

# Distributional Impacts of Country-of-Origin Labeling in the U.S. Meat Industry

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Concerns about the negative effects of U.S. meat and livestock imports on domestic livestock prices have increased interest in country-of-origin labeling (COOL) legislation. An equilibrium displacement model is used to estimate short-run and long-run changes in equilibrium prices and quantities of meat and livestock in the beef, pork, and poultry sectors resulting from the implementation of COOL. Retail beef and pork demand would have to experience a one-time, permanent increase of 4.05% and 4.45%, respectively, so that feeder cattle and hog producers do not lose producer surplus over a 10-year period.

*Key words:* country-of-origin labeling, equilibrium displacement model, producer surplus

## Introduction

Concerns about the negative effects of U.S. meat and livestock imports on domestic livestock prices have increased interest in country-of-origin labeling (COOL) legislation. Proponents of the legislation argue: (a) consumers have the right to know and choose the source of their meat products, (b) COOL would enhance food safety and quality, and (c) COOL would increase the demand for domestically produced products and improve domestic livestock prices. Opponents argue that implementation of COOL would be prohibitively expensive because of product blending, the number of ownership exchanges occurring in commodity livestock and meat markets, and the complexity of the meat supply chain. In addition, some research indicates COOL has functioned more as an indicator of quality in some products rather than as a measure of safety (Johansson and Nebenzahl, 1990; Peterson and Yoshida, 2004). The resulting debates have been both heated and expansive (Brester and Smith, 2000).

Several studies have attempted to quantify the expected costs of COOL (Davis, 2003; Hayes and Meyer, 2003; Sparks Companies, Inc., 2003). Annual cost estimates for the beef industry range from \$200 million to \$6.4 billion, and from \$20 million to \$1 billion for the pork industry. Proponents of COOL argue that most of the larger cost estimates are overstated (e.g., VanSickle et al., 2003). They also point to results of experimental

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Review coordinated by DeeVon Bailey. Editor's note: As a result of the passage of the 2002 Farm Security and Rural Investment Act, country-of-origin labeling has emerged as an important subject of interest to researchers and policy makers. The editors have therefore chosen to publish two side-by-side articles addressing this topic (pp. 185–205 and 206–227).

auctions and surveys which suggest some consumers may be willing to pay a premium for beef that has been labeled by country of origin (Loureiro and Umberger, 2003; National Cattlemen's Beef Association, 2002).

Conversely, others contend that while some consumers may be *willing* to pay for country-of-origin labeling, they *may not have* to pay for any of it—given the majority of beef and pork products are of domestic origin (Plain and Grimes, 2003). Consequently, imported meat products could sell at a discount rather than domestic products commanding a premium. In addition, the U.S. Department of Agriculture's Agricultural Marketing Service (USDA/AMS, 2003) found "little evidence that consumers are willing to pay a price premium for country of origin labeling ..." (p. 50), and that "estimated benefits associated with this rule are likely to be negligible" (p. 49). As noted by Zago and Pick (2004), welfare effects of labeling regulation ultimately depend upon the perception of quality differences between imported and domestic products and the size of regulatory costs.

Meat suppliers, retailers, and restaurants can voluntarily choose to label meat products by country of origin. Because such activity currently occurs only on a small scale, one might argue that market evidence suggests the costs of country-of-origin labeling exceed the benefits. However, it could also be argued that voluntary country-of-origin labeling does not occur because labeling benefits and costs may accrue at different levels in the marketing channel. Furthermore, if consumers do not trust the accuracy of voluntary labels, then adverse selection occurs as a result of asymmetric information. Thus, country-of-origin labeling benefits may only accrue if labeling is mandatory.

Historically in the beef and pork industries, increases in marketing and processing costs have been distributed across market levels. In the absence of a demand increase, consumers would only pay the entire costs of COOL if consumer demand for beef and pork products is completely inelastic. If consumer demands are not completely inelastic and demand increases are not large enough to maintain or increase equilibrium quantities, the incidence of COOL costs (i.e., the effects of increased marketing costs on market-level prices) depends primarily on relative demand and supply elasticities at each level of the marketing chain (Tomek and Robinson, 1990).

