According to USDA long term projections, U.S. imports of beef and pork (the two major components of red meat) in 2008 are

[1] Data on red meat imports were from red meat yearbook and data on live hog and cattle were from FAS online (HTS 4 digits classification). U.S. imports of live cattle decreased significantly in 2003 at a level of 1.75 million heads when U.S. banned Canadian live cattle due to the BSE discovery in Canada; but imports resumed immediately following the elimination of the ban and reached at a level of 2.30 million heads in 2006.

projected to reach 3.37 billion pounds and 1.04 billion pounds, respectively. Notably, the United States is currently the world's largest importer of beef and is among the top four importers of pork (USDA, 2007a).

Given the importance of meat imports in total meat disappearance in the U.S., understanding the demand for differentiated meats and livestock and the factors shaping it would help understanding this growing market. Understanding the demand and its parameters would be of importance to the U.S. meat and livestock producers as well as policy makers in developing effective policies targeted towards increasing U.S. producers' income and market shares. Furthermore, most of previous studies have focused on domestic aggregate consumer demand for red meat (Braschler 1983; Chavas 1983; Moschini and Meilke 1984; Eales and Unnevehr 1988; Brester 1996; among others) and few have investigated U.S. import demand for red meat.

This study contributes significantly in the literature, particularly in import demand analysis for red meat and livestock. This study differs from previous studies in several aspects. First, it disaggregates data using HTS-4 digit classification. The use of these data provides relevant parameter estimates since imports data are reported in the form of HTS classification. Second, this study includes consumption from domestically produced meat. This is very important given the fact that most of U.S. red meat consumption is from domestic supplies. Furthermore, the inclusion of domestically produced meat can mitigate the strong separability assumptions between domestic and imported meats (Alston *et al*., 1990 and Yang and Koo, 1994). Third, this study uses more recent monthly data from 1989 to 2006, covering the period in which bovine spongiform encephalopathy (BSE) was found in both Canada and the United States. The results of this study, therefore, provide new parameter estimates that give more precise and optimal policy analysis for both the United States as an importer and foreign suppliers.

The primary objective of this study is to estimate the U.S. import demand for red meat and livestock. The specific objectives of this study are to: (i) estimate U.S.'s import demand elasticities for red meat and livestock; and (ii) provide policy recommendations for U.S. imports of red meat and livestock. The analysis is based on estimations using the flexible nonlinear Almost Ideal Demand System (AIDS), applied to monthly data from 1989 to 2006. The results of this study are intended to provide and update parameter estimates, particularly import demand elasticities of red meat and livestock provided in the literature

The remainder of the paper is organized as follows. Section 2 describes the empirical AIDS model and its estimation. Section 3 discusses the data and their sources. Section 4 provides estimation results and subsequently discusses the main findings and their policy implications. The main conclusions are summarized in section 5.

2. Empirical Specification of the AIDS Model

Among the many demand specifications in the literature, the Rotterdam model and the Almost Ideal Demand System (AIDS) have been and mostly utilized models in empirical demand analysis. This is because the two approaches possess some useful properties including (local) flexibility, compatibility with demand theory, ease of use, familiarity and plausibility (Alston and Chalfant, 1993). The choice between the two depends on the specific data set being used (Berndt, Darrough and Diewert, 1977) and the specific situation that is being studied (Dhar, Chavas and Gould, 2003). The Rotterdam model, for example, may perform better than the AIDS for a particular data set or *vice* *versa*; and in some instances either model may not be suitable for a particular data set (See Alston and Chalfant, 1993).

This study uses the original version of the non-linear AIDS model for a number of reasons. First, the model designates theoretical demand equations that follow the basic tenets of economic rationality. It represents a flexible complete demand system and does not require the additivity of the utility function; furthermore, it satisfies the axiom of choice exactly and allows aggregation perfectly over consumers (Deaton and Muellbauer, 1980). The (locally) flexible functional forms also provide enough parameters to approximate any elasticity at a given point (Barnett and Seck, 2006). Second, although the Rotterdam model has also the desirable properties of demand theory, specification tests based on the test developed by Alston and Chalfant (1993) indicated that the AIDS model is superior to the Rotterdam for the data being used in this study. Third, the use of the non-linear AIDS can mitigate the criticism of the LA/AIDS version for being internally inconsistent and lacking in approximation properties (Buse 1994, 1998; Hahn, 1994; Moschini, 1995).

