NAFTA Impacts on the U.S. Competitiveness and Trade: Beef, Pork, and Poultry

Shida Henneberry
Professor (Contact author)
Department of Agricultural Economics
Oklahoma State University
Contact: srh@okstate.edu

and

Joao E. Mutondo
Graduate Research Assistant
Department of Agricultural Economics
Oklahoma State University

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Abstract

The restricted source differentiated almost ideal demand system (RSDAIDS) is used to estimate source differentiated meat demand for U.S. NAFTA partners. In the Canadian meat market, the estimated price and expenditure elasticities indicate that Canadian beef has a competitive advantage compared to U.S. beef, while U.S. pork has a competitive advantage compared to Canadian pork. In the Mexican meat market, the estimated expenditure elasticities indicate that an increase in Mexican meat expenditures would lead to an increase in the demand for meats from all sources. Seasonality and Canadian and U.S. BSE outbreaks had small impacts on Canadian and Mexican meat demand.

Key words: AIDS, BSE impacts, Competitive advantage, Canadian meat demand, Mexican meat demand, and source differentiation.

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The North American Free Trade Agreement (NAFTA), which took effect on January 1, 1994, reduced trade barriers among member countries and consequently integrated the North American livestock markets. Therefore, trade among NAFTA countries (Canada, Mexico, and the U.S.) has resulted in each country specializing in producing and exporting the types of livestock and products for which it has a comparative advantage compared to other countries. For instance, since Mexico does not have a large feed grain base, the demand for fed beef in this country has mainly been satisfied by imports from its NAFTA partners (Leuck 2005).

Canada and Mexico have become important markets for U.S. meat exports since the inception of NAFTA. U.S. agricultural exports to Canada almost doubled from $5.5 billion in 1994 to $10.6 billion in 2005, while agricultural exports to Mexico have more than doubled from $4.6 billion in 1994 to $9.4 billion in 2005 (USDA-FAS 2006a). Together, Mexico and Canada accounted for 40% of U.S. total exports of beef, 35% of U.S. total exports of pork, and 17% of U.S. total exports of poultry during the 2002-2005 period (USDA-FAS 2006a).

Despite NAFTA, the U.S. has found itself in a more competitive environment in Canada and Mexico, because these markets have become more open to international trade following the 1995 Uruguay Round Agreement on Agriculture (URAA) (Dyck and Nelson 2003). Furthermore, in Canadian and Mexican meat markets, competition between U.S. meats and meats from other sources is expected to increase in the near future with the implementation of the ongoing free trade areas of the America agreement (FTAA).[1] Additionally, the outbreaks of animal disease, and more specifically the 2003 outbreak of U.S. *Bovine Spongiform Encephalopathy* (BSE), have made U.S. meat exports subject to a more volatile demand. Given the increased competitiveness and the restrictions imposed on U.S. meats by its traditional importers, understanding the importance of economic and non-economic factors is crucial in determining the changes in the demand for U.S. meats.

Published research on the analysis of the Canadian and Mexican meat demand is limited to aggregate meats, without differentiation by supply source (Eales 1996; Dong, Gould, and Kaiser 2004; Golan, Perloff, and Shen 2001; and Gould et al. 2002). Ignoring source of origin, which is an intrinsic meat quality attribute, might produce misleading results. For example, Davis (1997) found a substitute relationship between U.S. produced and imported tobacco under a model that does not account for aggregation bias and a complement relationship with a model that does account for aggregation bias. Furthermore, a review of the literature shows that research on the analysis of Canadian and Mexican demand for U.S. produced meats is lacking.

Although NAFTA has integrated the North American meat market, U.S. meat exports to NAFTA countries have been subject to trade barriers due to animal disease outbreaks and antidumping duties. For instance, Canada and Mexico banned imports of beef from the U.S. in 2003 after the BSE outbreak in the U.S. Similarly, from early 1999 to May 2003, Mexico imposed antidumping duties on U.S. hogs. Over the past several years, antidumping petitions have been focused on U.S. pork legs (Zahniser 2007). Hence, the Canadian and Mexican source differentiated meat demand elasticities estimated in this study could be useful to decision makers in estimating the impacts of various policies and marketing strategies, such as antidumping duties, the much debated animal identification system and country of origin labeling. Moreover, the results of this study can be used in measuring trade and market impacts associated with animal and poultry disease outbreaks and the resulting policy and regulation changes on the welfare of U.S. meat producers and marketers.

Therefore, the primary objective of this study is to analyze the import demand for U.S. meats in Canada and Mexico. More specifically, this study estimates the impacts of economic variables (meat prices and expenditures) and non-economic variables (seasonality and the BSE outbreak in North America) on the demand for U.S. meats and meats from other sources in Canada and Mexico. This is the first study that estimates meat demand in U.S. NAFTA partners by supply source. To accomplish these objectives, the Canadian and Mexican source differentiated meat demand systems are specified and estimated using data that covers a more liberalized period when only import tariffs were in effect in U.S. meat export markets within NAFTA. The models differentiate meats by type and source of origin. The remainder of this study is organized as follows: in the next section, the model of the Canadian and Mexican meat demand is presented. Then, data and procedures used to estimate meat demand systems are described. This section is followed by a discussion of the empirical results. The Summary and conclusions are given in the last section.

The Model

To allow for source differentiation, a version of the almost ideal demand system (AIDS) model known as the restricted source differentiated AIDS (RSDAIDS) is used. The AIDS model has many desirable properties including being an arbitrary first-order approximation of any demand system, satisfying the axioms of choice, aggregating over consumers, and possessing a functional form consistent with household budget data (Deaton and Muellbauer 1980a).

