Welfare Implications of Selected Supply and Demand Shocks on Producers and Marketers of U.S. Meats

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Selected Paper Prepared for Presentation at the American Agricultural Economics Association Annual Meeting, Portland, Oregon, July 29 – August 1, 2007.

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Abstract

An equilibrium displacement model is developed and used to estimate the welfare impacts of government and industry-funded promotion programs, country of origin labeling (COOL), and the disease-driven, international bans on U.S. beef. The model goes beyond past studies by including the U.S. domestic market and both U.S. meat imports and exports, with meats differentiated by source of origin. The results indicate that while the benefits from beef and pork promotions are higher, the negative impacts of COOL are lower in a model with international trade than in a model without trade. International bans on U.S. beef decrease the welfare of producers and marketers of U.S. beef.

Key words: beef ban, country of origin, equilibrium displacement model, pork, poultry, promotion

Introduction

The effects of various supply and demand shocks on U.S. meat prices, quantities, and industry welfare have been widely studied (Mullen, Wohlgenant, and Farris 1988; Unnevehr, Gomez, and Garcia 1998; Chung and Kaiser 1999; Wohlgenant 1993; Kinnucan, Xiao, and Hsia 1996; Brester, Marsh, and Atwood 2004; Lusk and Anderson 2004; and Lusk and Norwood 2005). However, one notable deficiency among past studies is that meats were not differentiated by source of origin, and the U.S. international trade was typically not included. In most of these past studies, imported meats were ignored. If included, these meats were not differentiated by source of origin, and U.S. meat export markets were not considered. As a result, none of these previous models could evaluate the effects of the U.S. non-price export promotion programs and trade barriers such as meat bans on U.S. meat producers and marketers.

Although non-source differentiation might have been a realistic assumption in the past, this assumption no longer applies to the highly segregated world meat market. The world meat market has been divided into disease-restricted and disease-free countries primarily due to *Bovine Spongiform Encephalopathy* (BSE), foot-and-mouth disease (FMD), and avian influenza (AI). For example Japan and South Korea banned U.S. beef after the discovery of BSE in the U.S. in 2003. Therefore, source differentiating meats according to the supply source when estimating the impact of various supply and demand shocks on the U.S. and other countries' meat industries has become increasingly important.

Policy makers, producers, and consumers are interested in knowing the impacts of economic and non-economic variables on meat markets across the globe. This study provides a modeling framework and analyzes the economic impacts of selected, non-economic variables on producers and marketers of U.S. meats. An equilibrium displacement model is developed and used to estimate the impacts of non-economic variables (recent shocks and policy variables) on producers and marketers of U.S. meats. The non-economic variables whose impacts are studied here include government and industry-funded domestic and export promotion programs (beef and pork promotions), country of origin labeling (COOL), and animal disease-driven international bans on U.S. beef (ban of U.S. beef in Japan and South Korea).

The reminder of this study is organized as follows: the next section develops and describes the equilibrium displacement model. This section is followed by a description of the model parameters and a discussion of simulation methods and welfare measures of supply and demand shocks due to: (1) beef and pork promotions, (2) COOL; and (3) the Japanese and South Korean bans on U.S. beef. The simulated results and summary and conclusions are presented in the last two sections, respectively.

Equilibrium Displacement Model

An equilibrium displacement model is used to estimate welfare impacts of beef and pork promotions, COOL, and the Japanese and South Korean bans on U.S. beef. The structural specification of supply and demand relationships of meats (beef, pork, and poultry) provides the framework for the equilibrium displacement model (Wohlgenant 1993). This model includes U.S. domestically produced meats and U.S. meat imports from major countries [Australia, Canada, New Zealand, and the rest-of-the world (ROW)] plus U.S. meat exports to major countries (Canada, Japan, Mexico, and South Korea). Furthermore, the meat model specified here includes two distinct sectors: “retail” (consumer) and “farm” (producer). In addition, on the retail demand side, the model considers relationships (substitution and complementary relationships) between U.S. produced meats and meats from other supply sources in the U.S. domestic and export markets.

The food industry has become more concentrated and imperfectly competitive. For example, the four-firm concentration ratio in the U.S. beef packing industry increased from 0.30 in 1978 to 0.86 in 1994, and statistically significant monopoly/monopsony price distortions in slaughter cattle and wholesale beef markets have been reported (Sexton 2000; and Schroeter 1988). Therefore, although most equilibrium displacement models have assumed perfect competition as a base meat market structure assumption, the equilibrium displacement model developed in this study can assume either perfect or imperfect competition of the middle stage (processor-retailer) of the meat supply chain.

The equilibrium displacement model is based on certain theoretical assumptions (Brester and Wohlgenant 1997; and Wohlgenant 1993). For this study, these assumptions include: (a) the linearity of all supply and demand curves; and (b) the fact that any shifts in supply and demand curves are parallel. Chung and Kaiser (1999) report that the type of supply and demand shifts (parallel and pivotal) assumed is important when analyzing the effectiveness of two or more different policies on producers and consumers' welfare. However, the resulting outcome [gains or loses] does not vary with the type of shift assumed. Hence, given that this study does not compare the effectiveness of different policies on producers' and consumers' welfare, a parallel shift appears to be a reasonable assumption.; (c) fixed proportion production technology at the processors-retailers' market level. Fixed proportion technology means that the elasticity of substitution between market inputs and farm product at the processors-retailers' market level is zero; and (d) that substitution and complementary relationships are modeled on the demand side but not on the supply side. The model does not allow for production relationships (substitutes and complements) among the included meats because it assumes that specialized inputs and different production technologies are used in each meat type production. MacDonald et al. (1996) report that the meat industry has a high degree of specialization in production.

