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

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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). In estimating the model, expenditure endogeneity is imposed. Estimates of price elasticity suggest that fresh and frozen beef and live cattle are price elastic. Pork, sheep meat and hogs, on the other hand, are price inelastic. The study also finds that frozen beef and sheep meat, both mainly supplied by Australia and New Zealand, are expenditure elastic; whereas fresh beef, pork, live cattle and hogs are expenditure inelastic.

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 projected to reach 3.37 billion pounds and 1.04 billion pounds, respectively. Notably, the

[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.

United States is currently the world's largest importer of beef and is among the top four importers of pork (USDA, 2007a).

The upward trend in the U.S.'s meat and livestock imports in the future may be contributed to a more integrated North American market and the signing of the United States-Australia Free Trade Agreement (US-AUSFTA) as well as the development in trade dispute resolutions. Nevertheless, supply and demand variability related to livestock cycles and changes in buyers' preferences as well as sanitary and phytosanitary concerns are also expected to have a major influence on U.S. imports in the future.

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 and few have investigated U.S. import demand for red meat. Brester (1996) examined U.S. meat import demand, but limited the analysis to ground beef and table cuts. This study contributes significantly in the literature, particularly in import demand analysis for red meat and livestock.

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 quarterly 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. Such estimates provide useful information for economic and policy decisions. With more precise and updated information, producers and policy makers are better able to make important decisions.

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:

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

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

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

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

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

In this study, the demand system consists of six products: fresh beef, frozen beef, pork, sheep and goat meat, live cattle and hogs[2]. Broiler is not included in the analysis because the United States imports only small amounts of broiler products, accounting for less than one percent of domestic production. The grouping of these 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 hence should be disaggregated. Because of the data limitation, in this study the two groups are combined as live cattle. Following Alston *et al*., (1990) and Yang and Koo (1994), this

[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).

study assumes separability between domestic and import meat. The separability assumption is also justified because import data typically differ from domestic data (Winters, 1984).

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 six 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[3]. 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) argue 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

[3] Endogeneity refers to the fact that an independent variable included in the model is potentially a choice variable, correlated with unobservables relegated to the error term.

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[4]. 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:

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

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

[4] In the case of price endogeneity tests, we found only prices exhibit endogeneity: frozen beef and pork exhibit endogeneity. Considering that only two of six variables exhibit endogeneity and the difficulty in obtaining supply and demand shifters to construct reduced form equations for the prices, we do not control for endogeneity prices in the estimation process

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.

The sample statistics of expenditure shares for each product are summarized in Table 1. Over the sample period, the United States spent 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 accounted for of 17 and 14 percent of total expenditure, respectively. Sheep

meat imports are the least in term of expenditure shares with 4 percent of total import expenditures on red meat.

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	0.1696	0.0695	0.0532	0.3047
Frozen Beef	0.3056	0.0993	0.1336	0.6399
Pork	0.1423	0.0265	0.0796	0.2851
Sheep	0.0411	0.0244	0.0091	0.1058
Live Cattle	0.2819	0.1027	0.0505	0.5082
Live swine	0.0594	0.0294	0.0135	0.1356
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
Live Cattle	543.13	102.78	336.81	767.47
Live swine	78.08	19.53	31.82	120.19

Source: Authors' calculation. Average prices are expressed in nominal value. Prices of fresh beef, frozen beef, pork and sheep are per metric ton and prices of live cattle and hogs are per head.

As expected, sheep and goat meat prices are highest among red meat products with an average of $3493.7 per metric ton, followed by fresh beef, pork and frozen beef prices. A record high of 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 live cattle and hogs are $543.13 and 78.08 per head, 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.

The estimated price coefficients as reported in Table 2 show that the estimated coefficients associated with total expenditure are statistically significant with the exception of live cattle and sheep equations. Estimated own price coefficients are also significant but the pork price in pork equation. One should note that 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.

5.2. Elasticity Estimates

The estimated price and expenditure elasticities are presented in Table 3.