The RSDAIDS allows for source differentiation of various types of meats, while preserving the degrees of freedom and not assuming block separability. The main advantage of the RSDAIDS model is that it does not suffer from the aggregation bias over supply sources. That is, meat types (beef, pork, and poultry) from different sources are not considered homogeneous products with single prices. For parsimonious estimations, the RSDAIDS imposes block substitutability, which assumes that the cross-price effects of source differentiated products in good *j* on the demand for product *h* in good *i*, are the same for all products in good *j*. See Yang and Koo 1994, p. 399, for the block substitutability restriction. Hence, the prices for all products (meat from different sources) in good *j* are represented by a weighted average price for that good in the equation of a given source differentiated product. For example, in the source differentiated beef demand equations, prices of pork and poultry products (pork and poultry from different sources) are represented by weighted average prices of pork and poultry, or the weighted average prices for pork and poultry from different sources (p_j in equation 1 below). This assumption reduces the number of parameters that need to be estimated and therefore increases the degrees of freedom. In this study, following Yang and Koo (1994), a RSDAIDS model is used to estimate meat demand in Canada and Mexico. Note that the meat demand for each country is estimated separately from the other country. The RSDAIDS is specified as the following:

(1) $$w_{i_h} = \alpha_{i_h} + \sum_k \gamma_{i_{hk}} \ln(p_{i_k}) + \sum_{j \neq i} \gamma_{i_h j} \ln(p_j) + \beta_{i_h} \ln\left(\frac{E}{P^*}\right)$$

where subscripts *i* and *j* indicate goods (*i*, *j* = 1, 2, …N), and *h* and *k* indicate supply sources, w_{i_h} is the budget share of good *i* from source *h*, α_{i_h} is an intercept term for meat *i* from source *h*, $\gamma_{i_{hk}}$ is the price coefficient of source differentiated good, p_{i_k} is the price of good *i* from source *k* (with *k* including *h*), $\gamma_{i_h j}$ is the cross-price coefficient between source differentiated good *i* from source *h* and nonsource differentiated or aggregated good *j*, β is the real expenditure coefficient, *E* is group expenditures, p_j is the price of the nonsource differentiated or aggregate good *j* and is calculated as the weighted average of source differentiated *j* prices as:

(2) $$\ln(p_j) = \sum_k w_{j_{k,t-1}} \ln(p_{j_k})$$

$P*$ in equation (1) is a price index which for source differentiated AIDS is defined as:

(3) $$\ln(P^*) = \alpha_0 + \sum_i \sum_h \alpha_{i_h} \ln(p_{i_h}) + \frac{1}{2} \sum_i \sum_h \sum_j \sum_k \gamma^*_{i_h j_k} \ln(p_{i_h}) \ln(p_{j_k})$$

The RSDAIDS model in equation (1) above is nonlinear due to the nonlinear price index in equation (3). To make the system linear, Deaton and Muellbauer (1980a) suggest using Stone's price index, here specified as:

(4) $$\ln P^* = \sum_i \sum_h w_{i_h} \ln(P_{i_h})$$

The budget shares (w_{i_h}) that are used as dependent variables in equation (1), are also used as independent variables in the aggregate price calculation (equation 4). Hence, to avoid simultaneity bias, following Eales and Unnevehr (1988), this study uses lagged budget shares ($w_{i_{h,t-1}}$) to compute Stone's price index. Moreover; Moschini (1995) and also LaFrance (1998) recognize the lack of invariance of Stone's price index to units of measurement. Therefore in order to overcome this problem in this study, scaled meat prices are used to compute the Stone's price index., as proposed by Moschini (1995) and following Dameus et al (2002). Scaled meat prices are calculated by dividing source differentiated meat prices by their respective means and making them unit-less. Therefore, the index used in equation (4) is the Paasche-like index.

In addition, a seasonal indicator variable reflecting seasonal patterns in meat demand in Canada and Mexico and two indicator variables, reflecting the outbreaks of BSE in Canada and in the U.S, are included in the demand models for each of the U.S. NAFTA trading partners. The indicator variables are incorporated as intercept shifters in the RSDAIDS model (Henneberry, Piewthongngam, and Qiang 1999; Mutondo and Henneberry 2006). Therefore in this study, the intercept term in equation (1) is defined as:

(5) $$\alpha_{i_h} = \alpha^*_{i_h 0} + \sum_{g=1}^{G} \alpha_{i_{hg}} D_g$$

where D represents the three indicator variables (seasonality and the BSE outbreaks in the U.S. and in Canada).

Following Yang and Koo (1994), homogeneity and symmetry are imposed as shown in equations (6) and (7) respectively.

(6) $$\sum_k \gamma_{i_{hk}} + \sum_{j \neq i} \gamma_{i_h j} = 0$$

(7) $$\gamma_{i_{hk}} = \gamma_{i_{kh}}$$

Due to the inclusion of indicator variables in the RSDAIDS model in equation (1), the adding-up property of demand is imposed as:

(8) $$\sum_i \sum_h \alpha_{i_h 0} = 1;\ \sum_i \sum_h \alpha_{i_{hg}} = 0;\ \sum_h \gamma_{i_{hk}} = 0;\ \sum_i \sum_h \gamma_{i_h j} = 0;\ \sum_i \sum_h \beta_{i_h} = 0;$$

Marshallian own-price and cross-price elasticities (ε) and expenditure elasticity (η) of the RSDAIDS model are calculated as:

(9) $$\varepsilon_{i_h i_h} = -1 + \frac{\gamma_{i_{hh}}}{w_{i_h}} - \beta_{i_h}$$

(10) $$\varepsilon_{i_h i_k} = \frac{\gamma_{i_{hk}}}{w_{i_h}} - \beta_{i_h} \left(\frac{w_{i_k}}{w_{i_h}}\right)$$

(11) $$\varepsilon_{i_h j} = \frac{\gamma_{i_h j}}{w_{i_h}} - \beta_{i_h} \left(\frac{w_j}{w_{i_h}}\right)$$

Equation (9) represents own-price elasticities, (10) represents cross-price elasticities between the same goods from different sources, (11) represents cross-price elasticities between different goods, that is between good *i* from source *h* and aggregate good *j*. Expenditure elasticity is specified as:

$$\eta_{i_h} = 1 + \frac{\beta_{i_h}}{w_{i_h}} \quad (12)$$

The elasticities are calculated at mean level of expenditure shares. The statistical significance of elasticities is determined by the method offered by Mdafri and Brorsen (1993).[2]

Data

Quarterly data from 1995 (quarter one) to 2005 (quarter four) are used to estimate the parameters of the Canadian and Mexican source differentiated meat demand models. For this study, 1995 is chosen for the beginning of data because the Canadian and Mexican meat import markets were liberalized (elimination of the quota system) in 1995. This was also the year that the URAA began to be implemented. The types of meats studied here are: beef, pork, and poultry; with each meat differentiated based on the origin of supply (source differentiated). In addition, this study assumes that meats (beef, pork, and poultry) are weakly separable from other foods and nonfood commodities.