Following these assumptions, the equilibrium displacement model is presented below. The meat demand equation with its shifter is presented as:

(1) $$Q_{ijk}^{d*} = \boldsymbol{\eta}\mathbf{P}_{\mathbf{k}}^{\mathbf{d*}} - \boldsymbol{\eta}\boldsymbol{\varpi}_{\mathbf{ik}}$$

where Q_{ijk}^{d*} is the percentage of change in the quantity of meat of type *i* from country *j* demanded in country *k*. The subscript *i* denotes meat type and *i* =1,…, *I*. The subscript *j* denotes the country of origin of meat type *i*, (the supply source of meat of type *i* demanded in country *k* and *j* =1, 2,…, *J*). The source differentiated meat of type *i* is called a meat product. The subscript *k* denotes the consuming country (countries in which meat *i* from country *j* is demanded). The *k* destinations are (1) the U.S., (2) Canada, (3) Japan, (4) Mexico, and (5) South Korea. $\mathbf{P}_{\mathbf{k}}^{\mathbf{d*}}$ is the percentage of change in a vector of demand prices for source differentiated meats in country *k*, the star (*) represents the percentage change operator, so that $Q_{ijk}^{d*} = dQ_{ijk}^{d} / Q_{ijk}^{d} = d\ln(Q_{ijk}^{d})$; $\boldsymbol{\eta}$ represents a vector of own-price and cross-price demand elasticities for meats demanded in country *k*, and $\boldsymbol{\varpi}_{\mathbf{ik}}$ is a vector of demand shifters of meat *i* demanded in country *k*,

The meat supply equation with its shifter is presented as:

(2) $$Q_{ij}^{s*} = \varepsilon_{ij} P_{ij}^{s*} + \varepsilon_{ij}\gamma_{ij}$$

where Q_{ij}^{s*} is the percentage of change in the quantity of meat of type *i* supplied from country *j*. The *j* suppliers are the U.S., Canada, Japan, Mexico, South Korea, Brazil, Australia, New Zealand, Denmark, China, Thailand, and the ROW. Note that the *j* suppliers vary across the *k* destinations. P_{ij}^{s*} is the percentage of change in the supply price of meat of type *i* from country *j* (product *ij*); ε_{ij} is the own-price supply elasticity of meat *i* from country *j*, and γ_{ij} is the supply shifter of meat *i* from country *j*.

The market-clearing conditions are given by the respective quantity and price equilibrium conditions. For meat exporters, the quantity clearing equation is given as:

(3) $$Q_{ij}^{s*} = \tau_{ijj} Q_{ijj}^{d*} + \sum_{k \neq j}^{K} \lambda_{ijk} Q_{ijk}^{d*}$$

where Q_{ijj}^{d*} is the percentage of change in the quantity of meat *i* from country *j* that is demanded in the supplying country *j* (from its own source domestically produced), Q_{ijk}^{d*} is the percentage of change in the quantity of meat *i* from country *j* that is demanded in country *k* (exported by country *j* to country *k* or foreign demand), , $\tau_{ijj} = Q_{ijj}^{d} / Q_{ij}^{s}$ and it is the ratio between the quantity of meat *i* from country *j* that is demanded in the supplying country *j* (Q_{ijj}^{d}) and the quantity supplied of meat *i* from country *j* (Q_{ij}^{s}), $\lambda_{ijk} = Q_{ijk}^{d} / Q_{ij}^{s}$, and it is the ratio between the quantity of meat *i* from country *j* that is demanded in the importing country *k* (Q_{ijk}^{d}) and the quantity of meat *i* supplied from country *j* (Q_{ij}^{s}); and the other variables are as previously defined.

For meat importers, the quantity clearing equation is given as:

(4) $$Q_{ijk}^{s*} = Q_{ijk}^{d*}$$

Q_{ijk}^{s*} is the percentage of change in the quantity of meat of type *i* supplied from country *j* to the consuming country *k*. The percentage of change in the quantity supplied, Q_{ijk}^{s*}, and the quantity demanded, Q_{ijk}^{d*}, corresponds to the domestically produced meats and foreign produced meats when $j = k$ and $j \neq k$, respectively.

Given the farm supply and retail demand equations, the retail demand and farm supply equations can be linked with retail-farm price equations to ensure equilibrium across the two vertical channels. Following Sexton (2000), and Sexton and Zhang (2001), the retail-farm price linkage equations when allowing for imperfect competition at the middle stage (processors-retailers) of the marketing chain is given as follows:

(5) $$P_{ijk}^{d*}(1+\frac{\xi}{\eta_{ijk}}) = P_{ij}^{s*}\delta_{ijk}(1+\frac{\theta}{\varepsilon_{ij}}) - \upsilon_{ijk}$$

where P_{ijk}^{d*} is the percentage of change in the price of meat *i* from country *j* demanded in country *k*, η_{ijk} is the own-price demand elasticity of meat *i* from country *j* demanded in country *k*, ε_{ij} is the own-price supply elasticity of meat *i* supplied from country *j*, ξ and θ are market conduct parameters (conjectural elasticities), which measure the extent of retailer marketing power. ξ measures the departure from competition in selling the finished product at the retail level, with $\xi = 0$ denoting perfect competition (the retailers do not have market power in selling the finished product), $\xi = 1$ denoting pure monopoly, and $\xi \in [0,1]$ denoting various degrees of oligopoly market power, where high values denote greater departure from competition, θ measures retailers' departures from competition in buying the farm product, with $\theta = 0$ denoting perfect competition (the retailers do not have market power in buying the farm product), $\theta = 1$ denoting pure monopsony, and $\theta \in [0,1]$ denoting various degrees of oligopsony market power, where high values denote greater departure from competition, and $\delta_{ijk} = P_{ij}^{s} / P_{ijk}^{d}$ is the ratio between the supply price of meat *i* from country *j* and the demand price of meat *i* from country *j* demanded in country *k*, and the other variables are as previously defined.

Parameters Used in the Model

The parameter values assigned to the model are: own-price and cross-price demand elasticities (η), own-price supply elasticities (ε), quantity proportions (τ) and (λ), price proportions (δ), and the market conduct parameters, [conjectural elasticities, (ξ and θ)]. The own-price and cross-price demand elasticities (η) were estimated using a restricted source differentiated almost ideal demand system (RSDAIDS). The estimated demand elasticities reflect conditional elasticities since the RSDAIDS model is a complete demand system, which assumes weak separability between meats and other goods. Therefore, the estimated demand elasticities were converted into unconditional demand elasticities (Edgerton 1997; and Fan, Wailes, and Cramer 1995).

