Effects of Country of Origin Labeling in the U.S. Meat Industry with Imperfectly Competitive Processors

Chanjin Chung, Tong Zhang, and Derrell S. Peel

The study examines the impacts of implementing mandatory country of origin labeling (COOL) on producer and consumer welfare in the U.S. meat industry. The equilibrium displacement model developed in this study includes twenty-nine equations representing retail-, processing-, and farm-level equilibrium conditions for the beef, pork, and chicken industries. Unlike previous studies, the model allows trade between domestic- and foreign-origin products and considers the imperfectly competitive market structure of meat processers. Empirical results show that without a significant increase in domestic meat demand, producers are not expected to benefit from the mandatory COOL implementation. Results of a sensitivity analysis indicate that consumers tend to bear more COOL costs than producers, as the own-price elasticity becomes more inelastic, and that producers' benefits increase as the elasticity of domestic demand becomes more elastic with respect to the price of imported products. The existence of market power in upstream and downstream markets of processors negatively affects both consumer and producer surplus. One implication of our findings is that U.S. beef and pork producers' promotion and advertising programs would be successful in expanding domestic demand when the programs make the own-price elasticity of domestic demand more inelastic and the cross-price elasticity of domestic demand more elastic with respect to import price.

Key Words: checkoff, country of origin labeling, imperfect competition, price elasticity

The 2002 Farm Bill (PL 107-171) contained a country of origin labeling (COOL) provision that requires retailers to label the country of origin of the covered commodity, but implementation has been delayed twice by Congress. The 2008 Farm Bill (Food, Conservation, and Energy Act) made several changes to the COOL law, and the covered commodities now include whole muscle and ground products of beef, pork, chicken, lamb, and goat; seafood (wild and farm-raised fish and shell fish); fresh and frozen fruits and vegetables; peanuts, macadamia nuts, and pecans; and ginseng [see Preston and Kim (2009) for further discussion on the COOL law and USDA requirements].[1] Although the implementation of this provision is expected to affect U.S. agriculture and food industries and trade relations with neighboring countries significantly, there is still a great deal of uncertainty regarding the COOL effect.[2] Proponents of

Chanjin Chung and Derrell S. Peel are Professors in the Department of Agricultural Economics at Oklahoma State University in Stillwater, Oklahoma, and Tong Zhang is assistant professor in the Research Institute of Economics and Management at Southwestern University of Finance and Economics in Chengdu, China. This research was supported by the Oklahoma State University Agricultural Experiment Station and the USDA Cooperative State Research, Education & Extension Service, Hatch project #OKL02516.

1 COOL became law in the 2002 Farm Bill and was originally scheduled to become mandatory in 2004. The FY 2004 Consolidated Appropriations Act (PL 107-171) delayed mandatory implementation for most commodities until 2006. Mandatory COOL for seafood products was implemented in 2005. Another appropriations act in 2006 (PL 109-97) further delayed implementation of mandatory COOL until 2008. Several significant changes to the COOL law were made in the 2008 Farm Bill prior to implementation. USDA published the interim final rule on August 1, 2008, which has guided implementation pending publication of the final rule. The USDA Agricultural Marketing Service is expected to use the first six months of COOL implementation to focus on education and compliance rather than enforcement. The final rule for mandatory COOL was published in January 2009, but continued challenges by some groups and a possible review by the Obama administration perpetuate the uncertainty of COOL implementation.

2 Implementation of mandatory COOL for most products began on September 30, 2008 after years of discussion, controversy, modification, and delay. Even yet, challenges by some domestic producer groups and the recent WTO challenge by U.S. trade partners mean that uncertainty remains and additional modifications in COOL are likely in the future.

Agricultural and Resource Economics Review 38/3 (December 2009) 406–417

COOL claim that the new provision would increase the demand for U.S. agricultural products by promoting "Made in U.S.A." However, some producer groups such as the National Cattlemen's Beef Association (NCBA) and the National Pork Producers Council (NPPC) do not support mandatory COOL, expecting that the costs would outweigh the benefits. Packers and retailers are also concerned about the increased labor and infrastructure costs due to COOL requirements.

The objective of this research is to estimate the effects of the COOL policy in the U.S. meat industry. The study analyzes factors that affect the distribution of COOL costs between producers and consumers with consideration of market power and trade. An equilibrium displacement model (EDM) is developed with the variable proportion processing technology for the U.S. meat industry, which includes substitution relations between domestic and foreign products under imperfectly competitive market conditions at the processing level. The EDM is simulated to examine how mandatory COOL would affect livestock producers and meat consumers under alternative scenarios for own-price elasticity and cross-price elasticity between domestic and foreign products; for COOL costs; and for market power (processor's market power in both upstream and downstream markets). Under the proposed COOL policy, consumers will have substitution opportunities between two clearly differentiated products: domestic and foreign products, plus conventional substitutability among meat products.

Previous Research on COOL in the U.S. Meat Industry

COOL has been a moving target of proposed and revised requirements, which has made it difficult to understand what will be required and what the costs might be. The recently published final rule once again contains changes that, although relatively minor, have significant implications for costs to some industry sectors (Dunn and Gray 2008, Peel 2009). Although substantial research has been done to estimate the economic effects of COOL, most research has focused on estimating increased costs due to COOL requirements or on the consumer's willingness to pay for the country-of-origin labeled products. For example, Ernie Davis at Texas A&M University estimated $9 billion of total start-up costs for the beef industry (Smith 2003), while Sparks Companies, Inc. reported about $1.5 billion to $1.7 billion for beef and $452 million for pork (Sparks Companies, Inc. 2003). The USDA also put out its own estimate of $2 billion for the beef industry (USDA 2003). The low-end estimate comes from VanSickle et al. (2003), which ranges from $36 million to $132 million for the beef industry and $25 million to $32 million for the pork industry. Most of these estimates were based on earlier proposed regulations that were significantly more burdensome than those in the final rule, and thus the cost estimates are likely overstated.