As shown, all estimated own price elasticities are significant at least at the 10 percent level and have the expected signs with the exception for live swine. The estimate of own price elasticity for fresh beef is -1.76. This is higher than those reported by Moschini and Meilke (1989) who found that the Marshallian elasticities for beef were -0.98 (before structural change) and -1.05 (after structural change). Relatively high own price elasticity particularly for fresh beef is partly explained by the fact that fresh beef is mostly

Table 2. Estimated Coefficients of the Flexible AIDS Model with Symmetry and Homogeneity Restrictions and Controlling for Expenditure Endogeneity

	Budget Share					
	FrBeef	FzBeef	Pork	Sheep	LCattle	Hogs
FrBeef Price	-0.133 (0.022)***					
FzBeef Price	0.077 (0.043)*	-0.134 (0.083)*				
Pork Price	0.023 (0.020)	-0.012 (0.033)	0.027 (0.029)			
Sheep Price	0.015 (0.009)	-0.017 (0.013)	0.008 (0.009)	0.016 (0.007)**		
LCattle price	0.022 (0.019)	-0.099 (0.051)*	-0.037 (0.019)*	-0.015 (0.007)**	-0.063 (0.038)*	
LSwine Price	-0.006 (0.012)	-0.013 (0.019)	-0.009 (0.013)	-0.008 (0.006)	0.006 (0.009)	0.042 (0.011)***
Expenditure	-0.024 (0.014)*	0.137 (0.026)***	-0.086 (0.011)***	0.002 (0.004)	-0.000 (0.031)	-0.028 (0.006) ***
R^2	0.89	0.65	0.68	0.89	0.70	0.91
DW	1.92	2.23	2.57	2.39	2.07	2.44

FrBeef = fresh beef; FzBeef = frozen beef; LCattle = live cattle. Numbers in parentheses are estimated standard errors.
***, **, 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	LCattle	Hogs	Expenditure
FrBeef	**-1.755*****	0.399*	0.237**	0.091	0.168	-0.001	0.862***
	(0.113)	(0.230)	(0.096)	(0.062)	(0.112)	(0.072)	(0.085)
FzBeef	0.431**	**-1.246*****	-0.361***	-0.068	0.217	-0.144**	1.448***
	(0.195)	**(0.223)**	(0.093)	(0.053)	(0.149)	(0.056)	(0.085)
Pork	0.301**	-0.346*	**-0.380****	0.078	-0.119*	0.070	0.393***
	(0.119)	(0.192)	**(0.181)**	(0.066)	(0.071)	(0.087)	(0.077)
Sheep	0.348	-0.483**	0.251	**-0.603*****	-0.418**	-0.385**	1.426***
	(0.226)	(0.221)	(0.238)	**(0.170)**	(0.127)	(0.116)	(0.150)
LCattle	0.081	0.352**	-0.133**	-0.054**	**-1.225*****	-0.022	1.002***
	(0.072)	(0.163)	((0.053)	(0.025)	**(0.137)**	(0.029)	(0.109)
LSwine	-0.014	-0.427	0.182	-0.114	0.011	**-0.190**	0.525***
	(0.205)	(0.287)	(0.202)	(0.097)	(0.124)	**(0.157)**	(0.097)

FrBeef = fresh beef; FzBeef = frozen beef; LCattle = live cattle. Numbers in parentheses are estimated standard errors. ***, **, 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 0.237, for example, shows cross elasticity of fresh beef demand to a percentage change in pork price.

imported from Canada. The similarity between U.S. and Canadian beef which has marbled texture has resulted in fierce competition. With such competition, demand for beef, particularly U.S. imports appears sensitive to price changes. Furthermore, one should note that elasticities reported in this study are import demand elasticities; whereas those reported by Moschini and Meilke are elasticities for domestic demand. In demand theory, import (and export) demand elasticities are typically higher than domestic demand[5]. In addition, disaggregating products (like in this study) may result in different and relatively higher elasticities. Eales and Unnevehr (1988), for example, reported that estimates of beef elasticity were smaller than its constituent products.