A country is identified as a supply source of imports, if imports from that source constitute at least 10% of the total Canadian and Mexican imports of the selected meat. All other sources that supplied less than 10% of Canadian or Mexican total imports of the selected meat are aggregated as the Rest-of-the-World (ROW) category. Because retail/wholesale level prices for source differentiated meats in Canada and Mexico are not available, unit-value import prices are used to measure market prices for imported meats. Data on import values (in U.S. dollars) and volumes (in kilograms) are from various issues of USDA-ERS (2002) and USDA-FAS (2006b). Data on imported meat values are converted to Canadian dollars and Mexican pesos, using published exchange rates. Exchange rate data are from USDA-ERS (2006). Import prices (unit values) of individual source differentiated meats are calculated by dividing total import values by total import quantities.

Data on domestically produced meats are from various sources. For Canada, wholesale level data on the quantity of meat demanded are from Agriculture and Agri-Food Canada (2006). The Montreal wholesale prices of beef carcasses are used as a proxy for the price of Canadian beef. The weighted average of the Montreal wholesale prices of pork primals and subprimals are used as the price of Canadian pork. The Montreal wholesale prices of broilers are used as the price of Canadian poultry. Price data on Canadian beef and pork from 1995 to 2000 are from Iowa State University (1995-2000). Price data on Canadian beef and pork from 2001 to 2005 and price data on Canadian broilers are from Agriculture and Agri-Food Canada (2006). For Mexico, wholesale level data on the quantity of meat demanded are from Sistema Integral de Informacion Agroalimentar y Pesquera, SIAP, (2006). Data on wholesale prices of Mexican domestically produced meat are from USDA-FAS (2006c).

Seasonal and BSE indicator variables are included in the RSDAIDS model for Canada and Mexico. Three seasonal quarterly variables are included for the first, third, and fourth quarters, with the first quarter beginning on January 1. Two BSE indicator variables, one accounting for the BSE outbreak in Canada and another accounting for the BSE outbreak in the U.S., are included in the model of each country. The assumption here is that if the BSE outbreak would have had any impact on Canadian and Mexican meat demand, it would have been during the period when NAFTA countries banned beef imports from the North American infected countries. Therefore, the BSE indicator variables take the value of one during the beef import ban periods in other NAFTA countries. On the other hand, the lifting of the import ban by the NAFTA countries may have signaled the respective governments' confidence regarding the safety of beef to the Canadian and Mexican consumers. The assumption is that the Canadian and Mexican consumers may not have necessarily reacted in the same way to bans by (not nearby) countries in other continents, such as Japan and S. Korea. Hence, the period during which Japan and South Korea banned U.S. and Canadian beef is not considered in constructing the BSE dummy variables used in the Canadian and Mexican source differentiated meat demand.

The BSE outbreak in Canada began in May 2003, and lasted through August 2003, when the ban on Canadian beef from cattle younger than 30 months of age was lifted in NAFTA countries (Hahn et al. 2005). Consequently, the Canadian BSE outbreak indicator variable takes the value of one for the second and the third quarters of the year 2003 and zero otherwise. In the U.S., the BSE outbreak began in December 2003, and lasted through March 2004, when the ban of U.S. beef from cattle younger than 30 months of age was lifted in NAFTA countries (Hahn et al. 2005).[3] Therefore, in this study, the U.S. BSE outbreak indicator variable takes the values of one for the fourth quarter of the year 2003 and the first quarter of the year 2004 and zero otherwise.

Estimation Procedures and Statistical Tests

The seemingly unrelated regression (SUR) estimation method is used to estimate the model represented by equation (1) with block substitutability, symmetry, and homogeneity imposed. Due to the adding-up condition of the demand model, the contemporaneous covariance matrix is singular. Hence, the last equation for each demand system (Canada and Mexico) is dropped for estimation purposes. Poultry import demand from the U.S. and from the ROW are the selected equations to be dropped for the Canadian and Mexican meat demand systems, respectively. The parameter estimates for the dropped equations can be calculated using the adding-up restriction. However in this study, another equation for each demand model is dropped and the models are re-estimated in order to determine the parameters and the standard errors of the dropped equations (Henneberry, Piewthongngan, and Qiang 1999). The estimated parameters are similar and produce similar elasticities regardless of which equation is dropped.

System Misspecification Tests

The assumptions of normality of the error terms, joint conditional mean (no autocorrelation, parameter stability, and appropriateness of the functional form), and joint conditional variance (static and dynamic homoskedasticity and variance stability) are tested using system misspecification tests as suggested by McGuirk et al. (1995). Results of the system misspecification tests indicate that estimating the Canadian meat demand model using the model represented by equation (1) is not appropriate mostly due to the autocorrelation of the error terms. More specifically, the null hypothesis of no autocorrelation is rejected at the 1% significance level. However, misspecification test results indicate that model (1) is appropriate for the Mexican meat demand system. Kennedy (2003) reports that one of the sources of autocorrelation is misspecification of the equations' dynamics.

