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A Source-Differentiated Analysis of U.S. Meat Demand

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The Rotterdam model is used to estimate U.S. source-differentiated meat demand. Price and expenditure elasticities indicate that U.S. grain-fed beef and U.S. pork have a competitive advantage in the U.S. beef and pork markets, respectively. Expenditure elasticities reveal that beef from Canada has the most to gain from an expansion in U.S. meat expenditures, followed by ROW pork, U.S. grain-fed beef, and U.S. poultry. BSE outbreaks in Canada and the United States are shown to have small impacts on meat demand, while seasonality is found to have a significant effect in determining U.S. meat consumption patterns.

Key words: BSE, Rotterdam, seasonality, source-differentiation, U.S. meat demand

Introduction

The United States is one of the major importers in the global meat markets. In 2002, the United States was the largest importer of beef, accounting for 29.3% of the world volume of beef imports, while it was the third largest importer of pork, accounting for 12.7% of the world volume of pork imports [United States Department of Agriculture/Foreign Agriculture Service (USDA/FAS), 2005]. Moreover, supply and demand forces have made the U.S. meat market highly segmented. For example, U.S. beef exports are primarily composed of grain-fed, high-value cuts. In contrast, its imports are principally grass-fed, lower-value beef products for processing, generally as ground beef [USDA/Economic Research Service (ERS), 2007]. In the pork market, the U.S. imports from the rest of the world (ROW) (mainly Denmark) are mostly pork spare ribs, which are preferred by U.S. consumers (Leuck, 2001; USDA/ERS, 2006c).

U.S. meat imports are expected to expand even further in the future with the increase in market access resulting from bilateral and multilateral trade agreements, such as the 2005 U.S. and Australia Free Trade Agreement and the ongoing Agreement on the Free Trade Area of the Americas (FTAA). The growth in meat imports by the United States is expected to bring about an increase in competition between U.S. produced meats and U.S. imported meats from other countries. Moreover, the recent outbreaks of animal disease have caused more variability in demand for meats. For example, the global demand for U.S. beef significantly decreased during the 2003 outbreak of bovine

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spongiform encephalopathy (BSE) in the United States. Given the recent disease outbreaks and increased competition among meats from different sources, considering source of origin is important when analyzing the U.S. demand for meats.

With the rapid globalization of the U.S. domestic meat sector, the U.S. market has become increasingly complex and fragmented. Understanding the demand for source-differentiated meats in the United States and the factors shaping it would provide helpful insight about this complex consumer market. This knowledge is of importance to U.S. meat producers, marketers, and policy makers in developing effective marketing programs aimed at expanding sales and market shares.

Despite the importance of the topic, most earlier studies addressing the competitiveness (competitive advantage)[1] of U.S. produced meats have focused on the U.S. export markets (chiefly on Japan) and not on the United States as a meat importer. Moreover, most of the previous studies on U.S. meat demand have been limited to aggregate (non-source-differentiated) meat demand. While some investigations have estimated the demand relationships between various beef cuts, such as table cuts and ground beef (Brester and Wohlgenant, 1991; Eales and Unnevehr, 1988) or USDA graded beef (Lusk et al., 2001), none have differentiated meats by their source of origin—with the exceptions of Jones, Hahn, and Davis (2003) and Muhammad, Jones, and Hahn (2004) for lamb and mutton.

These aggregate (non-source-differentiated) demand studies implicitly assume that meat types (beef, pork, and poultry) from different sources are homogeneous with single prices. However, ignoring source of origin, which might be viewed as an intrinsic meat quality attribute, may lead to biased elasticity estimates and thus not reflect the true demand responses. As an example, Davis (1997) reported substitutability was found between U.S. produced and imported tobacco when using a model that did not account for aggregation bias, but the relationship changed to complementary with a model that did account for aggregation bias.

Hence, the primary objective of this study is to estimate the U.S. demand for source-differentiated meats, including meats that are produced in the United States and those that are imported. More specifically, this study seeks to analyze the impacts of economic factors (meat prices and expenditures) and non-economic factors (BSE and seasonality) on the U.S. demand for source-differentiated meats. Source-differentiated meat categories studied here include: U.S. grain-fed beef, U.S. grass-fed beef, U.S. pork, U.S. poultry, Australian beef, New Zealand beef, Canadian beef, beef from the ROW,[2] Canadian pork, and pork from the ROW.

This study is intended to offer a better understanding of U.S. meat buyers' preferences for meats from various sources, including U.S. produced meats, while taking into account the 2003 BSE outbreaks in North America plus the effects of seasonality. The

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[1] Competitive advantage may be defined as an advantage over competitors gained by offering meat buyers a greater value, either by lowering 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 meat buyers as a higher-value product. Furthermore, suppliers of higher-valued meat products would be expected to prefer facing an own-price inelastic demand. This is because the higher prices associated with their meats, compared to other meats from other suppliers, will 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 United States, is said to have a competitive advantage in a market that has a price-inelastic and expenditure-elastic demand.

[2] In this study, the ROW refers to the group of all other countries that export a specific type of meat to the United States, except those countries which are analyzed in this study and identified as U.S. competitors. For example, ROW beef is beef the U.S. imports from all other countries except for Australia, Canada, and New Zealand.

U.S. source-differentiated meat demand elasticities obtained here may be used in the analysis of the economic impacts of various policies and marketing strategies on U.S. meat producers and marketers. Examples are the analysis of the much debated country-of-origin labeling mandate or the animal and poultry disease outbreaks and the resulting policy and regulation changes. The general and partial equilibrium models, which are used in evaluating the welfare impacts of these policies, rely on accurate measures of price and expenditure demand elasticities.

The remainder of the paper continues as follows. First, we present a historical overview of U.S. meat trade policies. A model of U.S. source-differentiated meat demand is then developed, followed by a description of the data and estimation procedures. The next section is devoted to a presentation of the results. Summary remarks and conclusions are provided in the final section.