Following Deaton and Muellbaur, the non-linear Almost Ideal Demand System (NLAIDS) is specified as:

(1) $$w_i = \alpha_i + \sum_j \gamma_{ij} \ln(p_j) + \beta_i \ln\left(\frac{m}{p^*}\right),$$

where w_i is the budget share of good *i*, p_j is the price of good *j*, *m* is total expenditure on all goods in the demand system and P^* being the translog price index defined as:

(2) $$\ln(P^*) = \alpha_0 + \sum_k \alpha_k \ln(p_k) + \frac{1}{2}\sum_j \sum_k \gamma_{kj}^* \ln(p_k)\ln(p_j)\,.$$

α_i, β_i, and γ_{ij} are coefficient to be estimated where $\gamma_{ij} = \frac{1}{2}(\gamma^*_{ij} + \gamma^*_{ji})$.

To comply with the demand theory, the basic restrictions for the demand system can be imposed on the parameters. These are:

Adding up: $\sum_i \alpha_i = 1; \quad \sum_i \gamma_{ij} = 0; \quad \sum_i \beta_i = 0;$

Homogeneity: $\sum_j \gamma_{ij} = 0$, for i = 1, 2, ……., n;

Symmetry: $\gamma_{ij} = \gamma_{ji}$.

The uncompensated or Marshallian price elasticities can be derived from the Marshallian demand functions expressed in expenditure shares and is given by

$$(3) \qquad \varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \left(\frac{\beta_i}{w_i}\right)\left(\alpha_j + \sum_k \gamma_{kj} \ln p_k\right)$$

where δ_{ij} is the Kronecker delta that takes the value of one if $i=j$ and zero otherwise (Green and Alston 1990). The Income or expenditure elasticity for good i is given by

$$(4) \qquad \eta_i = 1 + \frac{\beta_i}{w_i}.$$

In this study, the demand system consists of six imported products: fresh beef, frozen beef, pork, sheep and goat meat, live cattle and hogs; and three domestically produced products: beef, pork, and chicken[2]. The grouping of imported products is based on the HTS-4 digit classification. Live cattle and hogs are included in the analysis because these two products are components of red meat and play important roles in the U.S. red meat consumption. It is realized that live cattle may be imported as feeder cattle or cattle for slaughter such that each category may be differentiated from the other; and

[2] For simplicity, at this point and on, the term red meat refers to all the six products (fresh beef, frozen beef, pork, sheep, live cattle and hogs).

hence should be disaggregated. Because of the data limitation, in this study the two groups are combined as live cattle.

3. Estimation Procedures

The system of share equations represented by (1) and (2) is nonlinear in the parameters and the parameter α_0 (the intercept term in the price equation 2) may be difficult to estimate and is often set to some predetermined value. Following Moschini, Moro and Green (1994), α_0 is set to zero. There are a total of nine demand equations in the system; but one equation: sheep equation drops out for the purpose of estimation. Therefore, the system has one less quantity demanded than price variables. The coefficients of dropped equation can be recovered from the adding-up restriction. In this study, another equation: live swine is dropped and the system is re-estimated to obtain the sheep equation and its associated standard errors. The results are very close to the parameters calculated from the adding-up restriction.

In empirical analysis, it is often argued that the demand system composed of equations (1) and (2) may suffer from expenditure endogeneity, *i.e*. biased and inconsistent estimates. The expenditure variable *m* in equation (1) may not be truly exogenous, since it is used to calculate the dependent variable (Henneberry, Piewthongngam and Qiang, 1999). In fact LaFrance (1991) argues that endogeneity of expenditure is likely to be a generic issue in the demand analysis and therefore should be taken care of in estimation. Price endogeneity can also arise in the estimation process when price determination involves significant interplay of supply and demand (Dhar *et al*, 2003) and if products are differentiated (Berry, 1994).