Dynamics are expected to be particularly important in the analysis of meat demand as meat consumers are unlikely to respond fully to changes in price, income, or other determinants of demand in the short run. Psychological habit factors, inventory adjustments, or institutional factors have been reported as reasons for lagged consumer response (Kesavan et al. 1993; Henneberry and Hwang 2007). To allow for lagged effects, the first-difference RSDAIDS model (model 13 below) as suggested by Eales and Unnevehr (1988) is used here for the Canadian meat demand system, while the Mexican meat demand is estimated using equation (1).

$$(13) \qquad \Delta w_{i_h} = \sum_k \gamma_{i_{hk}} \Delta \ln(p_{i_k}) + \sum_{j \neq i} \gamma_{i_h j} \Delta \ln(p_j) + \beta_{i_h} \Delta \ln\left(\frac{E}{P^*}\right)$$

Results of the misspecification tests for the Canadian meat demand system (model 13) fail to reject the null hypothesis of normality of the error terms at the 1% significance level. Similarly, test results of joint conditional mean and joint conditional variance fail to reject the null hypotheses that the conditional mean and conditional variance are properly specified at the 1% significance levels. From this point on, all of the discussions regarding Canadian meat demand refer to the results from equation (13) estimations.

Results of the misspecification tests for the Mexican meat demand system (equation 1) indicate the failure to reject the null hypothesis of normality of the error terms at the 1% significance level, except for the equations of Mexican demand for U.S. beef and poultry. Moreover, test results of joint conditional mean and joint conditional variance fail to reject the null hypotheses that the conditional mean and conditional variance are properly specified at the 1% significance levels. Furthermore, various hypotheses regarding Canadian and Mexican consumers' behavior including product aggregation, block separability, and endogeneity of the real expenditure variable are tested for the RSDAIDS model of each country (equation 13 for Canada and equation 1 for Mexico).

Product Aggregation and Block Separability

The product aggregation test is used to test the restrictions that the parameters of the RSDAIDS model are the same as the parameters of the nonsource differentiated AIDS model. The null hypothesis for this test is that each kind of meat can be aggregated (not to be separated by supply source) and estimated using the nonsource differentiated AIDS model (See Yang and Koo 1994, p. 400, for the product aggregation restrictions). Test results for the Canadian and Mexican meat demand systems are presented in tables 1 and 2, respectively. The results indicate that for the Canadian and Mexican meat demand models, the null hypothesis of nonsource differentiation for all meats is rejected at the 1% significance level. Therefore, the results support estimating the Canadian and Mexican demand for meats using a source differentiated model.

In addition, this study tests block separability within the meat group. The three different blocks are beef, pork, and poultry, with each block composed of meats from different sources. The block separability test is used to test whether consumers' preferences within each block can be explained independent of quantities of meats in the other blocks. More specifically, for parsimonious estimation, the question is whether each block of meat (such as beef from different sources) could be studied separately from meats in other blocks (such as pork and poultry from different sources) without incorporating their prices. This study uses quasi-separability of the cost function to test separability between blocks (For the test of quasi-separability of the cost function underlying the AIDS model, see Deaton and Muellbauer 1980b, p. 133; Hayes, Wahl, and Williams 1990, p. 561; and Yang and Koo 1994, p. 400). The null hypothesis for this test is that each block of meats is separable from all other meat blocks. For the two demand models, the null hypothesis test results (table 1 and 2) indicate the rejection of the null hypothesis at the 1% significance level for both Canadian and Mexican meat demand systems. Therefore, test results support estimating the demands for meats, including all three types of meats.

Endogeneity

Because expenditure variable E (in equations 1 for Mexico and 13 for Canada) is used to compute budget shares (w_{i_h}), which is the dependent variable, the expenditure variable might not be truly exogenous. Correlation between the expenditure variable and the error term causes the estimates to be biased and inconsistent. Hence, endogeneity of the real expenditure variable is tested using the Wu-Hausman endogeneity test.

For each demand model, the endogeneity test is performed by regressing the real expenditure variable (E), of each demand model on a set of instrumental variables (Johnston and DiNardo 1997). Two auxiliary regressions, one for the Canadian model and another for the Mexican model are performed. For the Canadian model, the real expenditure variable of Canadian meat demand model (equation 13) is regressed on a set of instrumental variables (source differentiated meat prices, the lagged real expenditure variable of the Canadian demand model, and the first-difference of the natural logarithm of the Canadian gross domestic product). Similarly, for the Mexican model, the real expenditure variable of Mexican meat demand model (equation 1) is regressed on a set of instrumental variables (source differentiated meat prices, the lagged real expenditure variable of the Mexican meat demand model, and the first-difference of the natural logarithm of the Mexican gross domestic product). For the auxiliary regressions described above, residuals were calculated. Residuals from Canadian auxiliary regression were included in the Canadian meat demand system and residuals from Mexican auxiliary regression were included in Mexican meat demand system as explanatory variables. A joint test was conducted to see whether the parameter estimates of these residuals equal zero. If the parameters estimates equal zero, the conclusion is that endogeneity does not exist. Test results for both Canadian and Mexican meat demand models fail to reject the null hypothesis that the real expenditure variable is exogenous at the 1% significance level.

Results

The calculated Marshallian demand elasticities (using equation 9-12), along with the estimated coefficients for the seasonal and BSE indicator variables for the Canadian and Mexican meat demand models, are presented in tables 3 and 4.[4] Estimation results for each country (using model 13 for Canada and model 1 for Mexico) are presented in the following sections.

Canadian Meat Demand: Expenditure and Price Elasticities

Table 3 presents the calculated Marshallian demand elasticities and the estimated coefficients for seasonal and BSE indicator variables for the Canadian meat demand model (equation 13). In the beef market, all expenditure elasticities are positive and the expenditure elasticities for beef from Canada (1.43) and the U.S. (1.00) are statistically significant. These results confirm the Canadian consumers' general preferences for grain-fed beef from the U.S. and Canada over any imported beef (grass-fed beef) from Australia and the ROW (mainly from New Zealand and South American countries) (Unterschultz, Quagrainie, and Vincent 1997).

In the pork market, all expenditure elasticities are positive, and the expenditure elasticity for pork from Canada and the U.S. are statistically significant. Similar to beef, these results are also consistent with the Canadian consumers' strong preferences for fresh pork from Canada and the U.S., compared to frozen pork from the ROW. Consistent with what is expected from economic theory, the results of the Canadian meat demand model show negative Marshallian own-price elasticities for individual meats. The magnitude of all estimated Canadian own-price elasticities for the studied meats fall in the range reported by Eales (1996).