An Overview of U.S. Meat Trade Policies

The U.S. government restricted the importation of meats through a quota system under the 1979 Meat Import Law (MIL). The law required the U.S. president to impose quotas on imports of beef, veal, mutton, and goat meat when the aggregate annual quantity supplied of such meats had exceeded a prescribed trigger level (U.S. Department of Homeland Security, 2005). The quota restriction under MIL was allocated to various supplying countries on the basis of their historic shares in the U.S. domestic market. However, the U.S. meat import quotas established under MIL were eliminated subsequent to the bilateral and multilateral trade agreements between the United States and other countries, including the Canada-U.S. Free Trade Agreement (CFTA), the North American Free Trade Agreement (NAFTA), and the Uruguay Round Agreement on Agriculture (URAA). A summary of U.S. meat trade liberalization is provided in table 1.

The U.S. import tariffs for beef, pork, and poultry from Canada and Mexico were totally eliminated in 1993 by CFTA and in 1994 by NAFTA, respectively. Under the URAA, the United States replaced the import quota system established under MIL with tariff-rate quotas (TRQs) for U.S. beef imports from non-NAFTA countries (table 1). Moreover, special safeguard provisions, which aim to limit import surges by allowing the United States to raise tariffs if the volume of imports exceeds a certain amount or if the import prices fall by a certain percentage of a base price, are in effect for U.S. beef imports (Obara, Dyck, and Stout, 2003).

Although significant progress has been made toward liberalization of the U.S. meat import market, sanitary and phytosanitary (SPS) measures are currently prevalent and constitute a major form of restricting meat imports. The United States banned beef imports from Canada in May 2003, when BSE was detected there. This ban continued until August 2003, when the United States lifted the ban of Canadian boneless beef from cattle less than 30 months of age, as cattle of this age are considered to have little risk of transmitting BSE (Hahn et al., 2005). Furthermore, fresh meats originating from certain countries such as Mexico and South American countries have not been allowed to enter the United States due to the prevalence of Classical Swine Fever, Exotic Newcastle Disease (END), Avian Influenza (AI), and foot-and-mouth disease (FMD) in those areas (Hahn et al., 2005; Leuck, 2001).

Table 1. Summary of U.S. Meat Trade Liberalization Resulting from CFTA, NAFTA, and URAA

Trade Partner	BEEF	PORK	POULTRY
NAFTA Countries	■ Import quotas for beef from Canada and Mexico were eliminated by CFTA and NAFTA agreements as of January 1, 1989 and January 1, 1994, respectively; 4.4¢ tariff/lb. of beef originating from Canada was phased out and eliminated in July 1993.	■ Tariffs of 1.2¢/kg for sausage and 6.4¢/kg for canned ham originating from Canada and Mexico were eliminated by CFTA and NAFTA agreements as of January 1, 1989 and January 1, 1994, respectively.	■ Import tariffs, which ranged from 2¢ to 10.6¢/kg for the U.S. imports of poultry originating from Canada, were supposed to be phased out over a 10-year period by CAFTA as of January 1, 1989. However, they were eliminated in July 1993. ■ Import tariffs, which ranged from 2¢ to 10.6¢/kg for the U.S. imports of poultry originating from Mexico, were eliminated by NAFTA as of January 1, 1994.
Non-NAFTA Countries	■ Import quotas were eliminated and replaced with TRQs of 378,214 tons/year for Australia, 213,402 tons/year for New Zealand, 200 tons/year for Japan, 20,000 tons/year for Argentina and Uruguay, and 64,805 tons/year for other countries by URAA in 1995. ■ Within-quota tariffs on cuts specially prepared for retail range from 4% to 10%. Within TRQs, tariffs are 4.4¢/kg. ■ Over-quota tariff lowered from 31.1% to 26.5% by URAA agreement from 1995 to 2000. ■ Special safeguard provisions to limit import surges on over-TRQ amounts are applied. ■ Tariff for beef offal is zero.	■ Tariffs on cuts specially prepared for retail were lowered from 2.2¢/kg to 1.4¢/kg by URAA agreement from 1995 to 2000. ■ Tariff for pork offal is zero.	■ Tariffs on poultry meat were lowered from 22¢/kg to 17.6¢/kg by URAA agreement from 1995 to 2000.

Sources: Hahn et al. (2005), and Dyck and Nelson (2003).

A Model of U.S. Source-Differentiated Meat Demand

Although information about source of origin of different meat types is available at the wholesale level, U.S. meat consumers generally are not given this information at the time of purchase. Consequently, the appropriate approach to derive U.S. source-differentiated meat demand appears to be one based on production theory, with the retailer's profit maximization or cost minimization as an objective, rather than an approach based on consumer theory. Using a two-stage budgeting procedure (a profit-maximization framework in the first stage and a cost-minimization framework in the second stage), Davis and Jensen (1994) derived a source-differentiated demand model of the form:

$$(1) \qquad q_{i_h} = q_{i_h}(\mathbf{p}_g, X_g),$$

where, in our study, q_{i_h} is the volume demanded of meat i from source h, $\mathbf{p}_g$ is the vector of prices of source-differentiated meats in meat group g, and X_g represents the total expenditure on meat group g.

According to Davis and Jensen (1994), the demand model represented in equation (1) is a conditional Marshallian constant cost input demand function that can be derived from the second stage of a two-stage profit-maximization problem. As they show and discuss, this second-stage demand function is observationally equivalent to the second-stage demand function coming from a two-stage utility-maximization problem.

The Empirical Model

The almost ideal demand system (AIDS) and the Rotterdam model have been frequently used in the literature in import demand estimations. Here we use the absolute price version of the Rotterdam model to estimate source-differentiated meat demands in the United States. Several past studies have employed the Rotterdam model to estimate demand for source-differentiated goods (e.g., Weatherspoon and Seale, 1995; Seale, Sparks, and Buxton, 1992).

Besides being theoretically reasonable for estimating import demand equations, the Rotterdam model is advantageous because it can be estimated using linear estimation procedures and the theoretical restrictions can be imposed and tested easily. Furthermore, it also allows for a theoretically correct specification of exogenous demand shifters with and without imposing functional restrictions on shift variables (Marsh, Schroeder, and Mintert, 2004).