Numerous studies have examined consumers' willingness to pay for COOL products. Loureiro and Umberger (2003) conducted a survey of 243 consumers in Colorado grocery stores during spring 2002. They found that Colorado consumers were willing to pay an average of 38 percent and 58 percent more for steak and hamburger labeled as "U.S. Certified Steak" and "U.S. Certified Hamburger," respectively, over the initial given prices. Another survey was conducted by Umberger et al. (2003) for consumers in Chicago and Denver, and they found that 73 percent of the consumers surveyed were willing to pay an 11 percent and 24 percent premium for steak and hamburger labeled with U.S. country of origin, respectively. The most commonly cited reasons by consumers for preferring COOL were: food safety concerns about imported beef; a preference for labeling source and origin information; a strong desire to support U.S. producers; and beliefs that U.S. beef is of higher quality. In a separate experiment by Umberger et al. (2003), consumers participated in an auction and bid on two steaks. One steak was labeled as "Guaranteed USA: Born and raised in the United States," and the other steak carried no label. On average, consumers were willing to pay a 19 percent premium for the steak labeled "Guaranteed USA: Born and raised in the United States."

A simple estimate of cost increases or consumers' willingness to pay could mislead the analysis of COOL effects because both cost increases and COOL premiums could be passed through the marketing channel, and the distribution of costs and benefits depend on various factors such as demand and supply elasticities, market structure, production technology, trade, and other factors. A few studies have estimated market-level welfare effects of COOL. Hayes and Meyer (2003) estimated the impact of COOL on the pork industry. Their study reports that, based on an own-price elasticity for pork of -0.7, their projected $10 per head increase in costs would result in a 7 percent decrease in the quantity of retail pork demanded, and U.S. exports could be reduced 50 percent by 2010 as a result of COOL regulation. Peel (2003) examined the impact of COOL on the Mexican beef cattle industry and on U.S and Mexican cattle and beef trade. The Peel study found that although Mexico had exported significant numbers of feeder cattle to the United States for many years, COOL would reduce cattle imports into the United States from Mexico significantly, resulting in increased availability of animals and increased fed beef production in Mexico. Specifically, Peel (2003) estimated that COOL would result in decreasing Mexican fed beef imports by 56,248 metric tons (12.2 percent decrease from the current imports) annually, lowering U.S. calf prices by $1.13/cwt., and decreasing feeder and fed cattle prices by 56 cents/cwt and 35 cents/cwt, respectively. The study indicated that COOL would potentially hurt U.S. beef producers due to a deteriorated U.S. and Mexican cattle and beef trade in the long run.

Lusk and Anderson (2004) considered horizontally linked beef, pork, and chicken demands as well as the vertical linkage of farm, wholesale, and retail sectors for their analysis of COOL effects. An equilibrium displacement model was developed for the market-level analysis, and results indicate that, as COOL costs are shifted from the producer to the processor and retailer, producers are increasingly better off while consumers are increasingly worse off. Producers are worse off if they have to pay any more than about one-fourth of the cost increase when there is no increased demand from COOL. At least a 2 percent to 3 percent increase in consumer demand is needed to achieve some level of producer benefits from COOL. An equilibrium displacement model framework was also developed by Brester, Marsh, and Atwood (2004) to examine short- and long-run effects of COOL in the U.S. beef, pork, and poultry industries. Results indicate that at least a one-time increase of 2.72 percent and 4.40 percent in consumer demand for beef and pork, respectively, is required to offset producer loss from COOL costs over a ten-year period. The two previous studies provide slightly different results because the results are specific to assumptions regarding demand and supply elasticities, production technologies at the processor level, and the size and distribution of COOL costs.

Although previous studies estimated the cost of COOL (Sparks Companies, Inc. 2003 and VanSickle et al. 2003); the willingness to pay (Loureiro and Umberger 2003, Umberger et al. 2003); and the market-level effects (Lusk and Anderson 2004, Brester, Marsh, and Atwood 2004) little is known about the effects of imperfect competition on the costs and benefits of COOL. The U.S. food industry has become more concentrated and imperfectly competitive in the last two decades. For example, the four-firm concentration ratio for the beef packing industry increased from 0.30 in 1978 to 0.86 in 2000 (Sexton 2000). The high concentration levels could allow packers to take advantage of oligopsony or oligopoly power by depressing cattle prices while boosting beef prices (Azzam and Schroeter 1995), and the processors' market power can be similarly applicable to the pork and chicken industries. Therefore, a reasonable expectation is that the packers' market power would affect the market-level effects of COOL.

Model

This study develops a Muth-type equilibrium displacement model that is able to estimate the impact of COOL on the meat production system and its trade relations. The model includes equilibrium conditions of each production stage, with considerations of trade and market conduct.

We consider a three-industry model in which two inputs, a farm input and a composite marketing input, are used in variable proportions under the constant returns to scale technology to produce two differentiated retail products: domestic and foreign. We assume that consumer demand is divided into domestic and foreign product demands under the proposed COOL policy. The model represents the beef, pork, and chicken industries horizontally, while it also reflects multiple stages of a vertical supply chain for each industry. The presence of market power at the processing level is also considered in this model in both downstream and upstream markets. COOL is expected to raise producers' (farmers and marketers) costs and consumers' willingness to pay for domestic beef and pork products. We do not expect that COOL will increase producers' costs in the chicken industry because all records are already well maintained at farm and processing levels due to the highly integrated industry. At the retail level also, no extra costs are expected for displaying domestic chicken separately from foreign-origin chicken because most chicken available in the market is domestic.[3] Likewise, no demand increase will occur due to implementing COOL.