The objective of this research is to estimate short-run and long-run changes in equilibrium prices and quantities of meat and livestock in the beef, pork, and poultry sectors which would result from the implementation of COOL. We develop an equilibrium displacement model that incorporates estimated COOL costs, accounts for interrelationships along the marketing chain for each meat sector, and allows for substitutability among meat products at the consumer level. The model is used to simulate price and quantity adjustments to COOL cost shocks and potential demand increases which might be induced by COOL. In addition, we estimate cumulative changes in producer surplus at each level of the marketing chain and consumer surplus at the retail level to determine the welfare effects of COOL on consumers and livestock and meat producers.

### Country-of-Origin Labeling

Country-of-origin labeling is mandated for most products imported by the United States under section 304 of the 1930 Tariff Act. However, several agricultural products, including livestock (but not processed livestock products) and several "natural" products (e.g., some fruits, nuts, and vegetables), are included on a "J" list of commodities exempt

from existing U.S. country-of-origin labeling requirements. Country-of-origin exempt products are generally combined with similar domestic products during processing and marketing (e.g., domestic and imported beef carcasses). For nonexempt products, current country-of-origin labeling legislation requires listing the source (country) of imported products through the marketing system until purchased by a final consumer.

The 2002 Food Security and Rural Investment Act added a new subtitle (Subtitle D, Country of Origin Labeling) to the Agricultural Marketing Act of 1946. The subtitle mandated voluntary COOL on September 30, 2002, and mandatory COOL by September 30, 2004. Unprocessed fresh, frozen, and ground beef and pork will be required to be labeled by country of origin, but poultry products, delicatessen food items, processed foods, restaurants, food services, and small retailers (those with less than \$230,000 of annual sales) will remain exempt. Recently, Congress approved a two-year delay for COOL implementation.

Provisions of the General Agreement on Tariffs and Trade (GATT) permit country-of-origin labeling if identical rules are applied to imported products from all World Trade Organization (WTO) member countries. However, GATT (Article III-4) requires that imports must be treated no less favorably than domestically produced products; i.e., domestic producers must also be subject to similar labeling requirements. The North American Free Trade Agreement (NAFTA) also permits country-of-origin labeling. However, country-of-origin labeling has to be maintained only until a commodity reaches the "ultimate purchaser." As noted above, this purchaser is the entity who buys the product in, or very close to, the form in which it is imported. Consequently, the compatibility of any given country-of-origin labeling requirement with GATT, NAFTA, and WTO trade agreements is a question of legal interpretation, and is typically resolved on a case-by-case basis.

Country-of-origin labeling for meat imports is currently required by some countries. Japan, for example, has insisted that all meat imports be labeled by country of origin since July 1, 1997. In the United States, beef imports are currently labeled by country of origin when entering the U.S. However, the meat processing sector is not currently required to maintain country-of-origin designations through the marketing sector to consumers.

### **U.S. Meat and Livestock Imports**

The United States imports feeder cattle from Mexico (which are subsequently finished in U.S. feedlots), trimmings and ground beef from Australia and New Zealand, and a mix of high-value muscle cuts, manufacturing/trimming beef, fed and cull slaughter cattle, and cattle carcasses from Canada. Over 75% of slaughter cattle imports have been grain-fed. Imported beef is inspected and must meet food safety standards equivalent to those for domestically produced beef products. Beef imported as live fed cattle or as carcasses is eligible for U.S. Department of Agriculture (USDA) quality grades. According to the USDA's Economic Research Service (USDA/ERS, 2003), beef imports from all sources represented 16.9% of total U.S. beef supplies. Fifty-one percent of all beef imports were trimming and manufacturing grade beef which is subsequently ground into hamburger. Live cattle imports (on a carcass weight basis) from Canada represented approximately 28% of U.S. beef imports in 2002.

The United States imported approximately 1.1 billion pounds of pork in 2002, which represented about 5.2% of total U.S. pork supplies. Over 80% of these imports originated

in Canada. In addition, the United States imported 5.7 million head of hogs and feeder pigs, representing about 5.7% of U.S. hog slaughter. Almost all hog imports originated in Canada (USDA/ERS, 2003).

The U.S. poultry industry is the world's largest producer and exporter of poultry meat. In 2002, U.S. poultry meat (broilers, other chicken, and turkey) exports were about 14.5% of domestic poultry supplies. Imports amounted to 16 million pounds, or less than 0.5% of domestic production (USDA/ERS, 2003). U.S. consumption of poultry meat (broilers, other chicken, and turkey) is considerably higher than either beef or pork consumption, but less than total red meat consumption. However, the United States imports only small amounts of poultry products.