Following Seale, Sparks, and Buxton (1992), and Marsh, Schroeder, and Mintert (2004), the absolute price version of the source-differentiated Rotterdam model with indicator variable demand shifters is specified as follows:

$$(2) \qquad w^*_{i_h} d\log(q_{i_h}) = \alpha_{i_h 0} + \sum_{l=1}^{3} \alpha_{i_h l} Z_l + \sum_{m=1}^{2} \alpha_{i_h m} D_m + \beta_{i_h} d\log(Q) + \sum_j \sum_k \gamma_{i_h j_k} d\log(p_{j_k}),$$

where subscripts i and j indicate goods (beef, pork, and poultry), h and k denote supply sources (country of origin), l represents the number of seasonality indicator variables, and m indicates the number of the BSE indicator variables; $w^*_{i_h}$ is the budget share variable of good i from source h, here defined as $w^*_{i_{ht}} = (w_{i_{ht}} + w_{i_{ht-1}})/2$; q_{i_h} is the quantity demanded of meat i from source h; Z_l is a quarterly indicator variable for seasonality; D_m represents the U.S. and Canadian BSE outbreak indicator variables; Q is the divisia volume index, here defined as $d\log(Q) = \Sigma_i \Sigma_h w_{i_h} d\log(q_{i_h})$; p_{j_k} is the price of meat j from source k (with j including h, and k including h); $\alpha_{i_h 0}$, $\alpha_{i_h l}$, $\alpha_{i_h m}$, β_{i_h}, and $\gamma_{i_h j_k}$ are parameters to be estimated; and $d\log(x_i) = dx_i / x_i$.

General demand restrictions of homogeneity, symmetry, and adding-up, which are derived from economic theory, are imposed using parameter constraints as shown in equations (3), (4), and (5), respectively:

(3) $$\sum_j \sum_h \gamma_{i_h j_k} = 0,$$

(4) $$\gamma_{i_h j_k} = \gamma_{j_k i_h},$$

(5) $$\sum_i \sum_h \alpha_{i_h 0} = 0, \quad \sum_i \sum_h \alpha_{i_h l} = 0, \quad \sum_i \sum_h \alpha_{i_h m} = 0,$$
$$\sum_i \sum_h \beta_{i_h} = 1, \quad \sum_j \sum_k \gamma_{i_h j_k} = 0.$$

The conditional Cournot (uncompensated) own-price and cross-price elasticities, the conditional Slutsky (compensated) own-price and cross-price elasticities, and expenditure elasticities are calculated at the mean of expenditure shares ($\bar{w}_{i_h}$) (Seale, Sparks, and Buxton, 1992). The statistical significance of elasticities is determined by the method reported by Mdafri and Brorsen (1993).[3]

Statistical tests are performed in the Rotterdam model [equation (2)]. Specifically, the assumption of normality of the error terms, joint conditional mean (no autocorrelation, parameter stability, and linear functional form), and joint conditional variance (static and dynamic homoskedasticity, and variance stability) are tested using the system misspecification tests as suggested by McGuirk et al. (1995). Moreover, various hypotheses regarding the U.S. meat demand model, including block separability and product aggregation, are tested for the U.S. source-differentiated Rotterdam model [equation (2)].

Block Separability Test

This study tests block separability within the meat groups. The three different blocks are beef, pork, and poultry, with each block (for beef and pork, since not much poultry is imported in the United States) composed of meats from different sources. The block separability test is used to test if meat buyers' preferences within each block can be explained independent of quantities of meats in the other blocks. More specifically, for parsimonious estimation, it is useful to know whether each block of meat (beef from different sources) could be studied separately from meats in other blocks (poultry and pork from different sources) without incorporating their prices (not including the prices of pork and poultry in the beef equations). We use quasi-separability of the cost function to test for separability between blocks [for the test of quasi-separability of the cost function, see Hayes, Wahl, and Williams (1990, p. 561); 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.

Following Hayes, Wahl, and Williams (1990), and Yang and Koo (1994), the restriction to be tested is given as follows:

(6) $$\gamma_{i_h j_k} = \bar{w}_{i_h} \bar{w}_{j_k} \gamma_{ij},$$

[3] The equations of own-price, cross-price, and expenditure elasticities can be written in matrix form as **e** = **Ab**, where **e** is the vector of estimated elasticities (ε's and η's), **b** is the vector of estimated Rotterdam model parameters (γ's and 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**)], given by VAR(**e**) = **A**VAR(**b**)**A**, where VAR(**b**) is the variance-covariance matrix of **b**.

where $\gamma_{i_h j_k}$ is the cross-price parameter between meat i from source h, and meat j from source k. For example, in testing the null hypothesis that the demand for U.S. produced grain-fed beef is separable from the demand for U.S. produced pork, $\gamma_{i_h j_k}$ is the cross-price parameter between U.S. produced grain-fed beef and U.S. produced pork; $\bar{w}_{i_h}$ is the mean of budget shares of meat i from source h within the meat group i (the mean of budget shares of U.S. produced grain-fed beef within the beef group for the above example); $\bar{w}_{j_k}$ is the mean of budget shares of meat j from source k within the meat group j (the mean of budget shares of U.S. produced pork within the pork group for the above example); and γ_{ij} is the cross-price parameter between groups i and j, estimated from an aggregate Rotterdam model (the cross-price parameter between beef and pork under the non-source-differentiated Rotterdam model for the above example).

Product Aggregation Test

The source-differentiated model used in this study is based on the assumption that meat buyers place different values on the same meat type originating from different sources. However, this assumption needs to be tested. The product aggregation test is used to test the restrictions that the parameters of the source-differentiated Rotterdam model are the same as the parameters of the non-source-differentiated Rotterdam model (aggregate 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 a non-source-differentiated Rotterdam model. Non-source differentiation (aggregation) reduces the number of parameters to be estimated, and therefore increases the degrees of freedom, compared to the non-aggregated models.

Following Yang and Koo (1994), testing for product aggregation (the model that does not differentiate meats by source of origin) can be done by testing the following restrictions:

$$(7) \qquad \begin{aligned} \alpha_{i_h} &= \alpha_i \quad \forall\, h \in i, \\ \gamma_{i_h j_k} &= \gamma_{ij} \quad \forall\, h, k \in i, j, \\ \beta_{i_h} &= \beta_i \quad \forall\, h \in i, \end{aligned}$$

where α_{i_h}, $\gamma_{i_h j_k}$, and β_{i_h} are the estimated intercept, own- and cross-price parameters, and expenditure parameters of the source-differentiated Rotterdam model presented in equation (2); α_i, γ_{ij}, and β_i are the estimated intercept, own- and cross-price parameters, and expenditure parameters of the non-source-differentiated Rotterdam model (aggregate model). For example, in testing the null hypothesis that beef can be aggregated (non-source differentiated), α_{i_h}, $\gamma_{i_h j_k}$, and β_{i_h} are the estimated intercept, own- and cross-price parameters, and expenditure parameters of the source-differentiated beef products (U.S. grass-fed beef, U.S. grain-fed beef, Canadian beef, Australian beef, New Zealand beef, and ROW beef) from equation (2), and α_i, γ_{ij}, and β_i are the estimated intercept, own- and cross-price parameters, and expenditure parameters of aggregate beef (not differentiated by source of supply) from the non-source-differentiated Rotterdam model.