Prior to estimation, tests for the presence of expenditure endogeneity using the Wu-Hausman procedure were performed. The results suggest that the hypothesis of endogeneity in expenditure can not be rejected, suggesting a need to control for endogeneity bias in the model estimation. In the case of prices, we found two of the nine prices exhibit endogeneity. Due to difficulty in obtaining supply and demand shifters and given that only two prices exhibit endogeneity, we treat prices as exogenous variables.

There are two approaches normally used to control for endogeneity in empirical studies, namely instrumental variable estimation and explicit specification of price and expenditure equations (Dhar *et al*,, 2003). The first approach involves determining a set of instruments that will be used in the estimation. In the case of nonlinear demand system, it is relatively difficult to select instrumental variables because the system itself involves many variables to be estimated. Berry (1994) stated that any straightforward application of instrumental variables for nonlinear equations such as in the AIDS model normally creates difficulty in estimation process. The second approach typically involves specifying reduced form functions which are estimated jointly with the share equations. This study adopts this approach because it is relatively straight forward and more applicable than the first approach.

The reduced form of expenditure equation is specified as a function of income and time trend (Blundell and Robin, 2000) and given by:

(5) $$\ln(m) = \phi_0 + \phi_1 \ln(Inc) + \phi_2 \ln(Inc^2) + \phi_3 T$$

where Inc is personal consumption expenditure and Inc^2 is the squared of personal consumption expenditure and T is time trend. Data on personal consumption expenditure are from Bureau of Economic Analysis (BEA) and expressed in billion of dollars. The reduced form of expenditure function (5) is estimated jointly with the share equation (1) and (2) using the full information maximum likelihood estimation (FIML).

3. Data and Sources

Monthly data from 1989 to 2006 are used in this analysis. Import data for all meat products were obtained from Foreign Agricultural Statistics (FAS online), USDA. Quantity of imports is expressed in numbers for livestock (cattle and hogs) and in metric tons for other products. Prices for livestock are in dollar per head and for other products they are in dollars per metric ton. Because imports prices for each product are not available, unit values are used as a proxy. The unit value is obtained by dividing import dollar values by import quantities. The drawback of this approach is that prices can only be observed when there is trade. When there is no trade, world prices, which are estimated equal to total import value from all countries divided by total quantity imported, are used. Expenditure is equal to the product of quantity imported and its corresponding price, which is also equal to import values.

Domestic consumption on red meat and chicken are obtained from National Agricultural Statistics (NASS) and other USDA publications: red meat yearbooks, poultry yearbook and livestock, and dairy and poultry outlook. Domestic beef consumption is in million pounds of retail weight equivalent, domestic pork consumption is in million pounds domestic chicken consumption is ready to cook of young chicken in thousand of pounds. Prices of domestic beef and pork are retail value in cents per pound and price of chicken is young composite chicken price in cents per pound. Total consumption of red domestically supplied and imported meat and chicken are calculated after unit values and prices are converted in the same measurements.

The sample statistics of expenditure shares for each product are summarized in Table 1. Over the sample period, the United States spent an average of 3.34 percent of its meat consumption on red meat and livestock imports. It is not surprising that the United States spent most of its meat consumption on domestically produced meat and chicken. Of total expenditure on red meat and livestock imports, the United States allocated some 34 percent of its import expenditures on livestock (cattle: 28 % and hogs: 6%). Surprisingly, live cattle and hogs alone accounted for as high as 51 percent and 14 percent of total expenditures on red meat imports, respectively. Frozen beef ranked first in red meat import expenditures, accounting for 31 percent with the maximum expenditure share of 64 percent. Fresh beef and pork imports accounted for of 17 and 14 percent of total expenditure on red meat and livestock imports, respectively. Sheep meat imports are the least in term of expenditure shares with 4 percent of total import expenditures on red meat imports.