Following Muth (1964) and Gardner (1975), our three-industry model for U.S. beef, pork, and chicken industries is represented in percentage changes as follows.[4]

Retail level

$$(1)\quad EQ^R_{BD} = \eta_{(BD,BD)}(EP^R_{BD} - E\delta_B) + \eta_{(BD,PD)}(EP^R_{PD} - E\delta_P) + \eta_{(BD,C)}EP^R_C + \eta_{(BD,BF)}EP^R_{BF} + \eta_{(BD,PF)}EP^R_{PF}$$

$$(2)\quad EQ^R_{BF} = \eta_{(BF,BD)}(EP^R_{BD} - E\delta_B) + \eta_{(BF,PD)}(EP^R_{PD} - E\delta_P) + \eta_{(BF,C)}EP^R_C + \eta_{(BF,BF)}EP^R_{BF} + \eta_{(BF,PF)}EP^R_{PF}$$

$$(3)\quad EQ^R_{PD} = \eta_{(PD,BD)}(EP^R_{BD} - E\delta_B) + \eta_{(PD,PD)}(EP^R_{PD} - E\delta_P) + \eta_{(PD,C)}EP^R_C + \eta_{(PD,BF)}EP^R_{BF} + \eta_{(PD,PF)}EP^R_{PF}$$

$$(4)\quad EQ^R_{PF} = \eta_{(PF,BD)}(EP^R_{BD} - E\delta_B) + \eta_{(PF,PD)}(EP^R_{PD} - E\delta_P) + \eta_{(PF,C)}EP^R_C + \eta_{(PF,BF)}EP^R_{BF} + \eta_{(PF,PF)}EP^R_{PF}$$

$$(5)\quad EQ^R_C = \eta_{(C,BD)}(EP^R_{BD} - E\delta_B) + \eta_{(C,PD)}(EP^R_{PD} - E\delta_P) + \eta_{(C,C)}EP^R_C + \eta_{(C,BF)}EP^R_{BF} + \eta_{(C,PF)}EP^R_{PF}$$

$$(6)\quad EQ^R_{BD} = \kappa_B EQ^F_{BD} + (1-\kappa_B)EQ^M_D$$

$$(7)\quad EQ^R_{BF} = \kappa_B EQ^F_{BF} + (1-\kappa_B)EQ^M_F$$

$$(8)\quad EQ^R_{PD} = \kappa_P EQ^F_{PD} + (1-\kappa_P)EQ^M_D$$

$$(9)\quad EQ^R_{PF} = \kappa_P EQ^F_{PF} + (1-\kappa_P)EQ^M_F$$

$$(10)\quad EQ^R_C = \kappa_C EQ^F_C + (1-\kappa_C)EQ^M_D$$

Farm level

$$(11)\quad EP^F_{BD} = EP^R_{BD} - \frac{1-\kappa_B}{\sigma_B}EQ^F_{BD} + \frac{1-\kappa_B}{\sigma_B}EQ^M_D + \eta_{B\psi}E\psi_B - \varepsilon_{B\Omega}E\Omega_B$$

$$(12)\quad EP^F_{BF} = EP^R_{BF} - \frac{1-\kappa_B}{\sigma_B}EQ^F_{BF} + \frac{1-\kappa_B}{\sigma_B}EQ^M_F + \eta_{B\psi}E\psi_B - \varepsilon_{B\Omega}E\Omega_B$$

$$(13)\quad EP^F_{PD} = EP^R_{PD} - \frac{1-\kappa_P}{\sigma_P}EQ^F_{PD} + \frac{1-\kappa_P}{\sigma_P}EQ^M_D + \eta_{P\psi}E\psi_P - \varepsilon_{P\Omega}E\Omega_P$$

$$(14)\quad EP^F_{PF} = EP^R_{PF} - \frac{1-\kappa_P}{\sigma_P}EQ^F_{PF} + \frac{1-\kappa_P}{\sigma_P}EQ^M_F + \eta_{P\psi}E\psi_P - \varepsilon_{P\Omega}E\Omega_P$$

$$(15)\quad EP^F_C = EP^R_C - \frac{1-\kappa_C}{\sigma_C}EQ^F_C + \frac{1-\kappa_C}{\sigma_C}EQ^M_D + \eta_{C\psi}E\psi_C - \varepsilon_{C\Omega}E\Omega_C$$

$$(16)\quad EQ^F_{BD} = \varepsilon^F_{BD}(EP^F_{BD} - E\mu_B)$$

$$(17)\quad EQ^F_{BF} = \varepsilon^F_{BF}(EP^F_{BD} - E\mu_B)$$

$$(18)\quad EQ^F_{PD} = \varepsilon^F_{PD}(EP^F_{PD} - E\mu_P)$$

$$(19)\quad EQ^F_{PF} = \varepsilon^F_{PF}(EP^F_{PF} - E\mu_P)$$

$$(20)\quad EQ^F_C = \varepsilon^F_C EP^F_C$$

[3] Meyer (2009) also claims that the cost of COOL should be minimal in the chicken industry because every bird is hatched, fed, and slaughtered in the United States, and every bird is owned by the same company.

[4] The current industry model could be generalized using a dynamic linear demand system by incorporating state variables as independent variables (see pp. 189-191, Phlips 1983).