## Model Development

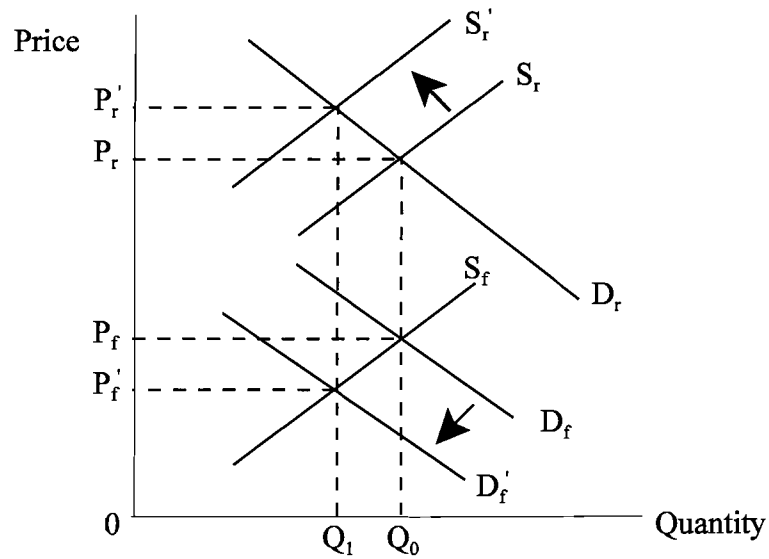
### *Modeling Strategy*

An equilibrium displacement model is developed assuming that COOL imposes additional marketing costs on suppliers at each market level. These costs are generated by increased commodity segregation, record keeping, verification, labeling, and certification. Conceptually, such costs shift relevant supply functions upward and to the left in each affected sector. A reduction in supply at the retail level causes a reduction in quantity demanded at that level. Concurrently, this change causes reductions in derived demand at each prior level in the marketing chain. In a competitive market, the impacts and distribution of added marketing costs on prices and quantities at each market level are determined by the size of cost impacts and relative supply and demand elasticities at each level.

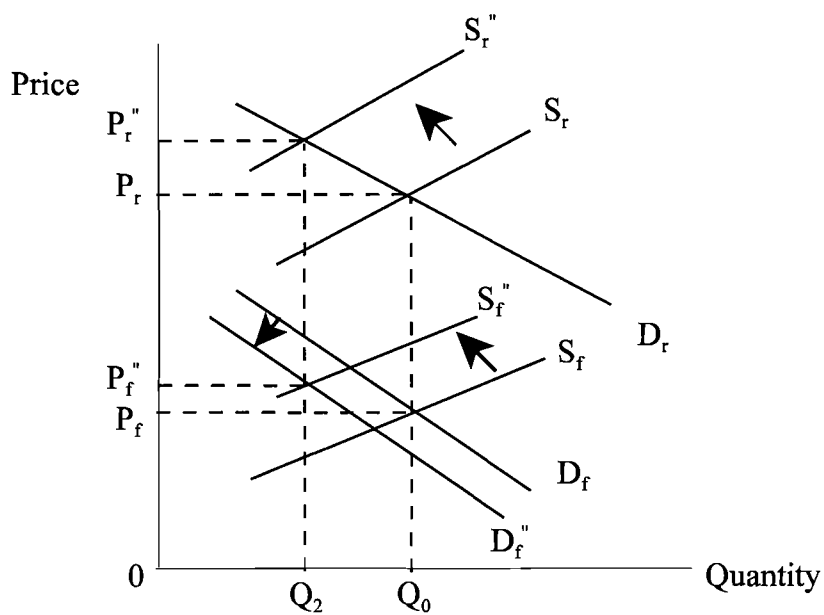
Figure 1 illustrates the relevant market linkages for a simplified case in which the beef industry marketing chain is separated into a retail and farm sector. To simplify the illustration, fixed input proportions between the farm input (cattle) and marketing services are assumed. Retail demand ( $D_r$ ) and farm supply ( $S_f$ ) are considered the "primary" relations, while the demand for cattle ( $D_f$ ) and the supply of beef ( $S_r$ ) are considered "derived" relations (Tomek and Robinson, 1990). The intersection of demand and supply at each level determines relative market clearing prices ( $P_r$ ) and ( $P_f$ ) and market clearing quantity ( $Q_0$ ). In this case, the farm-level market clearing quantity is represented graphically on a retail weight equivalent basis. The difference in equilibrium prices ( $P_r - P_f$ ) represents the farm-retail price spread or marketing margin.