Sheep and goat meat prices are highest among imported red meat products with an average of $3493.7 per metric ton, followed by imported fresh beef, pork and frozen beef prices. A record high of imported fresh beef price is $5483.4 per metric ton which occurred in June 2003, right after the BSE case was found in Canada. Average prices of imported cattle and hogs are $543.13 and 78.08 per head, respectively. Average domestic beef, pork and chicken prices are recorded as 314.89, 241.18, and 153.34 cents per pound, respectively.

4. Regression Results

5.1. Parameter Estimates

Table 2 presents the estimated coefficients of the flexible nonlinear AIDS model with symmetry and homogeneity restrictions and controlling for expenditure endogeneity. Because the test for autocorrelation indicated the presence of autocorrelation, the model was estimated allowing errors to be autocorrelated to the first order. Breusch-Pagan and white tests of heteroscedasticity were carried out. No heteroscedasticity was detected at the 5 percent level of significance by either of these tests.

There are a total of 63 parameter estimates, including expenditure and dummy variables for BSE. Because the parameter estimates of the demand system are based on the non-linear demand systems, price and income derivatives are non-linear functions of parameters and variables and therefore individual coefficients may not have the usual interpretations or expected signs. In this case, the discussion will focus on elasticity estimates and the coefficients of dummy variables for BSE.

5.2. Elasticity Estimates

Results for the estimated price and expenditure elasticities are reported in Table 3. In the imported products, fresh beef and cattle are much more elastic than frozen beef, pork, sheep, and hogs. Furthermore, fresh beef, sheep, cattle, and hogs are superior good. On the other hand, pork and frozen beef do not fall in the category of superior good. In the domestic products side, the three product included in the study are all price inelastic with beef having highest price elasticity (absolute value) of, followed by chicken and pork. Chicken is, however, the only superior good among the domestic products.

The estimate of own price elasticity for imported fresh beef is -1.19. This is higher than the own price elasticity of domestic beef which was found to be -0.782. Demand for imported frozen beef, on the other hand, is not sensitive to price changes. Its magnitude is -0.481 and not significant at any reasonable level of significance. These estimates suggest that imported fresh beef is much superior to imported frozen beef. This is true given the fact that imported fresh beef is high quality product; while imported frozen beef is relatively lower quality manufacturing beef. The superiority of fresh beef is also shown by its expenditure elasticity at 1.639 compared to 0.309 for imported frozen beef.

Similar to beef, estimate of own price elasticity for pork imports is higher than that of domestic pork, which is reasonable given that import (and export) demand elasticities are typically higher than domestic demand. As shown in Table 3, own price elasticities for pork imports and domestically produced pork are -0.656 and -0.469, respectively. Both import and domestic demand for pork have expenditure elasticities of less than one.

Own price elasticity of sheep meat imports is relatively high with its magnitude of -0.972. Expenditure elasticity for sheep meat imports is also found to be quite high at a level of 2.082. Domestic demand for chicken is inelastic with the magnitude of -0.541; but it is elastic in terms of expenditure. For the live animals, cattle imports seem to exhibit unitary price elastic with an own price elasticity of -1.02. This figure is smaller than the elasticity reported by Buhr and Kim (1997) who found that U.S. live cattle imports from Canada is price elastic with the magnitude of -1.5. Animal disease particularly BSE is argued to have contributed to less elastic import demand for cattle.

Since the discovery of BSE in May 2003, for example, the United States banned US imports of cattle from Canada. This can also be seen from a dummy variable representing BSE case, which will be discussed in the subsequent section. Estimate of own price elasticity for hogs imports is -0.423. The expenditure results suggest that both cattle and hogs imports are expenditure elastic.

Overall, the results for own price elasticities given in this study are quite reasonable. This can be shown when they are compared with previous studies, where estimates of own price elasticities in this study fall in the range of empirical estimates. As shown in Table 4, elasticity estimates of domestic demand for beef, pork, and chicken given in this study are relatively moderate compared with empirical studies as cited. In the case of import demand, we were not able to find empirical comparisons since there is no closed study that estimated import demand for red meat. Worth to mention is a study by Brester (1996) that reported that import demand elasticities for ground beef and table-cut beef are -0.96 and -0.80, respectively.