The Wald F-test is used to test the hypothesis of product aggregation over different supply sources. This test is conducted by imposing restrictions related to the assumption of product aggregation represented in equation (7) above on the parameters of the source-differentiated model [equation (2)]. If the Wald F-test results indicate the rejection of the null hypotheses [equation (7)], it can be concluded that meat buyers place different values on the same meat type originating from different sources. Hence, U.S. meat demand should be estimated using source-differentiated models.

Data and Estimation Procedures

Quarterly data from 1995 (quarter I) through 2005 (quarter IV) are used to estimate the parameters of the U.S. source-differentiated meat demand. For this study, 1995 is chosen for the beginning of the data because the major U.S. meat import barrier (import quota system) was eliminated in 1995. This is also the year that the URAA was implemented. The meats studied here are beef, pork, and poultry. Beef from the United States is differentiated by quality (grain-fed and grass-fed), and beef and pork are differentiated based on the origin of supply (source differentiated).[4] A country is identified as a supply source if imports from that source constituted at least 10% of the total imports of the selected meat. All other sources supplying less than 10% of the U.S. total imports of the selected meat are aggregated as the ROW. Using this criterion, U.S. meat imports are categorized as: beef from Australia, beef from Canada, beef from New Zealand, beef from the ROW, pork from Canada, and pork from the ROW. Poultry is not differentiated by supply source, since more than 95% of U.S. poultry consumption is supplied by U.S. producers.

Because retail prices for source-differentiated meats in the United States are not available, unit-value import prices are used to measure market prices for imported meats.[5] Source-differentiated import prices (unit values) of individual meats are calculated by dividing the total import values by the total import quantities. Data on import values (in thousands of U.S. dollars) and quantities (in metric tons) are from USDA/FAS (2006). Data on U.S. domestic meats at the wholesale level are derived from various sources. For U.S. produced beef and pork, quantity and price data are from USDA/ERS (2006a), and data for poultry are from USDA/ERS (2006b). The quantity of grain-fed beef is calculated as the sum of the quantities demanded of beef from steers and heifers. The quantity demanded of grass-fed beef is calculated as the sum of the quantity demanded of beef from cows and bulls. Slaughter steer price of choice 2–4 Nebraska Direct is used as the price of grain-fed beef. Slaughter cutter cow price is used for the price of grass-fed beef.

Seasonal and BSE indicator variables are included in the Rotterdam model to measure the impact of seasonality and BSE disease outbreaks on U.S. meat demand. Three seasonal quarterly variables are included for the first (January–March), third (July–September), and fourth (October–December) quarters. Two BSE dummy variables, one accounting for the BSE outbreak in Canada and another accounting for the

[4] Due to a lack of disaggregated trade data, this study implicitly assumes that each type of meat from the same source is a relatively homogeneous product. This assumption might be reasonable because the countries exporting meat to the United States generally specialize in exporting specific meat categories. For example, the majority of U.S. beef imports from Australia and New Zealand are composed of mainly grass-fed beef, while Canadian exports to the United States are primarily composed of grain-fed beef. However, some aggregation bias might still exist from the homogeneity assumption, which results from the actual differences in meat categories (cuts and organs) within each source-differentiated meat.

[5] Although unit values usually reflect perceived quality differences of imported meats, they may differ from wholesale prices when trade restrictions are in effect.

BSE outbreak in the United States, are included in the model. The BSE indicator variables are intended to reflect the period during which the BSE scare in the United States would have been most likely to occur. It is assumed here that if the BSE outbreak had any impact on the U.S. 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 U.S. meat buyers. We assume the U.S. meat buyers may not necessarily have reacted in the same way to bans by (not nearby) countries in other continents, such as Japan and South Korea. More specifically, U.S. and Japanese consumers are reported to react differently in terms of their meat demand to non-price and non-income concerns, including food safety issues (Tonsor and Marsh, 2007). 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 U.S. source-differentiated meat demand.

Although media coverage indices have been used to model demand response to food scares (Piggott and Marsh, 2004), this study uses indicator variables. Empirical applications of media coverage indices in modeling demand response to food scares have some important limitations. These shortcomings may be a result of the subjective nature of consumers' discrimination between positive and negative information, depreciation of the information effect due to the memory discount effect, and the differing effect of confirmatory news from the first news (Mazzocchi, 2006). Furthermore, collecting and analyzing adequate media coverage information can be a time-consuming and potentially expensive endeavor. Consequently, because the period when NAFTA countries banned beef imports from the North American infected countries is known, this study uses the BSE indicator variables.

The U.S. import ban on Canadian beef began in May 2003 and lasted through August 2003 when the ban of Canadian beef from cattle younger than 30 months of age was lifted in NAFTA countries (Hahn et al., 2005). Therefore, the Canadian BSE outbreak indicator variable takes the values of one for the second and the third quarters of the year 2003, and zero at other times. Similarly, the ban on U.S. beef from NAFTA countries began in December 2003 and lasted through March 2004, when NAFTA countries lifted the ban on U.S. beef from cattle younger than 30 months of age (Hahn et al., 2005). Thus, 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 at other times.

Animal disease outbreaks in Mexico and in South American countries such as Brazil, Argentina, and Uruguay have been frequently documented. However, animal disease outbreak variables for these countries are omitted here because none of these countries is a separate source of meat supply in the model used in this study (all are included in the ROW). Additionally, Hahn et al. (2005) report that the majority of U.S. imports from these countries are composed of highly processed or cooked meats which are sealed in air-tight containers. Accordingly, these meats may be perceived as safe. Therefore, animal disease outbreaks in these countries might not significantly impact U.S. meat demand.