If the additional costs of COOL occurred only at the retail level, retail supply would shift from  $S_r$  to  $S'_r$ , and the farm-level derived demand for cattle would decline to  $D'_f$  (figure 1). Retail price would increase to  $P'_r$ , and farm price would decline to  $P'_f$ . Marketing cost increases would be reflected by a larger marketing margin ( $P'_r - P'_f$ ), and a new equilibrium quantity would be established at  $Q_1$ . If retail demand were relatively inelastic, consumer expenditures would increase but farm revenues and producer surplus would decline along with farm price and quantity.

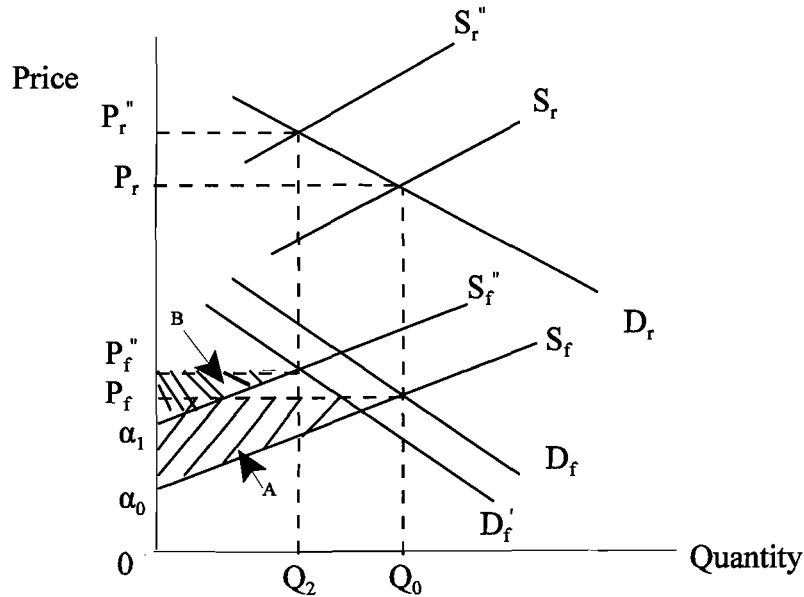
Figure 2 extends this simplified case by illustrating a situation in which COOL costs occur at both the retail and farm levels. The initial equilibrium occurs at  $P_r$ ,  $P_f$ , and  $Q_0$ . The effects of costs associated with COOL are reflected in reductions in both derived retail supply ( $S''_r$ ) and primary farm supply ( $S''_f$ ). The derived demand for cattle declines



**Figure 1. Effects of imposing COOL costs on the retail level**



**Figure 2. Effects of imposing COOL costs on the retail and producer levels**



**Figure 3. Changes in farm-level producer surplus resulting from imposing COOL costs on the retail and producer levels**

to  $D_f'$ . The new equilibrium prices are at  $P_r''$  and  $P_f''$ , and the new equilibrium quantity is  $Q_2$ . Whether  $P_f''$  is higher or lower than  $P_f$  depends upon relative supply and demand elasticities at each level. However,  $Q_2$  is unambiguously less than  $Q_0$ .

In figure 2, the new equilibrium farm price  $P_f''$  is higher than the original farm price of  $P_f$ . Nonetheless, the higher farm price does not mean producers are better off because of associated declines in farm output. Producer welfare effects can be measured by the change in producer surplus that results from moving the original equilibrium ( $P_f, Q_0$ ) to the new equilibrium ( $P_f'', Q_2$ ). In figure 3, shaded area A represents farm-level producer surplus at the original equilibrium price and quantity, and shaded area B represents farm-level producer surplus as a result of increased COOL marketing costs which affect the retail and farm levels. Assuming linear supply and demand functions, elasticity estimates and equilibrium prices and quantities can be used to calculate the sizes of the shaded areas. Absent a consumer demand increase, the change in producer surplus must be negative and is expressed as:

$$(1) \quad \Delta PS = B - A = \left[ \frac{1}{2}(P_f'' - \alpha_1)Q_2 \right] - \left[ \frac{1}{2}(P_f - \alpha_0)Q_0 \right],$$

where  $\Delta PS$  represents the change in producer surplus.