The cross-price elasticities in Table 3 represent substitutability or complementary among meat products and livestock studied here. In most cases cross-price elasticities are not significant with low in magnitudes. The relationships between imported beef (fresh and frozen) and domestic beef are worth to mention. As shown in Table 3, the cross-price elasticity of imported fresh beef with respect to the price of domestic beef is 1.785 and significant, suggesting that imported fresh beef and domestic beef are substitute to each other. Similarly, imported frozen beef and domestic beef are also substitute to each other with cross price elasticity of 1.611. When looking at the converse, however, the results show quite different in magnitudes. As shown that cross elasticity of domestic beef with respect to either imported fresh beef or frozen beef are nearly zero. This indicates that price of domestic beef has greater impacts on expenditure shares of imported beef than price of imported beef does on expenditure shares of domestic beef.

With respect to chicken, both imported fresh and frozen beef are found to be complementary products to domestic chicken. Similarly, domestic beef and domestic chicken are complementary products to each other. The fact that beef and chicken are complementary products is consistent with the study by Moschini and Meilke. Imported pork and domestic pork are substitute products; but their elasticity estimates are not significant. Pork and chicken show complementary relationships.

Looking at live animals, cattle and domestic beef are substitute products; while cattle and pork (imported and domestic) show complementary relationships. Hogs and domestic pork show much more substitute relationships as expected.

Estimates of expenditure elasticities are displayed in the last column in Table 3. All parameter estimates are statistically significant at the 1 percent level. Frozen beef and sheep are found to be expenditure elastic. This is interesting because these two goods are imported from Australia and New Zealand, while other goods are mostly imported from Canada. This likely suggests that U.S. imports for red meat from Australia is expenditure (income) driven, likely influenced by strong demand in the fast food/take out industry.

6. Concluding Comments

This paper analyzes U.S. imports of red meat (fresh beef, frozen beef, sheep meat, pork, live cattle, and hogs) using the flexible nonlinear AIDS model. The analysis also takes into account expenditure endogeneity. The flexible nonlinear AIDS model is adopted to avoid the problem associated with linear approximation and the inclusion of expenditure endogeneity is to avoid bias and inconsistent estimates that may occur in the estimation. Price and expenditure elasticities of U.S. imports of red meat are estimated based on price and expenditure coefficients from the NLAIDS model.

The estimated results reveal that fresh beef and live cattle are own price elastic; while other products are much more inelastic. Imported fresh beef is much more superior to imported frozen beef. Sheep, cattle, hogs, and chicken fall in superior good category. The cross price elasticities show more complementary relationships, with forty one of the seventy two cross price elasticities having a negative sign. Furthermore, the cross price elasticities point to interesting conclusions. In all cases, the cross price elasticities of imported products with respect to prices of domestic products outweigh the cross price elasticities of domestic products with respect to prices of imported products, in term of both the magnitudes and statistical significance. This suggests that consumers are more responsive to domestic prices than imported prices.

Dummy variable for BSE significantly affect imports of cattle, fresh beef, and hogs. Impact of BSE on possible structural change in elasticity is an upcoming topic that needs to be addressed and investigated. Still with an upcoming research, it would also be worthwhile to develop and estimate the models using disaggregated data that can take two forms: (i) based on higher HTS classification and (ii) based on import sources.

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Table 1. Expenditure Shares and Prices of U.S. Red Meat and Livestock

Imports, 1989:1 – 2006:12.

Meat/Import Source	Mean	Std. Dev.	Minimum	Maximum
Expenditure Shares				
Fresh Beef	0.0058	0.0026	0.0014	0.0121
Frozen Beef	0.0102	0.0034	0.0039	0.0230
Pork	0.0047	0.0009	0.0029	0.0069
Sheep	0.0014	0.0009	0.0003	0.0040
Cattle	0.0094	0.0034	0.0011	0.0192
Hogs	0.0019	0.0010	0.0005	0.0043
Domestic beef	0.3404	0.0233	0.2827	0.3951
Domestic Pork	0.3369	0.0199	0.2919	0.3993
Domestic Chicken	0.2893	0.0204	0.2341	0.3401
Average Prices				
Fresh Beef	2854.8	637.64	1986.5	5483.4
Frozen Beef	2139.6	372.15	1478.4	2918.5
Pork	2209.9	293.01	1516.7	2890.4
Sheep	3493.7	1185.9	1538.6	6402.4
Cattle	543.13	102.78	336.81	767.47
Hogs	78.08	19.53	31.82	120.19
Domestic beef	314.89	48.40	258.20	431.70
Domestic pork	241.18	28.78	187.40	289.80
Domestic chicken	153.34	9.89	135.65	178.88