Marshallian cross-price elasticities indicate gross substitutability or complementary relationships among products from different sources. While a significant positive Marshallian cross-price elasticity between meats from different suppliers may indicate substitutability, a significant negative cross-price elasticity may indicate a complementary relationship. The cross-price elasticity between U.S. and Canadian beef is positive and statistically significant. The substitutability between U.S. and Canadian beef is consistent with prior expectations from economic theory, since Canada and the U.S. both produce beef (grain-fed beef) of similar quality.

In the pork market, a clear relationship between meats from different sources is not evident because none of the cross-price elasticities are statistically significant. However in the poultry market, a statistically significant and greater than one cross-price elasticity in the demand equation for U.S. poultry indicates strong substitutability between U.S. and Canadian poultry. This competitive relationship is consistent with prior expectations from economic theory since both Canada and the U.S. produce poultry products of similar quality. Moreover, most of the cross-price elasticities between source differentiated meats and aggregate meat groups are not statistically significant (table 3). The exceptions are a significant competitive relationship between Canadian poultry and aggregate beef, and a significant complementary relationship between U.S. pork and aggregate poultry. Applications of these results will be discussed in the summary and conclusions section.

Canadian Meat Demand: Seasonality and BSE Effects

The parameter estimates of seasonal and BSE indicator variables are presented in table 3. In general, except in Canadian demand for ROW beef, seasonality does not show as having any statistically significant impact on meat demand in Canada. Moreover, the U.S. and Canadian BSE outbreaks show as having only small impacts on Canadian meat demand, which are not statistically significant in most cases. The Canadian BSE outbreak shows as having decreased the share of Canadian beef in Canada. This result is consistent with findings from past studies. Peng, McCann-Hiltz, and Goddard (2004) also found a significant negative impact of the Canadian BSE outbreak on the demand for beef in Alberta (Canada).

Interestingly, the U.S. and Canadian BSE outbreaks show as having a negative impact on the shares of Australian beef in Canada. The lowered share of Australian beef may be explained by the fact that during the U.S. and Canadian BSE outbreaks, Australia decreased its beef shipments to Canada in order to allow for the increased exports to markets that had banned Canadian and U.S. beef, mainly Japan and South Korea.

Mexican Meat Demand: Expenditure and Price Elasticities

Table 4 presents the full matrix of the calculated Marshallian demand elasticities with their respective standard errors and the estimated coefficients for seasonal and BSE indicator variables for the Mexican meat demand model (equation 1). The source differentiated meat expenditure elasticities are positive and all of them are statistically significant, except for Mexican demand for poultry from the ROW. These results confirm the Mexican consumers' preference for meats given an increase in the Mexican meat expenditures as reported in past studies (Dong, Gould, and Kaiser 2004; Golan, Perloff, Edward, and Shen 2001). Hence, policies that aim to increase Mexican per capita incomes and consequently increase Mexican meat expenditures are expected to increase the demand for meats in Mexico. Although the magnitude of the source differentiated expenditure elasticities are similar, poultry is the most expenditure elastic meat. U.S. pork and poultry and Mexican beef and poultry carry the largest expenditure elasticities compared to meats from other sources.

Consistent with economic theory, own-price elasticities for meats from different sources are negative, except for the statistically insignificant own-price elasticity for pork from the ROW. Because this study is the first study on source differentiated meat demand in Mexico as other studies have analyzed demand for Mexican meats only on an aggregate level (nonsource differentiated), comparing the results of this study with others is difficult. Nevertheless, the magnitude of own-price elasticities of Mexican-produced meats (beef, pork, and poultry) estimated in this study is comparable to own-price elasticities for Mexican meats reported by Sullivan et al. (1989).

As mentioned earlier, the cross-price elasticities may be an indicator of substitutability or complementary relationships among source differentiated meats. For the Mexican beef market, the majority of cross-price elasticities are positive and statistically significant, indicating substitutability of meats from different sources; except for the lack of substitutability found between Mexican and Canadian beef. This lack of competitiveness might be explained because of the quality differences and taste preferences for locally produced beef from Mexico compared to beef originating from Canada.

More specifically, in the pork and poultry markets, the results show a competitive relationship between U.S. pork and ROW pork and between U.S. poultry and ROW poultry. These results are consistent with previous expectations from economic theory because the U.S. and the ROW (mainly Canada) produce and export pork and poultry products of similar quality to Mexico. A lack of a substitutability relationship exists between U.S. pork and Mexican pork, and between Mexican pork and pork from the ROW. The difference in quality between pork products and cuts of pork from the U.S. and the ROW (mainly Canada) on one hand and Mexican pork on the other hand might explain the results. Furthermore, a complementary relationship is found between U.S. poultry and Mexican poultry. Similar to pork, differences in quality between fresh Mexican poultry (mainly composed of chicken products) and frozen and chilled poultry products (mainly composed of turkey cuts, mechanically deboned meats, chicken legs, and edible poultry offals) exported from the U.S. to Mexico might explain the relationship. Regarding cross-commodities, the majority of cross-price elasticities are statistically significant. Applications of those results are discussed in the summary and conclusions section.

Mexican Meat Demand: Seasonality and BSE Effects

The parameter estimates for the impacts of seasonality and the BSE outbreaks in Canada and the U.S. on the Mexican meat demand are presented in table 4. The majority of estimated coefficients of seasonal indicator variables are not statistically significant, except in the equations of beef and pork from Mexico. The results show that the shares of Mexican beef are higher in the fourth quarter (October-December) and lower in the first quarter (January-March) compared to the second quarter (April-June). Traditional celebrations such as Christmas in December (fourth quarter) might be the main reason for the increased demand for beef in quarter four compared to the second quarter.