Figures 1–3 illustrate only the “cost side” effects of COOL on retail and farm-level prices and quantities. However, COOL could potentially increase consumer demand for domestically produced beef products and result in an upward shift in the primary demand curve,  $D_r$ , (Loureiro and Umberger, 2003). It is useful to consider the size of a demand shift that would be required to ensure no reduction in producer surplus occurs at the farm level for cattle and hogs.

### A Structural Model

A structural model of supply and demand relationships in the beef, pork, and poultry industries provides the framework for an equilibrium displacement model. The commodity sectors consist of primary and derived relations within the farm-retail marketing chain. Within each meat sector, the model incorporates variable input proportions among livestock, meat, and marketing service inputs by allowing production quantities to vary across market levels (Tomek and Robinson, 1990; Wohlgenant, 1993). The use of variable input proportions permits input substitution in response to changing output and input prices (Wohlgenant, 1989). Interactions among the meat sectors are considered by modeling consumer substitution among meat products.

We model the beef marketing chain by considering four distinct sectors: retail (consumer), wholesale (processor), slaughter (cattle feeding), and farm (feeder cattle). The pork marketing chain is more integrated than the beef sector, and hence we consider demand and supply relations for only three sectors: retail, wholesale, and slaughter (hog feeding). Because the poultry sector is highly integrated, only the retail and wholesale sectors are considered. Finally, imported beef and pork products are subsumed by primary demands and wholesale supplies. Given that imports are not currently labeled at the retail level, U.S. demand and supply elasticities are assumed to be similar among imported and domestic beef and pork products.

In general terms, the structural supply and demand model is given by the following (error terms have been omitted):

#### BEEF SECTOR:

- |     |                                      |   |
|-----|--------------------------------------|---|
| (2) | Retail beef primary demand:          | $Q_B^r = f_1(P_B^r, P_K^r, P_Y^r, Z_B^r)$ |
| (3) | Retail beef derived supply:          | $Q_B^r = f_2(P_B^r, W_B^r)$               |
| (4) | Wholesale beef derived demand:       | $Q_B^w = f_3(P_B^w, Q_B^r, Z_B^w)$        |
| (5) | Wholesale beef derived supply:       | $Q_B^w = f_4(P_B^w, W_B^w)$               |
| (6) | Slaughter cattle derived demand:     | $Q_B^s = f_5(P_B^s, Q_B^w, Z_B^s)$        |
| (7) | Slaughter cattle derived supply:     | $Q_B^s = f_6(P_B^s, W_B^s)$               |
| (8) | Farm (feeder cattle) derived demand: | $Q_B^f = f_7(P_B^f, Q_B^s, Z_B^f)$        |
| (9) | Farm (feeder cattle) primary supply: | $Q_B^f = f_8(P_B^f, W_B^f)$               |

#### PORK SECTOR:

- |      |                                |   |
|------|--------------------------------|---|
| (10) | Retail pork primary demand:    | $Q_K^r = f_9(P_B^r, P_K^r, P_Y^r, Z_K^r)$ |
| (11) | Retail pork derived supply:    | $Q_K^r = f_{10}(P_K^r, W_K^r)$            |
| (12) | Wholesale pork derived demand: | $Q_K^w = f_{11}(P_K^w, Q_K^r, Z_K^w)$     |
| (13) | Wholesale pork derived supply: | $Q_K^w = f_{12}(P_K^w, W_K^w)$            |

$$(14) \quad \text{Slaughter hogs derived demand:} \quad Q_K^s = f_{13}(P_K^s, Q_K^w, Z_K^s)$$

$$(15) \quad \text{Slaughter hogs primary supply:} \quad Q_K^s = f_{14}(P_K^s, W_K^s)$$

*POULTRY SECTOR:*

$$(16) \quad \text{Retail poultry primary demand:} \quad Q_Y^r = f_{15}(P_B^r, P_K^r, P_Y^r, Z_Y^r)$$

$$(17) \quad \text{Retail poultry derived supply:} \quad Q_Y^r = f_{16}(P_Y^r, W_Y^r)$$

$$(18) \quad \text{Wholesale poultry derived demand:} \quad Q_Y^w = f_{17}(P_Y^w, Q_Y^r, Z_Y^w)$$

$$(19) \quad \text{Wholesale poultry primary supply:} \quad Q_Y^w = f_{18}(P_Y^w, W_Y^w)$$

Definitions of variables are presented in table 1. Within each meat sector, market levels are linked by downstream quantity (weight) variables (Wohlgenant, 1993). Each  $Z_i^j$  and  $W_i^j$  ( $i$  = the commodity sector,  $j$  = the market level) represent vectors of demand and supply shifters.