The iterative seemingly unrelated regression (ITSUR) estimation method is used to estimate the parameters of the Rotterdam model [equation (2)].[6] Due to the adding-up condition, the contemporaneous covariance matrix is singular. Therefore, one equation (pork from the ROW equation) is dropped from the system for estimation purposes. If the maximum-likelihood estimation method is used, the resulting estimates are invariant to which equation is dropped. Because the ITSUR estimations for the complete demand systems are equivalent to the maximum-likelihood estimates, the parameters estimated in this study are invariant to which equation is dropped. The theoretical restrictions of symmetry, adding-up, and homogeneity are imposed to make the model consistent with economic theory.

Results

Prior to the estimation of the parameters of the U.S. source-differentiated Rotterdam model [equation (2)], the appropriateness of the model was tested using the system misspecification tests as described in the model section above. Results of the system misspecification tests are presented in table 2. Test results indicate the failure to reject the null hypothesis of normality of the error terms at the 1% significance level. Results of the joint conditional mean and joint conditional variance tests indicate the rejection of the null hypotheses that the joint conditional mean and joint conditional variance are properly specified at the 1% significance level. This might be due to the autocorrelation of the error terms, which test results confirm in this study (table 2).

Dynamics are expected to be particularly important in the analysis of the U.S. meat demand system as meat buyers are unlikely to respond fully to changes in price, income, or other determinants of demand in the short run. Psychological factors (consumption habits), inventory adjustments, or institutional factors have been given as reasons for the lagged consumer response (Kesavan et al., 1993; Henneberry and Hwang, 2007). Therefore, to allow for the lagged effects, the final model is estimated using iterative seemingly unrelated regression, corrected for autocorrelation (Berndt and Savin, 1975; Piggott and Marsh, 2004).

Block separability and product aggregation tests were also conducted by imposing the restrictions related to block separability and product aggregation assumptions on the final model (corrected for autocorrelation), following the description given above in the model section for these tests. Test results of the null hypotheses of block separability among the included meats (table 2) indicate the rejection of the null hypotheses at the 1% significance level. Therefore, test results support estimating the U.S. source-differentiated Rotterdam model for meats, including all three types of meats. Furthermore, test results presented in table 2 reveal that the null hypothesis of non-source differentiation (product aggregation) for all meats is rejected at the 1% significance level. Hence, the results support estimating U.S. demand for meats using a source-differentiated model.

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[6] The U.S. meat demand system was also estimated using a linear as well as a nonlinear version of the AIDS model. While the linear approximation of the AIDS model (LA/AIDS) produced elasticities similar in magnitude and signs to the calculated elasticities using the Rotterdam model (Mutondo, 2007), the nonlinear AIDS model did not converge. Convergence failure of the nonlinear AIDS model is expected in cases where a large number of parameters need to be estimated using a limited number of observations (44 here).

Table 2. Misspecification Test Results for U.S. Source-Differentiated Meat Demand Using Rotterdam Model

System Misspecification Tests		Block Separability and Product Aggregation Tests [a]	
Hypothesis Tested	*p*-Value	Hypothesis Tested	*p*-Value
Normality Test: [b]		***Block Separability Test:***	
Grain-fed beef from the U.S.	0.4927	H_0: Beef is separable from all other meats	0.0001
Grass-fed beef from the U.S.	0.1265	H_0: Pork is separable from all other meats	0.0019
Beef from Australia	0.0414	H_0: Poultry is separable from all other meats	0.0014
Beef from Canada	0.5439	H_0: Overall block separability test	0.0001
Beef from New Zealand	0.8721	***Product Aggregation Test***	
Beef from the ROW	0.6813	H_0: Beef can be aggregated	0.0001
Pork from the U.S.	0.4967	H_0: Pork can be aggregated	0.0001
Pork from Canada	0.5963	H_0: Overall product aggregation test	0.0001
Pork from the ROW	0.8807		
Poultry from the U.S.	0.4506		
Joint Conditional Mean Test:			
H_0: Linear functional form	0.0001		
H_0: No autocorrelation	0.0001		
H_0: No structural changes	0.5072		
H_0: Overall joint conditional mean test	0.0001		
Joint Conditional Variance Test			
H_0: Static homoskedasticity	0.0001		
H_0: Dynamic homoskedasticity	0.1348		
H_0: No structural changes	0.6131		
H_0: Overall joint conditional variance test	0.0001		

[a] Block separability and product aggregation tests were performed using a model corrected for autocorrelation.
[b] The null hypothesis for the normality test is that the error terms of each equation are normally distributed.

Calculated Marshallian (uncompensated Cournot) and Hicksian (compensated Slutsky) demand elasticities with their standard errors in parentheses are presented in tables 3 and 4, respectively. Estimated parameters of seasonal and BSE indicator variables are also presented in table 3. It is important to note that the results discussed in the following sections represent U.S. demand for domestically produced and imported meats, estimated using wholesale-level data.

Price and Expenditure Elasticities

Consistent with economic theory, the majority of source-differentiated own-price elasticities are negative and statistically significant (tables 3 and 4). In the beef market, most own-price elasticities fall within the range of −0.15 to −2.59. This range is consistent with published own-price elasticities for beef reported by the U.S. Environmental Protection Agency (USEPA, 2002). The estimated own-price elasticities of imported beef from Australia and New Zealand are greater than 2.6 in absolute value (tables 3 and 4). As suggested by these results, beef imports from major grass-fed beef suppliers are sensitive to own-price in the U.S. domestic market. These findings support those reported by previous studies—i.e., the perceived lower-quality meats (such as grass-fed beef

Table 3. Rotterdam Model, U.S. Meat Demand, 1995.I–2005.IV: Uncompensated Cournot Price and Expenditure Elasticities, and Seasonality and BSE Impacts