Frozen beef is also found to be price responsive with its estimated elasticity of -1.25. This is smaller in absolute value than the elasticity for fresh beef and relatively close to the elasticities reported by Moschini and Meilke. U.S. imports for pork are found to be inelastic with the magnitude of -0.43. This estimate is smaller in absolute value than that reported by Eales and Unnevehr (-0.565 for compensated elasticity) but higher than that reported by Alston and Chalfant (1993), which was nearly zero elasticity. Similarly, U.S. imports for sheep meat are also price inelastic (-0.60). The relatively inelastic own price for sheep meat is probably due to the fact that this meat category is mainly consumed by certain ethnic groups. For example, Hispanics and Greeks favor lamb for Easter, Orthodox Easter and other holidays; Italian, Turks and other Middle Eastern People enjoy the lamb. It is a year-round staple for Muslims.

[5] It is not clear whether estimated elasticities reported in this study are reasonable in magnitude because there is no similar study related to the current study. Most empirical research has focused on domestic demand for meat (*e.g.*, Braschler, Chavas, Moschini and Mielke, Eales and Unnevehr, Brester, and among others). For the purposes of comparison, however, empirical estimates of elasticities for domestic demand for meat are worth mentioning.

For the live animals, cattle imports are found to be price elastic with an own price elasticity of -1.23. This figure is consistent with 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. U.S. imports for cattle are supplied by Canada and Mexico. The integration of the North American cattle markets through NAFTA has increased competition between suppliers as well as domestic producers. Increased market integration and competition may have contributed to a more elastic demand for cattle. On the other hand, estimate of elasticity for hogs imports is quite small (-0.17) and not significant.

The cross-price elasticities in Table 3 represent substitutability or complementary among meat products and livestock studied here. The cross-price elasticity of fresh beef with respect to the price of frozen beef and the cross-price elasticity of frozen beef with respect to fresh beef are 0.399 and 0.431, respectively. These elasticities are significant, suggesting that fresh beef and frozen beef are substitute for each other. One may question the substitutability between fresh beef and frozen beef given the fact that fresh beef and frozen beef are different in quality and use. We argue that the substitutability occurs in term of sources rather than products themselves. The main sources of frozen beef imports are Australia and New Zealand and the main source of fresh beef imports is Canada. Our data show that the share of U.S. beef imports from Canada has grown in recent years, which seems to have substituted U.S. imports for frozen beef originating in Australia and New Zealand. Note that the magnitude of cross elasticity of frozen beef with respect to fresh beef (0.431) is greater than that of fresh beef to frozen beef (0.399), suggesting that

the change in price of fresh beef has relatively bigger impact on the demand for frozen beef than the converse.

Cross price elasticities between beef (fresh and frozen) and pork point to interesting conclusions. Fresh beef and pork are found to be substitutes for each other; whereas frozen beef and pork tend to be complementary goods. This contrary finding is probably due to the nature of the characteristics of the goods where fresh beef is higher in quality than frozen beef. Frozen beef is mostly imported from Australia and New Zealand in the form of manufacturing grade beef for blending with U.S. trimmings. However, it is difficult to justify the exact relationships between frozen beef and pork.

In the case of sheep, we found more decisive relationships between sheep and other types of meat. As shown in Table 3, cross price elasticities of beef (fresh and Frozen) and pork with respect to sheep are not significant. Similarly, cross price elasticities of sheep with respect to fresh beef and pork are not significant. There is no evidence of substitutability or complementary relationships between sheep and the other types of meat. One exception is perhaps in the case of sheep and frozen beef, where a significant negative cross price elasticity is found.

With respect to live animals, most of cross price elasticities are found to be insignificant. One should note that cross-price elasticities between any meat product and imported live animal are calculated based on the same time period. Therefore they may not give significant meaning.

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.