Rather than attempting to estimate the own-price supply elasticities (ε) for meats supplied from different sources, this study relies on pre-existing estimates of own-price supply elasticities reported in the literature (Lusk and Anderson 2004; Wohlgenant 1993; and others). This approach is taken because the literature has credible estimates of own-price supply elasticities for the meat-supplying countries considered in this study. The quantity proportions (τ) and (λ) and the price proportions (δ) were calculated using the respective 2002 quantities and prices. To save space, the parameter values assigned to the model are not presented here; however, they can be obtained from the authors upon request. Following Zhang (2005), this study uses the value of 0.03 as retailer oligopsony market power (θ).

Simulation Methods and Welfare Measures

Once the parameters needed in the demand and supply equations (1) and (2), and in the equilibrium conditions equations (3) through (5) are assigned, the values of variables with asterisks can be calculated by solving the equations simultaneously. In matrix notation, equations (1-5) can be written as:

(6) $$\mathbf{A} \times \mathbf{Y} = \mathbf{B}$$

where $\mathbf{A}$ is a vector of parameters of endogenous variables in equations (1-5), $\mathbf{Y}$ is a vector of changes in endogenous variables, and $\mathbf{B}$ is a vector of the parameter of exogenous shifters. In this study, equation (6) is a matrix of 164×164. Relative changes in endogenous variables $\mathbf{Y}$ caused by relative changes in exogenous supply and demand shifters are calculated by solving equation (7).

(7) $$\mathbf{Y} = \mathbf{A}^{-1} \times \mathbf{B}$$

The model was simulated in Excel. An equivalent model was also written in SAS software and used to verify the accuracy of the Excel simulation. Once the values of $\mathbf{Y}$ have been determined by solving equation (7), the changes in producer surplus can be calculated. Changes in producer surplus at farm and retail levels in the case of parallel shifts are calculated from Wohlgenant (1993) (equation 10, p. 645) as follows:

(8) $$\Delta PS_{ij} = P_{ij}^{s} Q_{ij}^{s} (P_{ij}^{s*} + \gamma_{ij})(1 + 0.5 Q_{ij}^{s*}) \text{ (producer surplus at farm level)}$$

(9) $$\Delta PS_{ijk} = P_{ijk}^{d} Q_{ijk}^{d} (P_{ijk}^{d*} + \nu_{ijk})(1 + 0.5 Q_{ijk}^{d*}) \text{ (producer surplus at retail level)}$$

where ΔPS_{ij} is the change in farm producer surplus of meat *i* from country *j*, ΔPS_{ijk} is the change in retail producer surplus of meat *i* from country *j* demanded in country *k*, and the other variables are as previously defined.

Methods of Simulating Beef and Pork Promotions

The model described above is used to simulate the welfare impact of beef and pork promotions. The model is simulated by simultaneously shifting the supply and demand curves for U.S. beef and pork using 2002 average prices and quantities, and assuming perfect competition and retailer oligopsony market power. U.S. beef and pork supply curves are shifted to the left because in order to finance beef and pork promotions, U.S. beef and pork farmers have to pay additional costs through beef and pork check-off programs. To translate these costs into the percentage cost shifts (γ) required in the model, revenues from mandatory assessment under beef and pork check-off programs are divided by the respective total farm revenues for each industry (Lusk and Anderson 2004). In 2002, beef and pork check-off programs generated $35.7 million and $27.4 million respectively (USDA-ERS 2005). In the same period, the total farm revenues for cattle and hogs were $17,437 million and $6,860 million, respectively. Dividing the mandatory assessment of each check-off program by its respective farm revenue shows that in 2002, promotion increased farm production costs by 0.2% and 0.4% in the beef and pork industries, respectively. Therefore, shocks on U.S. beef and pork farm supply are induced by entering the corresponding shifters ($\gamma = 0.2\%$ for beef and $\gamma = 0.4\%$ for pork) in the farm supply equation [equation (2)]. The farm supply shifters are entered as negative numbers to represent added costs to the system.

On the demand side, the estimated demand shifter parameters of impact of generic advertising on beef and pork demands are mixed. Some studies find the parameters to be positive and statistically significant (Ward and Lambert 1993) while others find the parameters to be insignificant and fragile (Brester and Schroeder 1995; and Kinnucan et al 1997). Studies that have estimated the welfare impacts of beef and pork promotions have used demand shifter parameters that range from 0.05% to 5.7% for beef (Kinnucan 2003; and Wohlgenant 1993) and from 0% to 4.5% for pork (Kinnucan, Xiao, and Hsia 1996; and Wohlgenant 1993). With this data in mind, the higher estimates used by Wohlgenant (1993) are used here so that our results can be comparable to his. Therefore, shocks on demand for U.S. beef and pork are induced by entering the corresponding shifters ($w = 5.7\%$ for beef and $w = 4.5\%$ for pork) in the retail demand equation [equation (1)]. The demand shifters are entered as a positive number to represent consumer willingness to pay for the initial quantity of meat due to promotion.

Methods of Simulating the Welfare Impacts of COOL

The model described above is also used to simulate the welfare impacts of COOL. The additional parameters needed to estimate welfare impacts of COOL are supply and demand shifters. Supply shifters reflect a decrease in the beef and pork supply due to implementation of COOL while demand shifters reflect an increase in the demand for U.S. beef and pork after implementing COOL.

Regarding farm supply shifters, the assumption is that COOL costs are borne by U.S. beef and pork producers and foreign producers bear none of the costs associated with COOL. Implementation of COOL is reported to decrease the farm supply of U.S. beef within a range from 0.5% to 6.5% and the farm supply of U.S. pork within a range from 0.25% to 3% (Lusk and Anderson 2004). In this study, we use the medium values of 3% and 1% reported by Lusk and Anderson (2004) as farm supply shifters of U.S. beef and pork, respectively. Using the 2002 average farm revenues for beef and pork, 3% and 1%, decreases in farm supply for beef and pork correspond to total COOL costs of $17,436.9 million for beef and $68.8 million for pork. These costs fall within the range of COOL costs estimated by VanSickle et al. (2003) and Sparks Companies, Inc (2003).