	BEEF					
Explanatory Variables	U.S. Grain-Fed	U.S. Grass-Fed	Canada	Australia	New Zealand	ROW
U.S. Grain-Fed Beef Price	-0.712*** (0.120)	0.463** (0.218)	-0.542 (1.716)	-0.073 (1.068)	1.465 (0.905)	-0.066 (0.520)
U.S. Grass-Fed Beef Price	0.016 (0.020)	-0.507*** (0.138)	-1.286 (1.169)	0.097 (0.572)	0.426 (0.683)	0.299 (0.333)
Canadian Beef Price	-0.004 (0.041)	-0.314 (0.306)	-1.535*** (0.757)	0.043 (0.436)	-0.200 (0.382)	0.539 (0.220)
Australian Beef Price	-0.005 (0.013)	0.028 (0.121)	0.020 (0.359)	-2.747*** (1.086)	3.373*** (1.214)	0.001 (0.495)
New Zealand Beef Price	0.025** (0.013)	0.065 (0.097)	-0.120 (0.211)	2.261*** (0.808)	-4.057*** (1.356)	0.161 (0.447)
ROW Beef Price	-0.003 (0.007)	0.041 (0.041)	0.249** (0.107)	0.000 (0.289)	0.142 (0.394)	-1.285*** (0.262)
U.S. Pork Price	-0.266*** (0.071)	0.382** (0.157)	0.556 (1.133)	-0.897 (0.813)	-0.210 (0.781)	-1.010** (0.417)
Canadian Pork Price	-0.013** (0.006)	-0.060** (0.035)	0.001 (0.094)	0.896*** (0.293)	-1.035*** (0.442)	0.409** (0.192)
ROW Pork Price	0.010 (0.028)	-0.129 (0.122)	0.203 (0.480)	0.261 (0.693)	0.147 (0.692)	0.535 (0.360)
U.S. Poultry Price	-0.306*** (0.070)	-0.253** (0.143)	0.003 (1.108)	-0.830 (0.740)	-0.867 (0.586)	-0.457 (0.345)
Expenditure	1.258*** (0.223)	0.285 (0.427)	2.451 (3.593)	0.990 (2.214)	0.816 (1.712)	0.874 (1.021)
Quarter I	-0.0039 (0.007)	0.0040 (0.002)	0.0056 (0.004)	-0.0036 (0.002)	0.0031*** (0.001)	-0.0003 (0.001)
Quarter III	-0.0157*** (0.006)	0.0034** (0.002)	0.0026 (0.003)	-0.0024 (0.002)	-0.0042*** (0.001)	0.0003 (0.0004)
Quarter IV	-0.0392*** (0.005)	0.0055*** (0.001)	0.0058** (0.003)	-0.0051*** (0.002)	-0.0052*** (0.001)	-8.5557E-06 (0.0004)
BSE in Canada	0.0042 (0.006)	-0.0006 (0.002)	-0.0043 (0.004)	-0.0006 (0.002)	-0.0007 (0.001)	0.0002 (0.0005)
BSE in the U.S.	-0.0127 (0.008)	-0.0077*** (0.002)	0.0113** (0.005)	-0.0003 (0.002)	0.0006 (0.001)	0.0018** (0.001)

Notes: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively. Numbers in parentheses are asymptotic standard errors.

(table extended . . . →)

imported from Australia and New Zealand) have higher own-price elasticities, compared to perceived higher-quality meats (grain-fed beef from the United States and Canada) (Lusk et al., 2001; Brester and Wohlgenant, 1991; Eales and Unnevehr, 1988). Similar to beef, in the pork and poultry markets, most of the calculated own-price elasticities are less than one and fall within the range of -0.070 to -1.234 for pork and -0.104 to -1.250 for poultry, as reported by the USEPA (2002).

The compensated (Hicksian) cross-price elasticities (table 4) indicate net substitutability or net complementary relationships among products from different sources. While a significant positive Hicksian cross-price elasticity between meats from different suppliers may indicate substitutability, a significant negative cross-price elasticity may

Table 3. Extended

	PORK			POULTRY
Explanatory Variables	United States	Canada	ROW	United States
U.S. Grain-Fed Beef Price	-0.169*** (0.062)	-0.256 (0.284)	0.757 (2.335)	-0.322*** (0.081)
U.S. Grass-Fed Beef Price	0.038** (0.020)	-0.314** (0.174)	-1.464 (1.337)	-0.079*** (0.017)
Canadian Beef Price	0.044** (0.023)	0.024 (0.113)	0.603 (1.394)	0.017 (0.025)
Australian Beef Price	-0.030 (0.022)	0.955*** (0.314)	0.613 (1.639)	-0.031** (0.016)
New Zealand Beef Price	-0.005 (0.016)	-0.737** (0.316)	0.742 (1.095)	-0.023*** (0.009)
ROW Beef Price	-0.021*** (0.007)	0.258** (0.121)	0.231 (0.501)	-0.011*** (0.004)
U.S. Pork Price	-0.468*** (0.040)	1.378*** (0.345)	-1.139 (1.640)	-0.306 (1.054)
Canadian Pork Price	0.044*** (0.009)	-1.096** (0.279)	-1.640*** (0.404)	-0.008 (0.023)
ROW Pork Price	-0.014 (0.024)	-0.735*** (0.183)	-0.844** (0.448)	0.016 (0.019)
U.S. Poultry Price	-0.226*** (0.039)	-0.125 (0.179)	-1.334 (2.301)	-0.297*** (0.062)
Expenditure	0.805*** (0.120)	0.648 (0.550)	1.391 (1.230)	1.043*** (0.186)
Quarter I	0.0051 (0.003)	-0.0001 (0.0005)	0.0005 (0.0005)	-0.0087 (0.005)
Quarter III	0.0231*** (0.003)	0.0016 (0.0004)	0.0003 (0.0004)	-0.0077 (0.004)
Quarter IV	0.0392*** (0.003)	0.0017*** (0.0003)	0.0011*** (0.0004)	-0.0044 (0.003)
BSE in Canada	-0.0021 (0.003)	-0.0003 (0.0004)	-2.3363E-05 (0.0004)	0.0004 (0.004)
BSE in the U.S.	0.0043 (0.003)	-0.0005 (0.0004)	0.0003 (0.0006)	-0.0056 (0.005)

suggest a complementary relationship. Justifying a complementary relationship between meats is difficult since all meats are sources of animal protein and therefore are expected to substitute for one another in human consumption.