Marketing Input

$$\text{(21)}\quad \mathrm{E}P_D^M + \frac{\mathrm{E}\gamma_B}{1-\kappa_B} = \mathrm{E}P_{BD}^R + \frac{\kappa_B}{\sigma_B}\mathrm{E}Q_{BD}^F - \frac{\kappa_B}{\sigma_B}\mathrm{E}Q_D^M + \eta_{B\psi}\mathrm{E}\psi_B$$

$$\text{(22)}\quad \mathrm{E}P_F^M + \frac{\mathrm{E}\gamma_B}{1-\kappa_B} = \mathrm{E}P_{BF}^R + \frac{\kappa_B}{\sigma_B}\mathrm{E}Q_{BF}^F - \frac{\kappa_B}{\sigma_B}\mathrm{E}Q_F^M + \eta_{B\psi}\mathrm{E}\psi_B$$

$$\text{(23)}\quad \mathrm{E}P_D^M + \frac{\mathrm{E}\gamma_P}{1-\kappa_P} = \mathrm{E}P_{PD}^R + \frac{\kappa_P}{\sigma_P}\mathrm{E}Q_{PD}^F - \frac{\kappa_P}{\sigma_P}\mathrm{E}Q_D^M + \eta_{P\psi}\mathrm{E}\psi_P$$

$$\text{(24)}\quad \mathrm{E}P_F^M + \frac{\mathrm{E}\gamma_P}{1-\kappa_P} = \mathrm{E}P_{PF}^R + \frac{\kappa_P}{\sigma_P}\mathrm{E}Q_{PF}^F - \frac{\kappa_P}{\sigma_P}\mathrm{E}Q_F^M + \eta_{P\psi}\mathrm{E}\psi_P$$

$$\text{(25)}\quad \mathrm{E}P_D^M = \mathrm{E}P_C^R + \frac{\kappa_C}{\sigma_C}\mathrm{E}Q_C^F - \frac{\kappa_C}{\sigma_C}\mathrm{E}Q_D^M + \eta_{C\psi}\mathrm{E}\psi_C$$

$$\text{(26)}\quad \mathrm{E}Q_D^M = \varepsilon_D^M(\mathrm{E}P_D^M - \frac{\mathrm{E}\gamma_i}{1-\kappa_i})$$

$$\text{(27)}\quad \mathrm{E}Q_F^M = \varepsilon_F^M(\mathrm{E}P_F^M - \frac{\mathrm{E}\gamma_i}{1-\kappa_i})$$

where $\mathrm{E}Q_{ij}^k$ and $\mathrm{E}P_{ij}^k$ are percentage changes in quantity and price of the i^{th} meat with j^{th} origin at the k^{th} level, respectively: $\mathrm{E}Q_{ij}^k = d\ln Q_{ij}^k \approx dQ_{ij}^k/Q_{ij}^k$. Superscripts R, F, and M denote retail, farm, and processing level, respectively; subscripts B, P, and C denote beef, pork, and chicken, respectively; and subscripts D and F denote domestic and foreign origins, respectively. Demand elasticities are represented by $\eta_{ij,ij}$ for all i and j. For example, $\eta_{BD,BD}$ is the retail level own-price elasticity of demand for domestic beef, while $\eta_{PF,BD}$ is the retail level cross-price elasticity of demand for foreign pork with respect to the domestic beef price. Supply elasticities are represented by ε_{ij}^k for all i and j at farm and processing levels; $\psi_i = \xi_i/\eta_{ij}$ (i = beef, pork, poultry; j= domestic, foreign) are the Lerner indexes that denote oligopoly power; ξ_i are the output conjectural elasticity ($\xi_i \in [0, 1]$, $\xi = 0$ for perfect competition and $\xi = 1$ for pure monopoly); $\Omega_i = \theta_i/\varepsilon_{ij}$ are the Lerner indexes to denote oligopsony power in j-th origin of industry i, where θ is the input conjectural elasticity ($\theta \in [0, 1]$, $\theta = 0$ for perfect competition and $\theta = 1$ for pure monopsony); $\kappa_i = s_i(1+\Omega_i)/(1-\psi_i)$, where κ_i and s_i are cost shares of farm input for the industry i, with and without consideration of oligopoly and oligopsony power; σ_i is the Hicks-Allen factor substitution elasticity for industry; and $\eta_{i\psi} = \psi_i/(1+\psi_i)$, $\varepsilon_{i\Omega} = \Omega_i/(1+\Omega_i)$ for each industry i.

Exogenous shocks to the system of equations are given by $\mathrm{E}\delta_i$, $\mathrm{E}\mu_i$, and $\mathrm{E}\gamma_i/(1-\kappa_i)$. $\mathrm{E}\delta_i$ represents the percentage in consumers' willingness to pay for the initial quantity of meat i due to the new labeling policy. $\mathrm{E}\mu_i$ and $\mathrm{E}\gamma_i/(1-\kappa_i)$ represent the exogenous cost increase in percentage terms for i-th domestic industry (beef and pork) at farm and processing levels, respectively. As discussed earlier, we assume that COOL imposes no demand or cost increases for the chicken industry.