The supply shifters at the retail level are computed by dividing the COOL costs reported above by the respective retail revenues. Using this method, retail supply shifters for beef and pork are 1.73% and 0.36%, respectively. Each meat product that is marketed in the U.S. bears a cost proportional to its aggregate share of the market. Table 1 presents the supply shifters of each meat product under the examined possibilities of cost incidence. Four alternatives are examined for incidence of costs: (a) all costs are borne by U.S. meat producers; (b) the costs are equally divided between U.S. meat producers and retailers; (c) one-fourth of the costs are borne by U.S. meat producers and three-fourths of the costs are borne by retailers; and (d) all costs are borne by retailers. The farm and retail supply shifters are entered as negative numbers in the farm supply equation [equation (2)] and the retail supply equation [equation (5)] to represent added costs to the system.

Following Lusk and Anderson (2004), on the demand side, three scenarios of increases in demand for both U.S. beef and pork in the U.S. domestic market are examined: (a) no demand increase; (b) 2% increases in demand for beef and pork; and (c) 5% increases in demand for beef and pork. The demand shifters are entered as a positive number in the retail demand equation [equation (1)] to represent consumer willingness to pay for the initial quantity of meat due to the new labeling policy. The model is simulated by simultaneously shifting the supply and demand curves for beef and pork using 2002 average prices and quantities under both competitive markets and some degree of retailer oligopsony market power, i.e. $\theta = 0.03$.

Methods of Simulating Japanese and South Korean Bans on U.S. Beef

The model described above is used to simulate the welfare impacts of the Japanese and South Korean bans on U.S. beef. The Japanese and South Korean bans on U.S. beef are imposed by shifting the Japanese and South Korean demands for U.S. beef so that the change in quantity demanded for U.S. beef in Japan and South Korea decreases by 100 percent.

Using Excel solver, percentage decreases in demand for U.S. beef in Japan and South Korea that yield a 100-percent decrease in the percentage change of quantity demanded of U.S. beef in Japan and South Korea are estimated. The solver results indicate that to have a ban on

U.S. beef in Japan and South Korea, the demands for U.S. beef in Japan and South Korea should decrease by 466 percent and 825 percent, respectively. Therefore, the Japanese and South Korean bans on U.S. beef are simulated by shifting the equations of the Japanese and South Korean demands for U.S. beef [equation (1)] by 466 percent and 825 percent, respectively. Three ban alternatives are examined: (a) the Japanese ban on U.S. beef; (b) the South Korean ban on U.S. beef; and (c) both the Japanese and South Korean bans on U.S. beef. The model is simulated using 2002 average prices and quantities.

Results

The equilibrium displacement model is used to estimate the welfare impacts of selected supply and demand shocks. Specifically, the welfare impacts of beef and pork promotions, COOL, and Japanese and South Korean bans on U.S. beef are presented.

Welfare Impacts of Beef and Pork Promotions

The estimated welfare impacts of beef and pork promotions are presented in table 2. The results show that beef and pork promotions increase producer surplus for producers and marketers of U.S. beef and pork and decrease producer surplus for producers and marketers of U.S. poultry (table 2, scenario I). Wohlgenant (1993) also reports a positive impact of beef and pork promotions on U.S. beef and pork producers.

Moreover, the results indicate that although pork has a larger supply decrease ($\gamma = 0.4\%$) and a lower demand increase ($w = 4.5\%$) than beef ($\gamma = 0.2\%$ and $w = 5.7\%$), producers and marketers of U.S. pork benefit more from beef and pork promotions than producers and marketers of U.S. beef (table 2, scenario I). Economic theory suggests that under a demand increase (such as a demand increase due to promotion), the change in producer surplus is high if the own-price supply elasticity is less than the absolute value of the respective own-price demand elasticity. Therefore, a difference in the magnitude of own-price supply and demand elasticities of U.S. beef and pork may explain the results. Following Wohlgenant (1993), the model is simulated using lower values of U.S. beef and pork own-price supply elasticities than the respective own-price demand elasticities. The results, which are presented in table 2 (scenario II), show that similar to Wohlgenant (1993), producer and marketers of U.S. beef gain more from promotion than producers and marketers of U.S. pork.

The magnitudes of the estimated impact of beef and pork promotions on U.S. beef and pork producers reported in table 2 are lower than those reported by Wohlgenant (1993). The difference might be due to the additional 10-percent reduction in the production costs of U.S. beef and pork assumed in Wohlgenant's (1993) study. Therefore, the model is simulated assuming also a 10-percent decrease in the production costs for beef and pork. The results show \$1.84 billion and \$0.94 billion as a change in the producer surplus of U.S. beef and pork producers, respectively. These results are higher than \$1.58 billion and \$0.28 billion of change in producer surplus of U.S. beef and pork producers reported by Wohlgenant (1993). Hence, these results show that as economic theory predicts, adding export promotion increases the change in producer surplus of U.S. beef and pork producers.

Finally, consistent with economic theory, the results show that retailer oligopsony market power reduces the welfare of U.S. meat producers and increase the welfare of retailers of U.S. meats (table 2, scenario II). For example, the change in farmers' producer surplus for the overall meat industry decreases from \$1,122.92 million in a competitive market to \$1,079.38 million under retailer oligopsony market power; while the change in U.S. retailers' producer surplus increases from \$1,090.10 million in a competitive market to \$1,113.31 million under retailer oligopsony market power (table 2, scenario II). The retailer oligopsony market power seems to affect the allocation of gains from beef and pork promotions. More importantly, retailer oligopsony market power seems to be more likely to decrease the total welfare of the U.S. meat industry. For instance, the total meat industry producer surplus (the sum of producer surplus in the meat industry) decreases from $2,295.71 under a competitive scenario to $2,277.35 under retailer oligopsony market power (table 2, scenario II).