*An Equilibrium Displacement Model*

An equilibrium displacement model is a linear approximation of underlying and unknown demand and supply functions. The model's accuracy depends upon the degree of non-linearity of the true demand and supply functions and the magnitude of deviations from the equilibrium being considered. If these deviations are relatively small, then a linear approximation of the true demand and supply functions should be relatively accurate (Brester and Wohlgenant, 1997; Wohlgenant, 1993). Although *total* producer surplus measurements obtained from linear supply functions may or may not reflect actual values, *changes* in producer surplus caused by shifts in linear supply or demand functions should reflect actual values, providing such shifts are relatively small.

An equilibrium displacement model is developed by totally differentiating equations (2)–(19) and using log differentials to convert to elasticities. This procedure results in the following equilibrium displacement model which is used to approximate changes from initial equilibrium in the U.S. beef, pork, and poultry industries:

*BEEF SECTOR:*

$$(20) \quad EQ_B^r = \eta_{BB} EP_B^r + \eta_{BK} EP_K^r + \eta_{BY} EP_Y^r + Ez_B^r$$

$$(21) \quad EQ_B^r = \epsilon_B^r EP_B^r + Ew_B^r$$

$$(22) \quad EQ_B^w = \eta_B^w EP_B^w + \tau_B^{rw} EQ_B^r$$

$$(23) \quad EQ_B^w = \epsilon_B^w EP_B^w + Ew_B^w$$

$$(24) \quad EQ_B^s = \eta_B^s EP_B^s + \tau_B^{ws} EQ_B^w$$

$$(25) \quad EQ_B^s = \epsilon_B^s EP_B^s + Ew_B^s$$

$$(26) \quad EQ_B^f = \eta_B^f EP_B^f + \tau_B^{sf} EQ_B^s$$

$$(27) \quad EQ_B^f = \epsilon_B^f EP_B^f + Ew_B^f$$



**Table 1. Definitions of Variables for the Structural and Equilibrium Displacement Models**

Variable	Definition
$Q_B^r$	Quantity of beef at the retail level
$Q_B^w$	Quantity of beef at the wholesale level
$Q_B^s$	Quantity of fed cattle at the slaughter level
$Q_B^f$	Quantity of feeder cattle at the farm level
$Q_K^r$	Quantity of pork at the retail level
$Q_K^w$	Quantity of pork at the wholesale level
$Q_K^s$	Quantity of hogs at the slaughter level
$Q_Y^r$	Quantity of poultry at the retail level
$Q_Y^w$	Quantity of poultry at the wholesale level
$P_B^r$	Retail price of beef
$P_K^r$	Retail price of pork
$P_Y^r$	Retail price of poultry
$P_B^w$	Wholesale price of beef
$P_B^s$	Price of fed cattle
$P_B^f$	Price of feeder cattle
$P_K^w$	Wholesale price of pork
$P_K^s$	Price of hogs
$P_Y^w$	Price of poultry
$Z_i^j$	Demand shifters for the $i$ th commodity at the $j$ th market level
$W_i^j$	Supply shifters for the $i$ th commodity at the $j$ th market level
$z_B^r$	Increase in consumer demand for beef resulting from country-of-origin labeling
$z_K^r$	Increase in consumer demand for pork resulting from country-of-origin labeling
$w_B^r$	Increased costs of supplying retail beef resulting from country-of-origin labeling
$w_B^w$	Increased costs of supplying wholesale beef resulting from country-of-origin labeling
$w_B^s$	Increased costs of supplying fed cattle resulting from country-of-origin labeling
$w_B^f$	Increased costs of supplying feeder cattle resulting from country-of-origin labeling
$w_K^r$	Increased costs of supplying retail pork resulting from country-of-origin labeling
$w_K^w$	Increased costs of supplying wholesale pork resulting from country-of-origin labeling
$w_K^s$	Increased costs of supplying hogs resulting from country-of-origin labeling