5.3. Economic and Policy Implications

The results of this study have important policy and economic implications for both suppliers and domestic producers. Relatively high own price elasticity for fresh beef suggests that the industry is highly competitive and therefore pricing strategy is important for both suppliers (especially Canada) and U.S. domestic producers that directly compete with Canadian suppliers. Relatively high cross price elasticity between fresh beef and frozen beef also signals competition between the two goods and in turns between major suppliers: Canada and Australia/New Zealand. Australia/New Zealand may have advantages given the fact that own price elasticity of frozen beef is smaller in absolute value than fresh beef. Therefore, demand for frozen beef is less responsive to price changes than that of fresh beef. In addition, relatively higher expenditure elasticity provides further advantage for both Australia and New Zealand. But recall that Canada has geographical advantage compared to Australia/New Zealand. Canadian beef is also high in quality which is likely more desirable for American consumers. However, Canada is facing direct competition with the U.S. producers. Therefore, pricing strategy is very important given such high competition and high own price elasticity of import demand.

Fresh beef suppliers seem to compete with pork suppliers given the substitutability between the two goods. Major suppliers of U.S. pork imports are Canada (more than 80 percent) and European Union. Canadian pork producers have to compete with Canadian fresh beef suppliers to some degree. Relatively inelastic own pork price

provides an advantage to the pork suppliers because import demand is less responsive to a change in price. Besides, pork suppliers should not worry about frozen beef suppliers.

The interpretation regarding sheep is probably similar to frozen beef; in that sheep suppliers which are coincidentally Australia and New Zealand, have to compete with fresh beef suppliers (Canada). This is unfortunate that sheep is not a substitute good for fresh beef; but fresh beef is a substitute good for sheep meat. Therefore, it is likely that American consumers of sheep and goat meat will change their preferences to beef. The converse is not likely true. Sheep suppliers, however, can still expect from the growth in income since demand for sheep and goat meat is found to be expenditure elastic.

In the case of livestock, the parameter estimates for hogs may have less economic consequences given the fact that all estimates of price elasticities are not significant. Expenditure elasticity for hogs is significant but the magnitude is relatively small. The results for live cattle provide more meaningful information than hogs as most of the elasticity estimates are significant, especially own price elasticity. As shown in Table 4 that live cattle is own price elastic. Once again, price is a very important determinant in live cattle industry (*i.e.* U.S. imports of live cattle). A change in price is likely to have a significant impact on U.S. imports for this product[6]. Based on the results, it is concluded that pricing strategy is very important in U.S. imports of live cattle. It is likely that competition between live cattle suppliers (Canada and Mexico) and the domestic producers (USA) is subject to price competition, *ceteris paribus.* This finding is consistent with the study by Wachenheim *et al*. (2004) which found that Canada-U.S.

[6] Although in the recent years U.S. consumers have been concerned with the BSE case and the U.S. government banned live cattle imports, especially from Canada, the impact was not significant. A pretest of dummy variable that accounts for the BSE was insignificant.

price differentials of live cattle have significant impacts on Canadian exports of live cattle.

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, frozen beef and live cattle are own price elastic. Pork, sheep meat and hogs are found to be price inelastic. In term of expenditure, frozen beef and sheep are found to be in the elastic range and the rest of the products are expenditure inelastic. The results also found that accounting for expenditure endogeneity does not have significant impact on parameter estimates and statistical inferences. The elastic import demand particularly for fresh beef, frozen beef and live cattle have provided producers with useful information for marketing decisions. Such estimates will give the signal on the direction of trade for any price changes.

Given the present results, it would be worthwhile to develop and estimate the models using disaggregated data. Disaggregation can take two forms: (i) based on higher HTS classification and (ii) based on import sources. Such exercise would help answer the impact of endogeneity of both price and income on parameter estimates because, as Berry (1994) pointed out, endogeneity may arise and cause problem in differentiated product

analysis. Furthermore, product disaggregation may further explain market competition among suppliers, as demonstrated earlier in fresh beef and frozen beef case. The drawback of disaggregating the data is that one may face difficulty in working with analytically or empirically because of the highly non-linear demand functions. Linearization the model is an option; but one should consider the trade off of doing so.

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