Welfare Impacts of COOL

This section discusses the major results of impacts of COOL on U.S. meat producers and compares the results with those reported by Lusk and Anderson (2004). The estimated impacts of COOL on U.S. meat producers under the assumption of no-demand change are presented in table 3. The results indicate that implementation of COOL decreases producer surplus of U.S. beef and pork producers and increases producer surplus of U.S. poultry producers regardless of who pays for the costs of COOL. U.S. beef and pork producers lose from COOL implementation when they pay all the costs of COOL because beef and pork demands must increase to make the producer surplus neutral (Lusk and Anderson 2004). In addition, U.S. beef and pork producers lose from COOL when all COOL costs are borne by retailers. This result is because the absolute value of the own-price demand elasticities for beef and pork are greater than the elasticity of substitution between farm product and market input (fixed proportion technology) (Lusk and Anderson 2004). Poultry producers gain from COOL because COOL does not add additional costs to producing poultry and consequently consumers substitute away from relatively more expensive beef and pork to less expensive poultry.

Similar to Lusk and Anderson (2004), the results of this study show that producer surplus of U.S. beef and pork producers increases when COOL costs are increasingly borne by retailers. Different from Lusk and Anderson (2004), the results of this study also show that when COOL costs are increasingly borne by retailers, producer surplus of U.S. poultry producers decreases. This result is not because retail COOL costs decrease the retail supply of poultry *per se*, but because of the complementary relationships between U.S. poultry and other meat products covered by COOL. The model is simulated using only positive cross-price elasticities between U.S. poultry and other meat products covered by COOL. The results, which are presented in table 3 (scenario II) indicate that similar to beef and pork, poultry producers are better off when COOL costs are increasingly borne by retailers.

Furthermore, the results presented in table 3 (scenario I) show that retailer oligopsony market power decreases the producer surplus of U.S. beef and pork producers. However, different from what is expected from economic theory, results presented in table 3 (scenario I) also show that poultry producers gain from retailer oligopsony market power. This result does not mean that retailer oligopsony market power benefits poultry producers *per se*; but the difference in own-price supply and demand elasticities might explain the unexpected result. A one-sector model (a model, which ignores substitutability between meats at retail level and international trade) is used to examine the change in producer surplus when there is retailer oligopsony market power. The derivations produce the following equation.

(10) $$\Delta PS_i = \frac{\varepsilon_i \gamma_i + \eta_i \nu_i + \eta_i \varpi_i}{\eta_i \delta_i (1 + \frac{\theta_i}{\varepsilon_i}) - \varepsilon_i}$$

where ΔPS_i is the change in producer surplus of meat *i*, η_i is the own-price demand elasticity of meat *i*, ν_i is the retail supply shifter for meat *i*, ε_i is the own-price supply elasticity of meat *i*, δ_i is the farm share of retail dollar for meat *i*, θ_i is the retailer oligopsony market power parameter for meat *i*, γ_i is the farm supply shifter of meat *i*, and ϖ_i is retail demand shifter of meat *i*.

According to equation (10), a change in producer surplus depends on own-price demand and supply elasticities, retail and farm supply shifters, a retail demand shifter, a retailer oligopsony market power parameter, and a farm share of the retail dollar. Examining the denominator of equation (10), the observation is that if the own-price demand elasticity is lower (in absolute value) than the own-price supply elasticity, the change in producer surplus should tend to increase. Therefore, poultry producers might be gaining from retailer oligopsony market power because the own-price supply elasticity of U.S. poultry is higher than the respective absolute value of own-price demand elasticity. The model is simulated with greater (in absolute value) own-price demand elasticity for U.S. poultry than the respective own-price supply elasticity. Estimated results, which are presented in table 3, scenario III, indicate that consistent with economic theory, producer surplus of U.S. poultry producers decreases when retailers have oligopsony market power.

Finally, the assumptions related to a demand increase clearly affect the estimated welfare impacts (table 4). If the demands for beef and pork increase by at least two percent, poultry producers do not benefit from COOL (table 4). Poultry producers lose when beef and pork demands increase by at least two percent because consumers will increase their demand for beef and pork products and consequently negatively affect the demand for poultry. Although a two percent increase in the demand for beef and pork increases the producer surplus of U.S. pork producers, it does not increase the producer surplus of U.S. beef producers (table 4). Pork producers benefit and beef producers lose when a two percent increase in beef and pork demands occurs because COOL costs for pork are relatively lower than COOL costs for beef. However, if beef and pork demands increase by five percent, both beef and pork producers benefit from COOL (table 4).

The results obtained in this study are similar to results reported by Lusk and Anderson (2004). Both studies find that under no-demand increase, poultry producers benefit from COOL while beef and pork producers lose from COOL. Moreover, both studies find that if the demands for beef and pork increase by five percent, beef and pork producers benefit from COOL while poultry producers lose from COOL. However, some results obtained in this study are different from those reported by Lusk and Anderson (2004). This study finds that under no-demand increase, beef and pork producers lose from COOL regardless of who pays the costs of COOL. However, Lusk and Anderson (2004) report that under no-demand increase, 50/50 and 25/75 cost shares between U.S. meat producers and marketers increase the producer surplus of U.S. pork and beef producers. A difference in the elasticity of substitutions between market input and farm product used in the two studies explains the difference in the results.

More importantly, different from results reported by Lusk and Anderson (2004), this study finds that meat producers as a whole lose from the implementation of COOL even under two and five percent increases in demands for beef and pork (table 4). A difference in the magnitude between own-price supply and demand elasticities may explain the differences in the results. Different from this study, Lusk and Anderson (2004) used a model in which own-price supply elasticities of U.S. beef and pork are lower compared to the respective absolute value of own-price demand elasticities. Following Lusk and Anderson (2004), the model is simulated using relatively low own-price supply elasticities for beef and pork compared to the respective absolute values of own-price demand elasticities. The results, which are presented in table 5, indicate that similar to results reported by Lusk and Anderson (2004), two and five percent increases in demands for beef and pork benefits U.S. beef and pork producers and the whole U.S. meat industry.

The results of this study also show that under no-demand increase and all COOL cost being paid by producers, the negative impacts of COOL on U.S. beef and pork producers are largely lower compared to results reported by Lusk and Anderson (2004). Lusk and Anderson (2004) also found a lower negative impact of COOL on beef and pork producers under a model with U.S. meat imports compared to a model without trade. Therefore, these results suggest that models without trade might overestimate the negative impacts of COOL on U.S. beef and pork producers.