The system of equations can be solved using matrix algebra. The result is an explicit solution for changes in endogenous variables, which are percentage changes in equilibrium prices and quantities of beef, pork, and poultry at retail and farm levels. With these solutions, the change in producer surplus for the industry i is calculated as (Wohlgenant 1993):

$$\text{(28)}\quad \Delta PS_i = P_{iD}^F Q_{iD}^F(\mathrm{E}P_{iD}^{F*} - \mathrm{E}\mu_i)(1 + 0.5\mathrm{E}Q_{iD}^{F*})$$

Since consumers purchase both domestic and foreign meats in the retailing market, the change in consumer surplus should include changes in prices and quantities of domestic and foreign meats. Then, the change in consumer surplus for the industry i is calculated as (Lusk and Anderson 2004):

$$\text{(29)}\quad \Delta CS_i = -P_{iD}^R Q_{iD}^R(\mathrm{E}P_{iD}^{R*} - \mathrm{E}\delta)(1 + 0.5\mathrm{E}Q_{iD}^{R*}) - P_{iF}^R Q_{iF}^R \mathrm{E}P_{iF}^{R*}(1 + 0.5\mathrm{E}Q_{iF}^{R*}).$$

Asterisks in equations (28) and (29) denote the solutions from the system of equations.

Table 1. Parameter Values and Farm Revenue Data Used for Base Scenario

Product	Demand elasticity, $\eta_{ij,ij}$					Other parameters and data			
	Beef, domestic	Beef, foreign	Pork, domestic	Pork, foreign	Chicken	ε	σ	s	Farm revenue *(million $)*
Beef, domestic	-0.73 [a]	0.17 [a]	0.10 [b]	0.05 [e]	0.05 [b]	0.15 [c]	0.72 [d]	0.57 [e]	36,067 [f]
Beef, foreign	2.27 [a]	-2.83 [a]	0.05 [e]	0.10 [e]	0.05 [e]	10.0 [e]	0.72 [d]	0.57 [e]	-
Pork, domestic	0.23 [b]	0.10 [e]	-0.76 [a]	0.07 [a]	0.04 [b]	0.40 [c]	0.35 [d]	0.45 [e]	12,702 [f]
Pork, foreign	0.10 [e]	0.23 [e]	2.24 [a]	-2.93 [a]	0.04 [e]	10.0 [e]	0.35 [d]	0.45 [e]	-
Chicken	0.21 [b]	0.21 [e]	0.07 [b]	0.07 [e]	-0.33 [b]	0.65 [c]	0.11 [d]	0.50 [e]	21,460 [g]

[a] Decomposition of aggregate price elasticity using own-price elasticity estimates from Brester and Schroeder (1995)
[b] Brester and Schroeder (1995)
[c] Wohlgenant (1993)
[d] Wohlgenant (1989)
[e] Lusk and Anderson (2004)
[f] USDA/NASS (2008a)
[g] USDA/NASS (2008b)

Empirical Analysis of COOL in the U.S. Meat Industry

To estimate the economic effects of COOL, we first solve equations (1) to (27) for EQ_{ij}^k and EP_{ij}^k and then apply the solutions to equations (28) and (29) to calculate producer and consumer welfare effects. Equations (28) and (29) are simulated for various scenarios with alternative own- and cross-price elasticities, market power parameters, and COOL cost estimates.

Parameter Values and Farm Revenue Data Used for the Base Scenario

Parameter values and farm revenue data for the domestic beef, pork, and chicken industries are presented in Table 1 for the base scenario simulation. Parameter estimates and data reported in Table 1 are mostly obtained from previous studies and USDA publications. However, following Edgerton (1997) and James and Alston (2002), own- and cross-price elasticities of domestic and foreign products are obtained by decomposing the aggregate retail demand elasticities.

Assuming homothetic separability, the elasticity decomposition of aggregate retail demand of domestic and foreign products for each meat industry can be represented by (Edgerton 1997):

$$(30)\quad \eta_{DD} = S_D\eta - S_F\sigma_T, \quad \eta_{FF} = S_F\eta - S_D\sigma_T, \quad \eta_{DF} = S_F(\eta + \sigma_T), \quad \eta_{FD} = S_D(\eta + \sigma_T),$$

where η, η_{DD}, η_{FF}, η_{DF}, η_{FD} are elasticity of aggregate retail demand, own-price elasticity of domestic product, own-price elasticity of foreign product, cross-price elasticity of domestic product with respect to the price of foreign product, and cross-price elasticity of foreign product with respect to the price of domestic product, respectively; S_D and S_F are the expenditure shares of domestic and foreign products; and σ_T is the elasticity of substitution between domestic and foreign products. To derive own- and cross-price elasticities of domestic and foreign products presented in Table 1, we use -0.56 for the elasticity of aggregate retail demand for beef and -0.69 for the elasticity of aggregate retail demand for pork following Brester and Schroeder (1995). Additional estimates used for the decomposition include $S_D = 0.93$ for beef; $S_D = 0.97$ for pork (USDA/ERS 2007); and $\sigma_T = 3.0$ (James and Alston 2002). Finally, according to USDA/NASS's estimates, the total farm revenues for beef, pork, and chicken are $36,067 million, $12,702 million, and $21,460 million, respectively, in 2007 (USDA/NASS 2008a, 2008b).

COOL Cost Estimates

VanSickle et al. (2003) report that recurring annual costs from COOL would range from about $36 million to $132 million for the beef sector and $25 million to $32 million for the pork sector. Dividing these values by the revenue figures reported in Table 1 implies that COOL would increase costs by about 0.1 percent to 0.4 percent for beef and about 0.2 percent to 0.25 percent for pork. These values, 0.4 percent for beef and 0.25 percent for pork, are taken to represent the lower-bound cost estimates of COOL.