The estimated parameters of the BSE indicator variable show that the BSE outbreak in the U.S. decreased the shares of U.S. beef in Mexico. This decrease may be a result of the Mexican government restricting beef imports from the U.S. during the U.S. BSE outbreak. Results also show that the U.S. BSE outbreak increased the shares of Canadian beef, Mexican beef, and U.S. pork. This result is also consistent with previous expectations from economic theory since the decrease in Mexican consumption of U.S. beef during the U.S. BSE outbreak might have increased the consumption of other meat products such as Canadian beef, Mexican beef, and U.S. pork. Interestingly, the U.S. BSE outbreak decreased the shares of Mexican pork and poultry as well. The decrease in the shares of Mexican pork and poultry might not be due to the U.S. BSE outbreak *per se*, but it might be due to other factors, which are beyond the scope of this study. Pork- and poultry-related diseases such as classical swine fever, avian influenza, and exotic Newcastle are prevalent in some Mexican states (Hahn et al. 2005). For instance, the U.S. considers only eight Mexican States (Baja California, Baja California Sur, Campeche, Chihuahua, Quintana Roo, Sinaloa, Sonora, and Yucatan) to be free of classical swine fever and only three Mexican states (Campeche, Quintana Roo, and Yucatan) to be free of exotic Newcastlle disease (Zahniser 2007). Hence, the decrease in the shares of Mexican pork and poultry might be due to animal (pork and poultry) disease outbreaks in Mexico during the same period as the U.S. BSE outbreak.

Summary and Conclusions

This is the first study that estimates the impacts of economic (meat prices and expenditures) and non-economic (seasonality and the U.S. and Canadian BSE outbreaks) variables on the demand for meats from different sources in U.S. NAFTA trading partners Canada and Mexico. To assure that the specification and estimation procedures of the two meat demand systems are correct, various hypotheses regarding the Canadian and Mexican source differentiated meat demand models are tested. The hypotheses tested for each demand system includes: normality of the error terms, joint conditional mean, joint conditional variance, endogeneity of the real expenditure variable, separability among meats included in each meat demand model, and product aggregation. Results of the statistical tests support estimating a set of meat demand equations for the three types of meats (beef, pork, and poultry), each meat being differentiated by supply source, and using the RSDAIDS model (equation 1) for Mexican meat demand while using the first-difference version of the RSDAIDS model (equation 13) for Canadian meat demand. The estimated parameters of seasonal and animal disease outbreaks, plus the calculated expenditure and price elasticities, are used to access the competitiveness of meats from different sources in the Canadian and Mexican meat markets.

Competitive advantage may be defined as an advantage over competitors gained by offering consumers a greater value either by means of lower prices or by providing greater benefits and services, such as high quality products that justify higher prices (Porter 1985). In this study, any meat product that carries a higher and statistically significant expenditure elasticity compared to other meats is assumed to be perceived by consumers as a higher value product. Furthermore, suppliers that supply higher-valued meat products will prefer to face an inelastic own-price elasticity because the higher prices associated with their meats compared to other meats from other suppliers, may result in an increase in their total revenues (ceteris paribus). Therefore, in this study, a country that supplies higher-priced meat products, such as the U.S., is said to have a competitive advantage if it faces a price-inelastic and statistically significant expenditure-elastic demand.

In the Canadian meat demand model, following the above definition of competitive advantage, the calculated expenditure and price elasticities indicate that Canadian beef has a competitive advantage compared to U.S. beef. This indication is based on slightly lower own-price elasticity and higher expenditure elasticity of Canadian beef compared to U.S. beef. Unterschultz, Quagrainie, and Vincent (1997) also found that Quebec (Canada) consumers prefer beef from Alberta (Canada) compared to U.S. beef. In the pork market, based on the lower (in absolute value) own-price elasticity and slightly higher and statistically significant expenditure elasticity of U.S. pork compared to Canadian pork, pork from the U.S. is said to have a competitive advantage compared to pork from Canada. Seasonality and BSE outbreaks in the U.S. and Canada show as having small impacts on the Canadian meat market share. Nevertheless, the Canadian BSE outbreak decreased the Canadian beef market share of Canadian beef in Canada, while it increased the shares of Canadian poultry.

Different suppliers of pork and poultry in Canada might be interested in knowing how much they can increase their market share in the case of another Canadian BSE outbreak. Results indicate that a competitive relationship between aggregate beef and Canadian poultry supports higher poultry consumption in Canada in the case of a BSE outbreak, which might imply benefits to the Canadian poultry producers in terms of increased sales.

Regarding the Mexican meat demand, based on positive and statistically significant meat expenditure elasticities for source differentiated meats, an increase in the Mexican meat expenditures is expected to increase the demand for meats from different sources. According to Rabobank Group (2007), the Mexican economy is projected to grow 3.3% in 2007. Therefore, Mexican meat expenditures are expected to grow, which will translate into continued strong demand for meats, including U.S. produced meats. In the beef market, the results show that Mexican beef has a slight competitive advantage compared to U.S. and Canadian beef. This conclusion is based on the higher expenditure elasticity and lower (in absolute value) own-price elasticity of Mexican beef compared to beef from the U.S. and Canada. Mexican beef has a competitive advantage compared to beef from the U.S. and Canada because the majority of Mexican consumers prefer lean beef from traditionally pasture-fed animals compared to marbled beef from grain-fed animals (Rabobank Group 2007). However, a growing preference for marbled beef and U.S.-type cuts such as rib eye, especially among more affluent consumers, is expected to increase U.S. beef exports in the future.

In the pork and poultry markets in Mexico, the U.S. has a competitive advantage compared to other pork and poultry suppliers. This advantage is based on the lower (in absolute value) own-price elasticities and higher and statistically significant expenditure elasticities for pork and poultry from the U.S. compared to other pork and poultry products from other supply sources. More specifically, based on the results, the U.S. is expected to benefit in terms of increased poultry exports to Mexico in the near future with the removal of the Mexican temporary safeguard tariff-rate-quota (TRQ) on U.S. chicken leg quarters in 2008, and with poultry being the major component of increased per capita meat consumption in Mexico. Seasonality and BSE outbreaks in the U.S. and Canada show as having only small and mostly non-statistically significant impacts on Mexican meat demand. However, the U.S. BSE outbreak decreased the shares of U.S. beef and increased the shares of Canadian and Mexican beef and the shares of U.S. pork.