Welfare Implications of the Japanese and South Korean Bans on U.S. beef

As an extension from previous models, the model developed in this study is able to estimate the welfare impacts of animal disease-driven bans on meat from a specific source of origin. Table 6 presents the results of welfare impacts of Japanese and South Korean bans of U.S. beef on producers and marketers of U.S., Australian, Japanese, and South Korean beef. Concerning the Japanese ban on U.S. beef, the results show that the ban decreases the producer surplus of producers and marketers of U.S. beef and increases producer surplus of producers and marketers of Australian and Japanese beef (table 6 scenario, I).

The producer surplus of producers and marketers of U.S. beef decreases because as the major U.S. beef importer stops importing U.S. beef, the quantities of U.S. beef available in the U.S. domestic market and in other U.S. export markets increase. The increase in quantities of U.S. beef will tend to decrease the U.S. beef price, which leads to a decrease in producer surplus of producers and marketers of U.S. beef. The producer surplus of producers and marketers of Japanese and Australian beef increases because the shares of beef from these sources in the Japanese market increase as Japanese consumers substitute the non-existent U.S. beef with Japanese and Australian beef.

Regarding the South Korean ban on U.S. beef, the results show that the ban decreases producer surplus of U.S., Australian, and South Korean beef farmers (table 6 scenario, I). The reduction of producer surplus of Australian and South Korean beef farmers is an unexpected result. Complementary relationships between U.S. beef and Australian beef in the South Korean meat market might explain the result. Therefore, the cross-price elasticities between U.S. beef and Australian beef (-0.123 and -0.253) are changed to positive values (substitution relationship). The model is simulated and the results are presented in table 6, scenario II. The results indicate that similar to the Japanese ban on U.S. beef, the South Korean ban on U.S. beef decreases producer surplus of producers and marketers of U.S. beef and increases producer surplus of producers and marketers of Australian and South Korean beef. Finally, the results indicate that when both Japan and South Korea ban U.S. beef, producers and marketers of U.S. beef lose more while the producers and marketers of Australian, Japanese, and South Korean beef gain more compared to single ban (table 6 scenario, II).

Summary and Conclusions

This research is motivated by the lack of comprehensive partial equilibrium models, which can explain the impacts of demand and supply shocks on U.S. meat prices, quantities, and industry welfare. Previous models did not include the U.S. meat trade (imports and exports) with meats differentiated by supply source. Hence, those models were not able to evaluate the effects of U.S. non-price export promotion programs and trade barriers such as the disease driven international bans on U.S. beef. Different from past studies, this study builds an equilibrium displacement model, which includes U.S. produced meats, U.S. meat imports from major partners, and U.S. meat exports to major partners with meats differentiated by source of origin. More importantly, the model is flexible since it can simulate welfare impacts of supply and demand shocks, assuming either perfect or imperfect competition in the middle stage (processor-retailer) of the meat supply chain. The results indicate that the effectiveness of beef and pork promotion as well as the impacts of COOL vary according to the model used. The results indicate that while the benefits from beef and pork promotions are higher, the negative impacts of COOL are lower under a model with international trade than in a model without trade. More importantly, the model developed in this study is unique since it can estimate the welfare impacts of disease-driven international meat bans on meat producers and marketers.

Specially, as previously reported by Wohlgenant (1993) and others, this study finds that beef and pork promotions benefit U.S. meat industry, especially for producers and marketers of U.S. beef. More importantly, this study finds that beef and pork export promotions increase the positive impact of beef and pork promotions on the welfare of U.S. beef and pork producers. Consistent with economic theory, retailer oligopsony market power increases producer surplus of marketers of U.S. meats and decreases producer surplus of producers of U.S. meats. Similar to studies by Lusk and Anderson (2004) and Brester, Marsh, and Atwood (2004), implementation of COOL will not benefit the U.S. meat industry unless the implementation is accompanied by an increase in meat demand. Differentiating meats by source of origin and including both U.S. meat exports and imports decreases the negative impact of COOL on U.S. meat producers. For the Japanese and South Korean bans on U.S. beef, the conclusion is that consistent with economic theory, the Japanese and South Korean bans on U.S. beef reduce the welfare of producers and marketers of U.S. beef and increase the welfare of producers and marketers of other competing beef products. Finally, the results show that the negative impact of banning U.S. beef is greater under multiple bans (Japanese and South Korean bans) compared to a single ban.

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Table 1. COOL Supply Shifters for Different Meat Products

Meat Product	Share[1]	meat type shifter	meat product shifter
All Costs Borne by Producers (Farm level)			
U.S. fed beef	0.85	0.03	0.02550
U.S. nonfed beef	0.15	0.03	0.00450
U.S. Pork	1	0.01	0.01000
All Costs Borne by Marketers (Retail level)			
U.S. fed beef	0.776	0.017	0.01342
U.S. nonfed beef	0.137	0.017	0.00237
Beef from Australia	0.031	0.017	0.00053
Beef from Canada	0.032	0.017	0.00055
Beef from New Zealand	0.016	0.017	0.00028
Beef from the ROW	0.008	0.017	0.00014
Pork from the U.S.	0.947	0.004	0.00338
Pork from Canada	0.044	0.004	0.00016
Pork from the ROW	0.008	0.004	0.00003
Cost Share by Domestic Producers and Marketers (50/50)			
Producers (Farm Level)			
U.S. fed beef	0.85	0.015	0.01275
U.S. nonfed beef	0.15	0.015	0.00225
U.S. Pork	1	0.005	0.005
Marketers (Retail level)			
U.S. fed beef	0.776	0.009	0.00671
U.S. nonfed beef	0.137	0.009	0.00118
Beef from Australia	0.031	0.009	0.00027
Beef from Canada	0.032	0.009	0.00027
Beef from New Zealand	0.016	0.009	0.00014
Beef from the ROW	0.008	0.009	0.00007
Pork from the U.S.	0.947	0.002	0.00169
Pork from Canada	0.044	0.002	0.00008
Pork from the ROW	0.008	0.002	0.00002
Cost Share by Domestic Producers and Marketers (25/75)			
Producers (Farm Level)			
U.S. fed beef	0.85	0.0075	0.006375
U.S. nonfed beef	0.15	0.0075	0.001125
U.S. Pork	1	0.0025	0.0025
Marketers (Retail level)			
U.S. fed beef	0.776	0.01297	0.01006
U.S. nonfed beef	0.137	0.01297	0.00178
Beef from Australia	0.031	0.01297	0.00040
Beef from Canada	0.032	0.01297	0.00041
Beef from New Zealand	0.016	0.01297	0.00021
Beef from the ROW	0.008	0.01297	0.00011
Pork from the U.S.	0.947	0.00268	0.00254
Pork from Canada	0.044	0.00268	0.00012
Pork from the ROW	0.008	0.00268	0.00002

[1] Refers to the share of each meat product in the U.S. domestic market.