Table 2. COOL Effects in the U.S. Beef Industry with Alternative Own-Price Elasticities (million dollars per year)

	$\eta_{BD,BD}$		
	-0.45	**-0.73**	**-0.98**
ΔPS	-197.64	-285.87	-355.56
ΔCS	-813.21	-735.10	-624.46

Table 3. COOL Effects in the U.S. Beef Industry with Alternative Cross-Price Elasticities between Domestic and Foreign Beef (million dollars per year)

	$\eta_{BD,BF}$				$\eta_{BF,BD}$			
	0.50	**0.75**	**1.00**	**2.00**	**0.50**	**0.75**	**1.00**	**2.00**
ΔPS	-106.64	-67.71	128.24	335.37	-383.48	-371.78	-360.99	-349.12
ΔCS	-813.46	-870.69	-1038.34	-1720.00	-682.23	-701.11	-712.50	-723.46

For the upper bound of COOL cost estimates, we use the statistics reported by Sparks Companies, Inc. (2003). Sparks Companies reports that COOL would cost the beef sector approximately $1.620 million and the pork sector approximately $452 million per year. Dividing these statistics by the revenue figures reported in Table 1 implies that COOL would increase costs by about 5 percent for beef and about 3.5 percent for pork. For the medium estimates, we use 3 percent and 1.5 percent of cost increases for the beef and pork industries, respectively.[5] The expected COOL cost increases in the pork industry are a lot smaller than the expected cost increases in the beef industry because: (1) Canada is the only source of imported and marketed pigs; (2) little or no comingling of animals occurs as in the beef industry, which means that there will be little or no sorting costs due to COOL; and (3) COOL will be applied to a much smaller proportion of total output because roughly 65 percent of the pork carcass is cured, smoked, marinated, or spiced, which should be exempted from COOL (Meyer 2009). The Sparks report also provides the cost estimates for each segment of the beef and pork supply chains. Following the estimates in the report, we assume COOL costs are borne 20 percent by producers and 80 percent by marketers (processors and retailers).

Simulation Results with Beef Sector Only

Equations (28) and (29) are simulated for the beef sector only model to see how sensitive the simulation results are to assumptions about own-price elasticity, cross-price elasticity between domestic and foreign products, and market power parameters. Values of all other parameters are from the base scenario case reported in Table 1, and the medium estimates are used for the expected COOL cost increase. Market power parameters are set to zero (i.e., perfect competition) for the sensitivity analyses of own- and cross-price elasticities. Table 2 reports estimates of COOL effects in terms of changes in producer surplus and consumer surplus for a plausible range of own-price elasticities. The results show that consumers tend to bear a greater burden from COOL costs than producers as the own-price elasticity becomes more inelastic, which is consistent with findings from the tax incidence literature (Fisher 1981, Chang and Kinnucan 1991).

Table 3 reports results from the sensitivity analysis of the cross-price elasticity between domestic and foreign beef. The welfare effects of COOL are more sensitive to the elasticity of domestic demand with respect to the price of foreign products, $\eta_{BD,BF}$, than to the elasticity of foreign demand with respect to the price of domestic products, $\eta_{BF,BD}$. In fact, COOL has negligible welfare impacts for some values of $\eta_{BF,BD}$. As

[5] The requirements of USDA's 2009 final rule are more simplified and flexible than the bill that was originally passed in 2002, and the amounts of records that producers and marketers must keep have been reduced significantly. Recent investments in traceability and information management systems in the U.S. meat industry might also have reduced the additional amount of record-keeping requirements for producers and marketers. Therefore, if all market environments stayed the same, the lower-bound cost estimates of COOL should be more plausible than the medium- and upper-bound estimates.

Table 4. COOL Effects in the U.S. Beef Industry with Alternative Market Power Parameters (million dollars per year)

	ξ			θ		
	0.01	**0.03**	**0.10**	**0.01**	**0.03**	**0.10**
ΔPS	-334.15	-358.30	-418.75	-344.73	-457.35	-771.30
ΔCS	-816.23	-980.16	-1789.63	-795.50	-872.67	-1030.69

$\eta_{BD,BF}$ changes from 0.50 to 2.00, ΔPS increases from -\$106.64 million to \$335.37 million, while ΔCS decreases from -\$813.46 million to -\$1,720 million. However, as $\eta_{BF,BD}$ changes from 0.50 to 2.00, ΔPS increases only from -\$383.48 million to -\$349.12 million, while ΔCS decreases only from -\$682.23 million to -\$723.46 million. The results seem to make sense because the majority of products in the market are domestic products.

Estimates of Table 4 show the effects of market power at the processor level. Previous studies report relatively low estimates of conjectural elasticities for the processing sector. For example, Schroeter (1988) reports conjectural elasticities of 0.0141-0.0190 for the U.S. cattle procurement market for the period of 1980-1983. Most recently, Carlberg, Hogan, and Ward (2009) report 0.045 and 0.022 conjectural elasticities for the U.S. cattle procurement market in 1994 and1996, respectively. Based on these estimates, we use three alternative values of conjectural elasticities for both oligopoly and oligopsony parameters: 0.01, 0.03, and 0.10. As we assume imperfect competition in upstream and downstream markets, both producers and consumers tend to lose. However, marketers' oligopoly power affects consumers more, while marketers' oligopsony power affects producers more. Overall, market power effects are relatively small within the range of estimates reported from previous studies.

Simulation Results with Beef, Pork, and Chicken Sectors

The full three-sector model, equations (1) to (27), and equations (28) and (29) are used to examine the COOL effect in the U.S meat industry. Simulation results are reported in Table 5. All parameter values and farm revenue data used for the simulations are from Table 1. We assume no demand change for *Scenario 1*, a 2 percent demand increase of domestic beef and pork for *Scenario 2*, and a 5 percent demand increase of domestic beef and pork for *Scenarios 3* to *5*. The 2 percent and 5 percent demand increases are assumed based on empirical findings from Lusk and Anderson (2003) and Brester, Marsh, and Atwood (2004).[6] Following many previous studies that use the equilibrium displacement model (e.g., Gardner 1976, Wohlgenant 1993, Chung and Kaiser 1999, Lusk and Anderson 2004, Brester, Marsh, and Atwood 2004), the demand increases are applied in the price direction for *Scenarios 2* to *5*. For all scenarios except *Scenario 5*, market power parameters are set to zero. For each scenario, we simulate the model for three different potential cases of COOL cost increases for the beef and pork industries: low, medium, and high.