Hahn et al. (2005) report the prevalence of pork and poultry diseases in some Mexican states. Given that pork and poultry diseases occur rather frequently in Mexico, suppliers of various meats in Mexico might be interested in knowing the implications of outbreaks in those diseases on the demand for their meats. The competitive relationship between aggregate pork on one hand and Canadian and Mexican beef on the other hand, may indicate that the demand for Canadian and Mexican produced beef might increase following a pork disease outbreak (such as foot-and-mouth disease and classical swine fever) in Mexico. Similarly, an outbreak of poultry diseases such as Avian Influenza (AI) and Exotic Newcastle (EN) is expected to increase the shares of beef from the U.S. and the ROW, based on the competitive relationships between these meats.

Footnotes

1. Besides the ongoing free trade areas of the Americas agreement, Canada has a free trade agreement with Costa Rica, while Mexico has free trade agreements with Costa Rica, Nicaragua, Guatemala, Honduras, and El Salvador.

2. The equations of own-price, cross-price and expenditure elasticities, equations (9)-(12), can be written in matrix form as:

(14) $$\mathbf{e} = \mathbf{Ab}$$

where e is the vector of estimated elasticities (ε's, η's), b is the vector of estimated RSDAIDS model parameters (γ's, β's), and A is a matrix of constants (budget shares), The standard errors are calculated by taking the square root of the variance covariance matrix of e, VAR(e) in equation 15 below.

(15) $$\text{VAR}(e) = A\text{VAR}(b)A^{'}$$

where VAR(b) is the variance covariance matrix of b.

3. Animal disease dummy variables incorporate the period of time when the trade of fresh meat products was banned due to animal disease outbreaks.

4. Because meats account for a small fraction of Canadian and Mexican consumers' disposable income, which leads to the Marshallian and Hicksian elasticities being nearly identical. Therefore in order to save space, Hicksian elasticities are not presented here.

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Table 1. Block Separability and Product Aggregation Test Results for the Canadian Meat Demand Model

Block Separability Test

Ho: Beef is separable from all other meats.
F=0.48
df: 8 for numerator and 241 for denominator
Ho: Pork is separable from all other meats.
F=3.24**
df: 6 for numerator and 241 for denominator

Ho: Poultry is separable from all other meats.
F=2.55**
df: 4 for numerator and 241 for denominator

Ho: All of above
F=1.86**
df:18 for numerator and 241 for denominator

Product Aggregation Test

Ho: Beef can be aggregated.
F=458.25**
df: 18 for numerator and 241 for denominator

Ho: Pork can be aggregated.
F=1068.18**
df: 10 for numerator and 241 for denominator

Ho: Poultry can be aggregated.
F=1231.21**
df: 4 for numerator and 241 for denominator

Ho: All of above
F=1328.74**
df: 32 for numerator and 241 for denominator

Note: (*) and (**) denote significance at 5% and 1%, respectively

Table 2. Block Separability and Product Aggregation Test Results for the Mexican Meat Demand Model

Block Separability Test

Ho: Beef is separable from all other meats.
F=13.66**
df: 8 for numerator and 306 for denominator
Ho: Pork is separable from all other meats.
F=40.94**
df: 6 for numerator and 306 for denominator

Ho: Poultry is separable from all other meats.
F=14.04**
df: 6 for numerator and 306 for denominator

Ho: All of above
F=21.97**
df: 20 for numerator and 306 for denominator

Product Aggregation Test

Ho: Beef can be aggregated.
F=296.53**
df: 18 for numerator and 306 for denominator

Ho: Pork can be aggregated.
F=195.08**
df: 10 for numerator and 306 for denominator

Ho: Poultry can be aggregated.
F=161.06**
df: 10 for numerator and 306 for denominator

Ho: All of above
F=234.18**
df: 38 for numerator and 306 for denominator

Note: (*) and (**) denote significance at 5% and 1%, respectively.

Table 3. Marshallian Demand Elasticities and Seasonality and BSE Impacts, Canadian Meat Demand Using First-difference RSDAIDS Model, 1995:I-2005:IV

Explanatory Variables	Beef				Pork			Poultry	
	U.S.	Australia	Canada	ROW	U.S.	Canada	ROW	U.S.	Canada
Price of beef from the U.S.	-1.649**	-0.159	0.152**	1.067**					
	(0.462)	(0.804)	(0.060)	(0.589)					
Price of beef from Australia	-0.038	-1.334**	0.006	-0.481					
	(0.271)	(0.752)	(0.036)	(0.496)					
Price of beef from Canada	1.599**	-0.108	-1.622**	0.235					
	(0.637)	(1.390)	(0.231)	(1.021)					
Price of beef from ROW	0.513**	-0.743	-0.008	-0.908					
	(0.291)	(0.728)	(0.034)	(0.736)					
Price of pork from the U.S.					-0.404**	-0.004	-0.297		
					(0.167)	(1.597)	(0.374)		
Price of pork from Canada					-0.142	-1.088**	-0.116		
					(0.167)	(0.153)	(1.207)		
Price of pork from ROW					-0.035	-0.001	-1.283**		
					(0.042)	(0.008)	(0.253)		
Price of poultry from the U.S.								-1.135**	0.098
								(0.285)	(0.087)
Price of poultry from Canada								1.268**	-0.642**
								(0.734)	(0.289)
Price of beef					-0.278	-0.089	-0.505	0.790	0.424**
					(0.244)	(0.283)	(2.554)	(0.679)	(0.115)
Price of pork	-0.274	-0.808	0.260	-1.246				-0.585	0.001
	(0.669)	(1.230)	(0.204)	(0.845)				(0.684)	(0.462)
Price of poultry	-1.153	0.927	-0.208	0.984	-0.526*	0.047	1.059		
	(0.845)	(1.566)	(0.250)	(1.211)	(0.306)	(0.244)	(1.764)		
Expenditutre	1.003**	2.226	1.430**	0.350	1.383**	1.134**	1.141	-0.338	0.119
	(0.511)	(1.612)	(0.279)	(0.998)	(0.394)	(0.304)	(2.369)	(0.704)	(0.479)
Quarter one	0.004	-0.003	-0.030	0.012**	-9.239E-04	0.019	0.003	-0.001	0.016
	(0.005)	(0.003)	(0.016)	(0.003)	(0.001)	(0.016)	(0.001)	(0.002)	(0.014)
Quarter three	-0.005	0.001	-0.002	-0.010**	-0.001	0.002	5.023E-04	0.005	0.009
	(0.005)	(0.003)	(0.016)	(0.003)	(0.001)	(0.016)	(0.001)	(0.002)	(0.013)
Quarter four	0.004	0.003	-0.017	-0.008	-3.360E-04	0.013	0.003	0.005	0.022
	(0.005)	(0.003)	(0.017)	(0.003)	(0.001)	(0.019)	(0.001)	(0.003)	(0.015)
BSE outbreak in Canada	0.013	-0.022**	-0.099**	9.064E-05	-0.001	0.021	0.002	0.007	0.069**
	(0.010)	(0.005)	(0.026)	(0.005)	(0.002)	(0.027)	(0.001)	(0.005)	(0.023)
BSEoutbreak in the U.S.	-1.423E-02	-0.012*	0.032	-0.003	0.003	-0.010	-2.214E-04	1.774E-04	-0.002
	(0.010)	(0.005)	(0.026)	(0.005)	(0.002)	(0.029)	(0.002)	(0.005)	(0.023)