Table 2. Results of Welfare Impacts of Beef and Pork Promotions ($ millions)

Description	Beef	Pork	Poultry	Meat Industry
Scenario I				
Perfectly competitive market				
Change in producer surplus at farm level in the U.S.	270.09	342.59	-493.66	119.02
Change in producer surplus at retail level in the U.S.	265.79	340.74	-420.44	186.09
Change in producer surplus at retail level in Canada	2.16	2.36	-3.38	1.14
Change in producer surplus at retail level in Japan	6.56	10.83	-1.50	15.90
Change in producer surplus at retail level in Mexico	8.30	8.48	-11.37	5.41
Change in producer surplus at retail level in South Korea	5.78	0.62	-2.02	4.38
Total	558.68	705.62	-932.37	331.94
Retailer oligopsony Market Power (θ=0.03)				
Change in producer surplus at farm level in the U.S.	265.68	343.00	-503.92	104.76
Change in producer surplus at retail level in the U.S.	275.12	366.69	-448.95	192.86
Change in producer surplus at retail level in Canada	2.24	2.54	-3.61	1.17
Change in producer surplus at retail level in Japan	6.80	11.66	-1.60	16.86
Change in producer surplus at retail level in Mexico	8.56	9.14	-12.15	5.56
Change in producer surplus at retail level in South Korea	6.00	0.66	-2.15	4.51
Total	564.40	733.69	-972.38	325.72
Scenario II				
Perfectly competitive market				
Change in producer surplus at farm level in the U.S.	877.61	501.49	-256.17	1,122.92
Change in producer surplus at retail level in the U.S.	821.27	487.46	-218.63	1,090.10
Change in producer surplus at retail level in Canada	5.66	3.35	-1.72	7.29
Change in producer surplus at retail level in Japan	17.48	15.36	-0.77	32.07
Change in producer surplus at retail level in Mexico	21.99	11.92	-5.79	28.12
Change in producer surplus at retail level in South Korea	15.36	0.88	-1.03	15.21
Total	1,759.37	1,020.46	-484.11	2,295.71
Retailer oligopsony Market Power (θ=0.03)				
Change in producer surplus at farm level in the U.S.	854.86	482.92	-258.39	1,079.38
Change in producer surplus at retail level in the U.S.	838.41	505.60	-230.70	1,113.31
Change in producer surplus at retail level in Canada	5.79	3.48	-1.82	7.45
Change in producer surplus at retail level in Japan	17.86	15.94	-0.81	33.00
Change in producer surplus at retail level in Mexico	22.42	12.37	-6.11	28.68
Change in producer surplus at retail level in South Korea	15.71	0.91	-1.08	15.53
Total	1,755.05	1,021.22	-498.91	2,277.35

Notes: Scenario I uses the base model parameter values. Under Scenario II, the own-price demand elasticity for fed beef, nonfed beef, and U.S. pork in the U.S. domestic market are set to be -1.357, -2.178, and -1.207, respectively.

Table 3. Results of Welfare Impacts of COOL ($ millions)

Description	All Costs Borne by Domestic Producers	Cost Shared by Domestic Producers and Marketers		All Costs Borne by Marketers
		50/50	25/75	
Scenario I				
No Demand Change				
Perfectly competitive market				
Change in U.S. beef producer surplus	-90.75	-75.73	-68.21	-60.69
Change in U.S. pork producer surplus	-35.67	-32.68	-31.18	-29.69
Change in U.S. poultry producer surplus	76.29	73.81	72.57	71.34
Retailer Oligopsony Power (θ=0.03)				
Change in U.S. beef producer surplus	-94.02	-76.85	-68.26	-59.66
Change in U.S. pork producer surplus	-37.53	-33.66	-31.72	-29.78
Change in U.S. poultry producer surplus	79.57	75.86	74.00	72.14
Scenario II				
No Demand Change				
Perfectly competitive market				
Change in U.S. beef producer surplus	-89.40	-74.17	-66.55	-58.93
Change in U.S. pork producer surplus	-37.62	-34.92	-33.57	-32.22
Change in U.S. poultry producer surplus	124.66	129.42	131.80	134.18
Retailer Oligopsony Market Power (θ=0.03)				
Change in U.S. beef producer surplus	-92.54	-75.21	-66.54	-57.86
Change in U.S. pork producer surplus	-39.60	-35.95	-34.12	-32.30
Change in U.S. poultry producer surplus	128.83	130.47	131.29	132.11
Scenario III				
No Demand Change				
Perfectly competitive market				
Change in U.S. beef producer surplus	-88.84	-73.59	-65.96	-58.33
Change in U.S. pork producer surplus	-38.42	-35.76	-34.42	-33.09
Change in U.S. poultry producer surplus	144.21	149.70	152.44	155.19
Retailer Oligopsony Market Power (θ=0.03)				
Change in U.S. beef producer surplus	-92.48	-75.15	-66.48	-57.81
Change in U.S. pork producer surplus	-40.28	-36.64	-34.82	-33.00
Change in U.S. poultry producer surplus	142.43	144.24	145.14	146.05

Notes: Scenario I uses the base model parameter values. Under scenario II, the negative values of cross-price elasticities between U.S. poultry and U.S. pork; U.S. poultry and Canadian pork; and U.S. poultry and ROW pork in the U.S. domestic market are changed from their original values of -0.648, -0.887, and -0.892, respectively to 1.648, 1.88, and 1.892, respectively. Under scenario III, in addition to scenario II, the own-price U.S. poultry supply elasticity is changed from 0.65 to 0.3, and the own-price U.S. poultry demand elasticity is changed from -0.005 to -0.8.