For the U.S. beef market, the results show that U.S. grain-fed beef is a net substitute for beef from various sources, especially with U.S. grass-fed beef and imported beef from Canada and New Zealand (first row, table 4). The substitutability between U.S. grain-fed beef with U.S. grass-fed beef and beef from New Zealand is an unexpected result because of the difference in quality between U.S. grain-fed beef with these beef products. However, the substitutability relationship between U.S. grain-fed beef and Canadian beef is consistent with prior expectations since both beef products are produced from grain-fed cattle of similar quality. Moreover, the magnitude and statistical significance of cross-price elasticities indicate that while the demand for U.S. grain-fed beef is not strongly impacted by the prices of imported beef and U.S. grass-fed beef (first column,

Table 4. Rotterdam Model, U.S. Meat Demand, 1995.I–2005.IV: Compensated Slutsky Price Elasticities

	BEEF					
Explanatory Variables	U.S. Grain-Fed	U.S. Grass-Fed	Canada	Australia	New Zealand	ROW
U.S. Grain-Fed Beef Price	-0.271*** (0.091)	0.563*** (0.164)	0.316*** (0.128)	0.274 (0.747)	1.751*** (0.660)	0.240 (0.381)
U.S. Grass-Fed Beef Price	0.075*** (0.022)	-0.494*** (0.135)	-1.173*** (0.128)	0.143 (0.559)	0.464 (0.671)	0.339 (0.327)
Canadian Beef Price	0.011 (0.041)	-0.311 (0.306)	-1.505*** (0.084)	0.055 (0.437)	-0.190 (0.384)	0.550*** (0.220)
Australian Beef Price	0.008 (0.021)	0.031 (0.120)	0.044 (0.039)	-2.737*** (1.079)	3.381*** (1.208)	0.009 (0.492)
New Zealand Beef Price	0.033*** (0.013)	0.067 (0.097)	-0.103*** (0.023)	2.268*** (0.810)	-4.052*** (1.359)	0.167 (0.448)
ROW Beef Price	0.004 (0.006)	0.043 (0.042)	0.264*** (0.012)	0.005 (0.290)	0.147 (0.394)	-1.280*** (0.262)
U.S. Pork Price	0.092*** (0.036)	0.463*** (0.117)	1.254*** (0.060)	-0.615 (0.614)	0.022 (0.666)	-0.761** (0.336)
Canadian Pork Price	-0.001 (0.005)	-0.057** (0.035)	0.024*** (0.010)	0.905*** (0.294)	-1.028*** (0.444)	0.418** (0.193)
ROW Pork Price	0.015 (0.028)	-0.128 (0.122)	0.214*** (0.053)	0.265 (0.694)	0.151 (0.692)	0.539 (0.359)
U.S. Poultry Price	0.034 (0.036)	-0.176** (0.084)	0.665*** (0.060)	-0.562 (0.413)	-0.646** (0.347)	-0.221 (0.198)

Notes: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively. Numbers in parentheses are asymptotic standard errors.

(table extended . . . →)

table 4), the price of U.S. grain-fed beef has a more noticeable impact on the demand for other beef products (first row, table 4).

With respect to other suppliers, beef from New Zealand and Australia are shown to be substitutes (table 4). The substitutability between imported beef from Australia and New Zealand is consistent with prior expectations, as both countries supply beef from grass-fed cattle to the U.S. beef market. Substitutability also exists between Canadian beef and ROW beef. The U.S. beef imports from the ROW (primarily South American countries) are mainly composed of further processed, grass-fed beef products due to the prevalence of animal diseases (particularly foot-and-mouth disease) in those countries. Hence, the substitutability between Canadian beef and ROW beef might be consistent with previous expectations because the further processed (value-added) beef from the ROW might be perceived by U.S. meat buyers as having a similar value compared to grain-fed Canadian beef. However, Canadian beef shows a statistically significant complementary relationship with U.S. grass-fed and New Zealand beef. Again, these results are consistent with prior expectations since the U.S. imports of beef from Canada are principally composed of high-quality beef cuts graded as choice and select from grain-fed cattle. The choice and select quality beef are not expected to compete with U.S. grass-fed beef mainly from cows and bulls and New Zealand grass-fed beef (used mostly for hamburger meat).

For the pork market, the estimated cross-price elasticities show that U.S. pork competes with pork from Canada (table 4). However, ROW pork shows a complementary

Table 4. Extended

	PORK			POULTRY
Explanatory Variables	United States	Canada	ROW	United States
U.S. Grain-Fed Beef Price	0.113*** (0.044)	-0.029 (0.204)	1.244 (2.294)	0.044 (0.047)
U.S. Grass-Fed Beef Price	0.075*** (0.019)	-0.284** (0.173)	-1.400 (1.335)	-0.030** (0.014)
Canadian Beef Price	0.054*** (0.023)	0.032 (0.113)	0.621 (1.394)	0.030 (0.025)
Australian Beef Price	-0.022 (0.022)	0.962*** (0.312)	0.627 (1.638)	-0.021 (0.015)
New Zealand Beef Price	0.001 (0.016)	-0.733** (0.317)	0.239 (1.096)	-0.016** (0.008)
ROW Beef Price	-0.016** (0.007)	0.262** (0.121)	0.751 (0.501)	-0.005 (0.004)
U.S. Pork Price	-0.238*** (0.038)	1.562*** (0.276)	-0.744 (1.607)	-0.009 (0.023)
Canadian Pork Price	0.052*** (0.009)	-1.090*** (0.281)	-1.627*** (0.405)	0.002 (0.003)
ROW Pork Price	-0.011 (0.024)	-0.733*** (0.183)	-0.838** (0.449)	0.020 (0.019)
U.S. Poultry Price	-0.008 (0.022)	0.051 (0.098)	-0.959 (2.280)	-0.015 (0.036)

relationship with U.S. and Canadian pork. The lack of substitutability might be due to differences in meat cuts and products between pork from North America (the United States and Canada) and pork from the ROW. While Canada and the United States produce similar quality pork products, mainly composed of whole pork carcasses, the U.S. imports from the ROW are primarily composed of spare ribs and hams from Denmark.

Regarding cross-meat product relationships (e.g., the relationship between source-differentiated beef and source-differentiated pork), the results show a substitution relationship between U.S. pork on one hand and U.S. grain-fed beef, U.S. grass-fed beef, and Canadian beef on the other hand. Moreover, Canadian pork shows a substitute relationship with beef from Canada, Australia, and the ROW. There is no clear relationship between U.S. poultry and source-differentiated beef and pork products since the majority of cross-price elasticities are not statistically significant. (In the summary and conclusions section, the discussion addresses the implications of these relationships.)