Source: Authors' calculation. Average prices are expressed in nominal value. Prices of fresh beef, frozen beef, pork and sheep are in US dollar per metric ton; prices of cattle and hogs are in US dollar per head; prices of domestic beef, pork, and chicken are in cents per pound.

Table 4. Own Price Elasticity: Present and Empirical Estimates

Products	Present Study	Eales & Unnevehr[a]	Moschini & Meilke[b]	Alston & Chalfant[c]	Expenditure Elasticity[d]
Imported					
Fresh Beef	-1.194	-	-	-	1.639
Frozen Beef	-0.481	-	-	-	0.309
Pork	-0.656	-	-	-	0.913
Sheep	-0.972	-	-	-	2.082
Cattle	-1.020	-	-	-	1.178
Hogs	-0.423	-	-	-	1.830
Domestic					
Beef	-0.782	-0.570	-0.983 (-1.050)	-0.98	0.868
Pork	-0.469	-0.762	-1.015 (-0.839)	-0.17	0.879
Chicken	-0.541	-0.276	-0.090 (-0.104)	-0.94	1.291

[a]Compensated aggregate elasticities (1988); [b]before (after) structural breaks (1989); [c]Estimated using the Rotterdam Model (1993); [d]Present study

Table 2. Estimated Coefficients of the Flexible AIDS Model: Controlling for Expenditure Endogeneity

	Budget Share								
	FrBeef	FzBeef	Pork	Sheep	Cattle	Hogs	Dbeef	Dpork	Dchk
Price fresh beef	-0.0012								
	(-0.75)								
Price frozen beef	-0.0017	0.0047							
	(-1.01)	(1.14)							
Price Pork	-0.0003	0.0006	0.0016						
	(-0.38)	(0.65)	(1.95)*						
Price sheep	0.0008	-0.0008	0.0001	0.0004					
	(1.33)	(-1.10)	(0.29)	(0.98)					
Price live cattle	-0.0002	0.0014	-0.0006	-0.0004	-0.0002				
	(-0.03)	(0.65)	(-1.36)	(-1.30)	(-0.13)				
Price hogs	-0.0014***	-0.0012*	-0.0003	0.0001	-0.0001	0.0011			
	(-2.89)	(-1.95)	(-0.64)	(0.55)	(-0.23)	(3.68)***			
Price dom. beef	0.0133***	0.0108	-0.0005	0.0038	0.0158**	0.0019	0.0386		
	(4.56)	(1.05)	(-0.22)	(2.82)**	(2.25)	(1.35)	(0.92)		
Price dom. pork	0.0038	-0.0094	0.0015	-0.0003	-0.0168***	0.0031**	-0.0781**	0.1470***	
	(0.90)	(-0.93)	(0.92)	(-0.28)	(-3.07)	(2.45)	(-2.01)	(2.96)	
Price chicken	-0.0139***	-0.0044	-0.0023*	-0.0034	0.0009	-0.0032***	-0.0048	-0.0512*	0.0826**
	(-4.09)	(-0.48)	(-1.69)	(-3.26)***	(0.17)	(-3.94)	(-0.16)	(-1.68)	(2.50)
BSE	-0.0017**	0.0007	0.0007	0.0002	-0.0064	0.0015***	0.0033	-0.0094	0.0111
	(-1.98)	(0.24)	(1.48)	(0.65)	(-2.99)***	(4.34)	(0.28)	(-0.79)	(1.20)
Expenditures	0.0037**	-0.0071*	-0.0004	0.0015	0.0017	0.0017***	-0.0448**	-0.0406	0.0843
	(2.57)	(-1.80)	(-0.62)	(3.28)***	(0.72)	(3.96)	(-2.55)	(-2.15)**	(7.06)***
R^2	0.879	0.470	0.745	0.871	0.659	0.925	0.646	0.501	0.893
DW	1.527	2.801	1.847	2.136	1.478	2.022	2.089	2.075	1.914