Table 4. Results of Welfare Impacts of COOL ($ millions)

Description	All Costs Borne by Domestic Producers	Cost Shared by Domestic Producers and Marketers		All Costs Borne by Marketers
		50/50	25/75	
Two Percent Demand Increase for Beef and Pork				
Perfectly competitive market				
Change in U.S. beef producer surplus	-44.36	-29.31	-21.78	-14.24
Change in U.S. pork producer surplus	50.69	53.69	55.20	56.70
Change in U.S. poultry producer surplus	-53.06	-55.51	-56.74	-57.96
Total	-46.73	-31.13	-23.32	-15.50
Retailer Oligopsony Power (θ=0.03)				
Change in U.S. beef producer surplus	-48.45	-31.24	-22.64	-14.03
Change in U.S. pork producer surplus	47.70	51.60	53.55	55.50
Change in U.S. poultry producer surplus	-51.48	-55.16	-57.00	-58.84
Total	-52.23	-34.80	-26.09	-17.37
Five Percent Demand Increase for Beef and Pork				
Perfectly competitive market				
Change in U.S. beef producer surplus	25.38	40.48	48.03	55.59
Change in U.S. pork producer surplus	181.04	184.06	185.58	187.09
Change in U.S. poultry producer surplus	-244.55	-246.97	-248.17	-249.38
Total	-38.13	-22.43	-14.56	-6.70
Retailer Oligopsony Power (θ=0.03)				
Change in U.S. beef producer surplus	20.07	37.32	45.95	54.58
Change in U.S. pork producer surplus	176.35	180.27	182.24	184.20
Change in U.S. poultry producer surplus	-245.47	-249.09	-250.90	-252.71
Total	-49.05	-31.50	-22.71	-13.93

Table 5. Results of Welfare Impacts of COOL ($ millions)

Description	All Costs Borne by Domestic Producers	Cost Shared by Domestic Producers and Marketers		All Costs Borne by Marketers
		50/50	25/75	
No Demand Change				
Perfectly competitive market				
Change in U.S. beef producer surplus	-218.58	-201.40	-192.81	-184.21
Change in U.S. pork producer surplus	-40.99	-39.09	-38.13	-37.18
Change in U.S. poultry producer surplus	32.32	31.16	30.58	30.00
Total	-227.25	-209.33	-200.36	-191.39
Two Percent Demand Increase for Beef and Pork				
Perfectly competitive market				
Change in U.S. beef producer surplus	58.92	76.26	84.94	93.62
Change in U.S. pork producer surplus	155.55	157.48	158.45	159.41
Change in U.S. poultry producer surplus	-23.39	-24.55	-25.12	-25.70
Total	191.08	209.19	218.27	227.33
Five Percent Demand Increase for Beef and Pork				
Perfectly competitive market				
Change in U.S. beef producer surplus	480.89	498.47	507.27	516.08
Change in U.S. pork producer surplus	454.57	456.53	457.51	458.49
Change in U.S. poultry producer surplus	-106.48	-107.63	-108.21	-108.78
Total	828.98	847.37	856.57	865.79

Note: The own-price demand elasticities for U.S. fed beef, U.S. nonfed beef, U.S. pork, and U.S. poultry are changed from -0.357, -0.170, -0.207, and -0.005 to -1.357, -2.178, -1.207, and -0.33, respectively.

Table 6. Results of Welfare Impacts of Japanese and South Korean Bans on U.S. Beef ($ millions)

Description	Japanese Ban	South Korean Ban	Both Japanese and South Korean Ban
	Producer Surplus	Producer Surplus	Producer Surplus
Scenario I			
Farm Level			
Change in U.S. beef producer surplus	-220.62	-375.71	-593.12
Change in Australian beef producer surplus	196.10	-183.95	-2.51
Change in Japanese beef producer surplus	2,703.82		2767.79
Change in South Korean beef producer surplus		-18.25	27.33
Retail Level			
Change in U.S. beef producer surplus in the U.S.	-199.23	-340.74	-541.52
Change in U.S. beef producer surplus in Canada	-1.48	-2.60	-4.05
Change in U.S. beef producer surplus in Japan	-2.37	-8.73	-6.39
Change in U.S. beef producer surplus in Mexico	-6.78	-9.74	-17.71
Change in U.S. beef producer surplus in South Korea	-4.29	-3.59	-5.92
Change in Australian beef producer surplus in Japan	25.99		-0.35
Change in Australian beef producer surplus in S. Korea		0.07	0.002
Change in Japanese beef producer surplus in Japan	2,704.68		2,768.67
Change in producer surplus of South Korean beef		-18.25	27.34
Scenario II			
Farm Level			
Change in U.S. beef producer surplus	-217.03	-351.23	-565.31
Change in Australian beef producer surplus	195.79	204.77	415.62
Change in Japanese beef producer surplus	2,703.79		2,681.93
Change in South Korean beef producer surplus		14.45	60.59
Retailer Level			
Change in U.S. beef producer surplus in the U.S.	-195.97	-317.84	-514.96
Change in U.S. beef producer surplus in Canada	-1.46	-2.42	-3.84
Change in U.S. beef producer surplus in Japan	-2.33	-7.60	-6.17
Change in U.S. beef producer surplus in Mexico	-6.67	-9.74	-17.91
Change in U.S. beef producer surplus in South Korea	-4.24	-3.38	-5.73
Change in Australian beef producer surplus in Japan	25.96		52.84
Change in Australian beef producer surplus in S. Korea		16.48	32.14
Change in Japanese beef producer surplus in Japan	2,704.65		2,682.79
Change in producer surplus of South Korean beef		14.45	60.59

Notes: Scenario I uses the base model parameters. Under scenario II, cross-price elasticities between U.S. beef and Australian beef and between Australian and U.S. beef are 0.123 and 0.253, respectively