Notes: System weighted R^2=0.59. Numbers in parenthesis are asymptotic standard errors. Single (*) and double (**) asterisks denote significance at 5% and 1% level respectively.

Table 4. Marshallian Demand Elasticities and Seasonality and BSE Impacts, Mexican Meat Demand Using RSDAIDS Model, 1995:I-2005:IV

Explanatory	Beef				Pork			Poultry		
variables	U.S.	Canada	Mexico	ROW	U.S.	Mexico	ROW	U.S.	Mexico	ROW
Price of beef from the U.S.	-2.026**	0.604	0.045**	1.763**						
	(0.238)	(0.576)	(0.028)	(0.576)						
Price of beef from Canada	0.096	-0.171	-0.059**	0.706**						
	(0.092)	(0.353)	(0.011)	(0.254)						
Price of beef from Mexico	0.343*	-2.507**	-1.170**	-0.003						
	(0.197)	(0.477)	(0.031)	(0.569)						
Price of beef from the ROW	0.067**	0.167**	-0.001	-0.754**						
	(0.022)	(0.060)	(0.003)	(0.115)						
Price of pork from the U.S.					-0.053	0.024	1.426**			
					(0.189)	(0.023)	(0.395)			
Price of pork from Mexico					-1.221**	-0.838**	-3.631**			
					(0.238)	(0.037)	(0.519)			
Price of pork from the ROW					0.222	-0.055**	0.437			
					(0.189)	(0.008)	(0.284)			
Price of poultry from the U.S.								-0.165*	-0.033**	4.397**
								(0.088)	(0.008)	(0.573)
Price of poultry from Mexico								-0.384**	-0.831**	0.916
								(0.147)	(0.021)	(0.971)
Price of poultry from the ROW								0.222	0.158**	-1.119
								(0.194)	(0.036)	(1.264)
Price of beef					-0.260	0.552**	1.402**	-0.856**	0.137**	0.053
					(0.224)	(0.028)	(0.452)	(0.260)	(0.044)	(1.590)
Price of pork	-0.854**	0.815**	0.276**	-3.399**				0.020	-0.585**	-5.237**
	(0.130)	(0.440)	(0.017)	(0.311)				(0.147)	(0.023)	(0.906)
Price of poultry	1.429**	0.254	-0.125**	0.857**	-1.237**	-0.653**	-0.392			
	(0.155)	(0.502)	(0.024)	(0.500)	(0.248)	(0.029)	(0.477)			
Expenditure	0.947**	0.838**	1.034**	0.812**	1.110**	0.970**	0.758**	1.163**	1.154**	0.989
	(0.056)	(0.198)	(0.008)	(0.130)	(0.070)	(0.008)	(0.143)	(0.191)	(0.035)	(1.233)
Quarter one	0.006	0.004	-0.016**	-5.721E-06	0.002	0.003	4.984E-04	-0.001	0.009	-1.60E-04
	(0.004)	(0.002)	(0.004)	(0.0004)	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)	(0.0003)
Quarter three	0.003	8.847E-04	-7.120E-05	-2.035E-04	-0.001	-0.003	2.269E-04	-0.002	-0.005	2.38E-04
	(0.004)	(0.002)	(0.004)	(0.0003)	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)	(0.0003)
Quarter four	0.012	-1.357E-04	0.011**	-0.001	4.997E-04	-0.019**	-0.001	0.001	-0.028	6.30E-05
	(0.004)	(0.002)	(0.004)	(0.0004)	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)	(0.0004)
BSE outbreak in Canada	-0.004	-4.748E-04	0.014	-1.194E-03	0.005	-0.019**	0.001	0.002	0.002	-0.001659
	(0.010)	(0.006)	(0.009)	(0.0008)	(0.005)	(0.006)	(0.001)	(0.003)	(0.006)	(0.0008)
BSE outbreak in the U.S.	-0.015*	0.018**	0.031**	-3.547E-04	0.015**	-0.043**	0.001	-2.066E-03	-0.022**	-9.30E-05
	(0.007)	(0.004)	(0.007)	(0.0006)	(0.003)	(0.004)	(0.001)	(0.002)	(0.005)	(0.0006)

Notes: System weighted R^2=0.753. Numbers in parenthesis are asymptotic standard errors. Single (*) and double (**) asterisks denote significance at 5% and 1% level, respectively.