FrBeef = fresh beef; FzBeef = frozen beef; Dbeef = domestic beef; Dpork=domestic pork; Dchk=domestic chicken. Numbers in parentheses are estimated t-statistics. ***, **, and * are significant at the 1 percent, 5 percent and 10 percent levels, respectively.

Table 3. Elasticity Estimates Controlling for Expenditure Endogeneity

	FrBeef	FzBeef	Pork	Sheep	Cattle	Hogs	Dbeef	Dpork	Dchk	Exp.
FrBeef	**-1.194*****	-0.344	0.048	0.147	0.001	-0.235**	1.785***	0.159	-2.01***	1.639***
	(0.287)	(-1.21)	(0.34)	(1.44)	(0.01)	(-2.74)	(3.50)	(0.21)	(-3.41)	(0.248)
FzBeef	-0.187	**-0.481**	0.062	-0.092	0.134	-0.127**	1.611*	-0.385	-0.844	0.309
	(-1.17)	**(0.382)**	(0.74)	(-1.27)	(0.65)	(-2.10)	(1.73)	(-0.35)	(-0.95)	(0.385)
Pork	0.063	0.130	**-0.656*****	0.021	-0.126	-0.056	-0.031	0.376	-0.638*	0.913***
	(0.36)	(0.71)	**(0.176)**	(0.27)	(-1.37)	(-0.65)	(-0.07)	(1.07)	(-1.84)	(0.139)
Sheep	0.425	-0.613	-0.018	**-0.972*****	-0.284	0.103	1.895*	-1.223	-1.657**	2.082***
	(1.06)	(-1.32)	(-0.07)	**(0.027)**	(-1.32)	(0.68)	(1.95)	(-1.46)	(-2.17)	(0.330)
Cattle	0.004	0.136	-0.062	-0.043	**-1.020*****	-0.004	1.544**	-1.930***	0.199	1.178***
	(0.05)	(0.61)	(-1.29)	(-1.26)	**(0.160)**	(-0.13)	(2.16)	(-3.03)	(0.38)	(0.246)
Hogs	-0.683**	-0.663**	-0.134	0.036	-0.024	**-0.423****	0.284	0.890	-1.112**	1.830***
	(-2.74)	(-2.14)	(-0.66)	(0.35)	(-0.18)	**(0.155)**	(0.39)	(1.47)	(-2.68)	(0.210)
Dbeef	0.035***	0.043	-0.000	0.007	0.046**	0.004	**-0.782*****	-0.127	-0.092	0.868***
	(4.15)	(1.52)	(-0.05)	(1.36)	(2.28)	(0.85)	**(0.115)**	(-1.06)	(-1.05)	(0.052)
Dpork	0.007	-0.018	0.005	-0.001	-0.051***	0.007**	-0.136	**-0.469****	-0.224**	0.879***
	(0.59)	(-0.59)	(1.10)	(-0.24)	(-3.00)	(2.04)	(-1.25)	(0.172)	(-2.51)	(0.056)
Dchk	-0.010	-0.040	-0.012**	-0.007	0.005	-0.007**	-0.248**	-0.404***	**-0.541*****	1.291***
	(-1.22)	(-1.23)	(-2.05)	(-1.58)	(0.30)	(-2.26)	(-2.20)	(-3.55)	**(0.114)**	(0.041)

FrBeef = fresh beef; FzBeef = frozen beef; Numbers in parentheses are estimated t-values. ***, **, and * are significant at the 1 percent, 5 percent and 10 percent levels, respectively. Columns represent 1 percent percentage price change and rows represent percentage change in demand. A number of -0.548, for example, shows cross elasticity of fresh beef demand to a percentage change in frozen beef price.