Simulation results show that if there is no demand increase for domestic beef and pork (*Scenario 1*), the cost increase due to COOL is expected to decrease producer surplus in the U.S. beef and pork industry and increase producer surplus for the chicken industry. The simulation results show that change in producer surplus for beef producers ranges from -\$52.64 million to -\$611.84 million. The producer loss in the pork industry ranges from \$15.49 million to \$181.77 million. The producer gain in the chicken industry ranges from \$33.80 million to \$295.05 million due to the substitution effects in meat consumption. As

[6] There are no estimates available in the literature for how much consumer demand would increase due to COOL. However, Lusk and Anderson (2004) find that at least 2 percent to 3 percent of demand increase is needed to see some level of producer benefits due to COOL, and they conduct an economic analysis of COOL under the assumption of 2 percent and 5 percent demand increases for both domestic beef and pork. Brester, Marsh, and Atwood (2004) also suggest that at least 2.72 percent and 4.40 percent of demand increase is needed for domestic beef and pork to offset the projected COOL costs. We assume symmetric demand increases of 2 percent and 5 percent for domestic beef and pork following Lusk and Anderson (2004). The demand shift could be derived from own- and cross-advertising elasticities estimated by previous studies (e.g., Piggott et al. 2007). However, these advertising elasticities were estimated for the generic advertising programs that do not differentiate between domestic and foreign products. The demand shifts in our study, however, are expected from advertising programs that promote domestic U.S. beef and pork over imported beef and pork.

Table 5. COOL Effects in the U.S. Meat Industry: Beef, Pork, and Chicken (million dollars per year)

Expected COOL cost increase[a]	Beef		Pork		Chicken	
	ΔPS	ΔCS	ΔPS	ΔCS	ΔPS	ΔCS
Scenario 1. No demand change						
Low	-52.64	-297.12	-15.49	-72.59	33.80	-25.15
Medium	-285.87	-735.10	-50.99	-396.55	110.15	-120.85
High	-611.84	-3150.91	-181.77	-872.35	295.05	-335.75
Scenario 2. 2% demand increase for domestic beef and pork						
Low	334.52	1108.49	198.88	357.53	-68.38	63.20
Medium	298.91	658.00	188.05	246.98	-7.48	7.08
High	165.40	-265.12	115.05	-45.06	127.73	-128.95
Scenario 3. 5% demand increase for domestic beef and pork						
Low	837.25	2834.54	371.31	714.69	-115.02	105.02
Medium	779.02	2425.50	362.45	679.05	-82.33	103.96
High	611.05	1522.98	321.42	394.97	1.91	-2.86
Scenario 4. 5% demand increase for domestic beef and pork with more inelastic own-price elasticity and more elastic cross price elasticity between domestic and foreign products[b]						
Low	1422.94	2245.34	571.88	501.37	-149.30	51.93
Medium	1107.07	2011.21	555.35	453.19	-101.05	43.75
High	890.25	1200.17	475.67	217.88	-38.48	-17.54
Scenario 5. 5% demand increase for domestic beef and pork with imperfectly competitive retail/processing industry: $\xi = \Theta = 0.02$						
Low	821.46	2557.98	343.35	654.30	-121.62	89.08
Medium	723.82	2167.59	325.47	611.45	-90.61	87.90
High	499.17	1471.42	288.43	356.17	1.63	-3.19

[a] For the beef industry, we assume 0.4% (low), 3% (medium), and 5% (high) cost increase; for the pork industry, we assume 0.25% (low), 1.5% (medium), and 3.5% (high) cost increase; and no cost increase is assumed for the chicken industry. The increased COOL cost is assumed to be borne 20% by producers and 80% by marketers.

[b] Own-price elasticities are reduced to half (in absolute values) of those elasticities in Table 1 while cross-price elasticities are increased to twice (in absolute values) those elasticities in Table 1.

the COOL costs increase, the loss of beef and pork producers increases while the gain of chicken producers increases. Consumers lose from all cases, while the consumer loss increases as COOL costs increase.

Alternatively, if COOL increases consumer willingness to pay for domestic beef and pork by 2 percent (*Scenario 2*), beef and pork producers no longer lose money due to COOL. Beef producers' gains range from $165.40 million to $334.52 million, while pork producers' gains range from $115.05 million to $198.88 million each year. As domestic beef and pork demand increases, chicken consumption and prices decrease, and thus chicken producers' surpluses decrease. Due to the increased consumption of domestic beef and pork, the change in consumer surplus becomes positive except for the high-cost case.

Scenario 3 increases the demand for domestic beef and pork by 5 percent. With the 5 percent demand increase, beef and pork producers are estimated to gain significantly more, and the change in consumer surplus turns positive for all levels of cost increase. Chicken producers are worse off compared to *Scenario 2,* due to the increased substitution with domestic beef and pork.