Concerning expenditure elasticities in the beef market, all expenditure elasticities are positive (table 3). Moreover, the expenditure elasticity estimates of U.S. grain-fed beef and Canadian beef (which is mainly composed of grain-fed beef) are both greater than one (1.258 and 2.451, respectively). These values are consistent with U.S. consumers preferring grain-fed beef from the United States and Canada over grass-fed beef imported from Australia and New Zealand and U.S. grass-fed beef. Additionally, the estimated expenditure elasticity of Canadian beef is higher than that of U.S. grain-fed beef. Consequently, a Wald *F*-test was conducted to test the hypothesis of the two elasticities being equal. Test results (p-value = 0.744) failed to reject the null hypothesis that the two elasticities are equal. This failure to reject the equality of the two elasticities is at least partially due to the imprecision in estimating the Canadian expenditure elasticity, which is not significantly different from zero.

With reference to the pork market, all expenditure elasticities are positive; however, only the expenditure elasticity of U.S. pork is statistically significant (table 3). The U.S. demand for ROW pork is expenditure elastic (1.391). This result is consistent with the general preferences for pork in the United States, since U.S. pork imports from the ROW are primarily composed of high-quality spare ribs and hams from Denmark, which are preferred by U.S. consumers (USDA/ERS, 2006c). In the poultry market, the expenditure elasticity of U.S. poultry is positive, greater than one, and statistically significant (table 3).

Effects of Seasonality and BSE on U.S. Meat Demand

The parameter estimates of seasonal and BSE indicator variables are presented in table 3. In the beef market, the coefficients of seasonal indicator variables show that the budget shares of most of the beef products (U.S. grain-fed beef, Australian beef, and New Zealand beef) are lower in the fourth quarter compared to the second quarter. These results are consistent with seasonal consumption patterns in the United States—i.e., the fourth quarter (October–December) is associated with the traditional holiday season when Americans consume more poultry meat than beef compared to other seasons. In the pork market, the results of the seasonal indicator variables show that the shares of pork from different sources are higher in the fourth quarter compared to the second quarter. Since most of the pork consumption in the United States is in the form of breakfast meats, the consumption of pork is expected to decrease during the warm summer months (second quarter). This is consistent with prior expectations because consumers are more likely to eat hot breakfasts during the colder seasons.

The results for BSE impacts suggest that the BSE outbreak in Canada did not affect the source-differentiated meat shares in the United States. However, the BSE outbreak in the United States decreased the shares of U.S. grass-fed beef and increased the shares of Canadian and ROW beef. The negative impact of the U.S. BSE outbreak on the U.S. grass-fed beef market share is consistent with previous expectations because U.S. grass-fed beef, which is composed of cows and bulls, is considered to carry a higher risk of transmitting BSE. Similarly, the findings that the U.S. BSE outbreak increased the shares of Canadian and ROW beef are consistent with previous expectations. This increase might have resulted from meat buyers substituting beef from those import sources (which were perceived safe by U.S. consumers) for U.S. grass-fed beef during the U.S. BSE outbreak.[7]

Summary and Conclusions

This study estimates the impacts of economic factors (meat prices and expenditure) and non-economic factors (seasonality and BSE outbreaks in the United States and Canada)

[7] Although there was a BSE outbreak in Canada in May 2003, prior to the U.S. BSE outbreak in December 2003, Canadian beef might have been considered safe by U.S. consumers. This is because the U.S. government had already lifted the ban on Canadian fresh beef products from cattle younger than 30 months of age as of August 2003, signaling the safety of Canadian beef to U.S. consumers (Hahn et al., 2005).

on the U.S. quantity demanded for source-differentiated meats, using the absolute price version of the Rotterdam model. To assure that the system specification and estimation procedures were correct, various hypotheses regarding the U.S. source-differentiated meat demand model were tested. The tested hypotheses include: normality, joint conditional mean, joint conditional variance, separability among meats included in the system, and product aggregation. The results of misspecification tests show that the joint conditional mean and joint conditional variance are not well specified, primarily due to autocorrelation of the error terms. Hence, the model was estimated using iterative seemingly unrelated regression with autocorrelation correction. Moreover, the results of statistical tests support estimating a set of meat demand equations for the three types of meats (beef, pork, and poultry), with each meat being differentiated by the supply source (source differentiated).

This study is one of the first to analyze source-differentiated meat demand in the U.S. domestic market. Our results shed light on the preferences for meats from different sources, including domestically produced meats in the U.S. meat market. Furthermore, the impacts of seasonality and the BSE outbreaks in the United States and Canada on the U.S. demand for source-differentiated meats are analyzed. The estimated price and expenditure elasticities are used to access the competitiveness of U.S. produced meats in the U.S. domestic market.

Following the definition of competitive advantage, the results of this study indicate that U.S. grain-fed beef has competitive advantage in the U.S. market, compared to beef from other major supplying sources. This conclusion is based on its relatively small own-price elasticity (in absolute value) and greater than one and statistically significant expenditure elasticity, compared to beef from other major suppliers. In the pork market, similar to beef, U.S. produced pork has competitive advantage compared to pork from other sources. This is because the expenditure elasticity of U.S. pork is statistically significant and the own-price elasticity of U.S. pork is the lowest (in absolute value) among own-price elasticities of pork from other sources.

The results of this study would have implications for the global meat suppliers to the U.S. market in the event of market condition changes, free trade agreements, and animal disease outbreaks. For example, if the increased availability of Australian beef in the United States resulting from the 2005 U.S./Australia free trade agreement reduces the relative price of Australian beef, and given the large positive and statistically significant New Zealand/Australia cross-price elasticities, New Zealand producers are expected to have the most to lose in terms of decreased exports and reduced U.S. market shares.

Another current application of this study is the implication of animal disease outbreaks on the meat share of various suppliers in the U.S. market. The substitute relationship of U.S. produced pork with U.S. and Canadian produced beef may indicate that the demand for U.S. pork might increase following a cattle disease such as the BSE outbreak in North America. Finally, market development activities intended to increase meat consumption in the United States are expected to have the most significant impact (in terms of percentage change in sales volume) on U.S. and Canadian grain-fed beef, ROW pork, and U.S. poultry compared to other meat products.

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