Scenario 4 examines the effects of alternative own-price elasticities and cross-price elasticities between domestic and foreign products in producer and consumer welfare. Tables 2 and 3 show that in the single-sector analysis, the own-price elasticity and cross-price elasticity of domestic demand with respect to the price of foreign products tend to have a significant impact on consumers' and producers' welfare changes. *Scenario 4* conducts further analysis on this issue using the three-sector model. For *Scenario 4,* we reduce own-price elasticities to half (in absolute values) of those estimates reported as the base scenario in Table 1, while increasing cross-price elasticities to twice those elasticities in Table 1. Therefore, in *Scenario 4,* $\eta_{BD,BD}$ = -0.36, $\eta_{PD,PD}$ = -0.38, $\eta_{CD,CD}$ = -0.16, $\eta_{BD,BF}$ = 0.34, and $\eta_{PD,PF}$ = 0.14. Results from *Scenario 4* in Table 5 are consistent with findings from Tables 2 and 3. As we reduce the own-price elasticities (in absolute values), and increase the cross-price elasticities of domestic demand with respect to the foreign product price, we find that COOL effects become more favorable to domestic producers. The results also show that own-price elasticity and cross-price elasticity of domestic demand with respect to foreign product price are important factors in evaluating welfare effects of COOL. Welfare effects of COOL are sensitive to the values of own-price elasticity and cross-price elasticity of domestic demand with respect to foreign product price. Compared to *Scenario 3*, *Scenario 4* leads to a significant increase of producer gain ranging from $890.25 million to $1,422.94 million for the beef industry and from $375.67 million to $471.88 million for the pork industry, while the new scenario results in a further loss to chicken producers that ranges from -$38.48 million to -$149.30 million.

Finally, *Scenario 5* investigates market power effects in evaluating welfare effects of COOL. Results are consistent with those in Table 4. Compared with the results from *Scenario 3*, market power effects appear to be marginal when we assume conjectural elasticities of 0.02 in both upstream and downstream markets.

Conclusions

This study uses an equilibrium displacement model to examine the impacts of mandatory COOL implementation on producer and consumer welfare in the U.S. meat industry. The equilibrium displacement model developed in this study includes twenty-nine equations representing retail-, processing-, and farm-level equilibrium conditions for the beef, pork, and chicken markets. The model extends previous work on this topic by allowing trade between domestic and foreign origin products and considers imperfectly competitive market structure for the meat processing industry.

To examine factors affecting the welfare distribution of COOL, we simulated the beef sector-only model using alternative own-price elasticities, cross-price elasticities of domestic demand with respect to import price, and market power parameters. Simulation results show that consumers tend to bear more COOL costs than producers when the own-price elasticity is less elastic. The cross-price elasticity of domestic demand with respect to import price is also an important factor in determining the welfare distribution of COOL. Producer surplus increases as the elasticity of domestic demand becomes more elastic, with respect to the price of imported products. Effects of imperfect competition in upstream and downstream markets are also examined in this study. The presence of market power in upstream and downstream markets negatively affects both consumers and producers. However, market power in the upstream market reduces consumer surplus more, while market power in the downstream market reduces producer surplus more. The overall impact of market power tends to be relatively small within the range of market power estimates of previous studies.

The beef sector-only model was extended to the three-sector model to examine the COOL effects in U.S. beef, pork, and chicken industries simultaneously. The three-sector model allows not only substitution in consumption of three meat products but also trade between domestic and imported products. The model also considers imperfect competition in both the buying and selling markets of processors. Simulation results show that there will be no benefits to beef and pork producers without any demand increase. In this case, COOL benefits only chicken producers, assuming COOL does not impose costs to chicken producers, processors, or retailers. This assumption is reasonable because the chicken industry is highly integrated, and therefore all records are already well kept. No extra cost increases due to COOL will occur at the retail level either, because most chicken available at retailers is domestic. If COOL can increase consumer demand for domestic beef and pork, it can indeed benefit domestic beef and pork producers. For example, when a 2 percent demand increase is assumed for domestic beef and pork, beef and pork producers are expected to benefit up to $334.52 million and $198.88 million each year, respectively. When we simulate the model with an assumption of a 5 percent demand increase, producers' annual benefit significantly increases up to $837.25 million and $371.31 million for the beef and pork industries, respectively. Producer gains are larger when we assume demand is less own-price and more cross-price elastic, which is consistent with the results from the beef sector-only model and microeconomic (Tomek and Robinson 1987) and tax incidence (Fisher 1981, Chang and Kinnucan 1991) theories. The theories suggest that more cross-price elastic demand leads to more inelastic total demand, which results in less tax borne by producers than consumers. Market power effects are also tested in the three-sector model. Consistent with the earlier results from the single-sector model, the assumption of imperfect competition in upstream and downstream markets affects producer surplus negatively. However, market power effects are relatively small when market power estimates are limited to within the range of estimates reported from previous studies.

Findings from both single- and three-sector models indicate that producers can benefit from the implementation of COOL only when COOL increases the demand of domestic products. One way to increase the demand of domestic products is to run successful promotion and generic advertising programs for domestic products. The promotion and advertising efforts can not only expand domestic demand but also increase U.S. consumers' loyalty to the U.S. "COOL" product, while making domestic demand more inelastic with respect to the own-price and more elastic with respect to the cross-price for imports. Current commodity checkoff programs may not be ready to fund this type of promotion and advertising effort because both domestic producers and importers pay for the programs. However, as we can see from checkoff programs of other countries such as Korea, it is possible to promote domestic agricultural products using only domestic producers' money and, if possible, government matching funds [see Roh, Han, and Chung (2007) for the discussion of government matching funds for Korean beef checkoff programs]. For researchers, our findings clearly show that welfare effects of COOL are highly sensitive to alternative estimates of own-price elasticity and cross-price elasticity of domestic demand with respect to the price of imported products. Finally, it should be noted that our findings are based on assumed values of demand shifts and COOL costs. Although we carefully selected these values from previous studies, further research in estimating these values, particularly COOL costs, should achieve a better understanding of COOL effects in the U.S. meat industry.

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