*PORK SECTOR:*

$$(28) \quad EQ_K^r = \eta_{PB}EP_B^r + \eta_{KK}EP_K^r + \eta_{PY}EP_Y^r + Ez_K^r$$

$$(29) \quad EQ_K^r = \varepsilon_K^r EP_K^r + Ew_K^r$$

$$(30) \quad EQ_K^w = \eta_K^w EP_K^w + \tau_K^{rw} EQ_K^r$$

$$(31) \quad EQ_K^w = \varepsilon_K^w EP_K^w + Ew_K^w$$

$$(32) \quad EQ_K^s = \eta_K^s EP_K^s + \tau_K^{ws} EQ_K^w$$

$$(33) \quad EQ_K^s = \varepsilon_K^s EP_K^s + Ew_K^s$$

*POULTRY SECTOR:*

$$(34) \quad EQ_Y^r = \eta_{YB}EP_B^r + \eta_{YK}EP_K^r + \eta_{YY}EP_Y^r$$

$$(35) \quad EQ_Y^r = \varepsilon_Y^r EP_Y^r$$

$$(36) \quad EQ_Y^w = \eta_Y^w EP_Y^w + \tau_Y^{rw} EQ_Y^r$$

$$(37) \quad EQ_Y^w = \varepsilon_Y^w EP_Y^w$$

The term  $E$  in the above equations represents a relative change operator—e.g.,  $EQ_B^r = dQ_B^r/Q_B^r = \ln(Q_B^r)$ . Table 2 provides definitions for all parameters. In addition, each  $z_i^j$  and  $w_i^j$  represent single elements of the demand ( $\mathbf{Z}_i^j$ ) and supply ( $\mathbf{W}_i^j$ ) shifters. Specifically, these elements represent percentage changes from initial equilibria resulting from the implementation of COOL. That is,  $z_i^j$  represents potential demand (preference) shifters for primary beef and pork demand caused by positive consumer reactions to COOL. Similarly,  $w_i^j$  represents cost shifters for the primary and derived beef and pork supply functions. All other elements of  $\mathbf{Z}_i^j$  and  $\mathbf{W}_i^j$  are assumed to remain constant. Note that COOL-induced supply and demand shifters are not included for the poultry sector because poultry is exempt from COOL regulations.

For any given set of elasticity estimates, equations (20)–(37) can be used to determine the relative changes in endogenous quantities and prices for any given exogenous changes in costs and/or consumer demand. In matrix notation, equations (20)–(37) can be written as:

$$(38) \quad \mathbf{A} \cdot \mathbf{Y} = \mathbf{B} \cdot \mathbf{X},$$

where  $\mathbf{A}$  is an  $\{18 \times 18\}$  matrix of elasticities,  $\mathbf{Y}$  is an  $\{18 \times 1\}$  vector of changes in the endogenous price and quantity variables,  $\mathbf{B}$  is an  $\{18 \times 9\}$  matrix of parameters associated with the exogenous variables, and  $\mathbf{X}$  is a  $\{9 \times 1\}$  vector of percentage changes in the exogenous cost and demand shift variables. Relative changes in the endogenous variables ( $\mathbf{Y}$ ) caused by relative changes in COOL-induced supply and demand shifts ( $\mathbf{X}$ ) are calculated by solving equation (38) as:

$$(39) \quad \mathbf{Y} = \mathbf{A}^{-1} \cdot \mathbf{B} \cdot \mathbf{X}.$$

**Table 2. Parameter Definitions, Estimates, and Sources for the Equilibrium Displacement Model**

Parameter	Definition	Elasticity Estimate		Source
		Short Run	Long Run	
$\eta_{BB}$	Own-price elasticity of retail beef demand	-0.70 <sup>a</sup>		Brester, 1996
$\eta_{BK}$	Cross-price elasticity of retail beef demand with respect to pork price	0.19 <sup>a</sup>		Brester, 1996
$\eta_{BY}$	Cross-price elasticity of retail beef demand with respect to poultry price	0.05 <sup>a</sup>		Brester, 1996
$\eta_{KB}$	Cross-price elasticity of retail pork demand with respect to beef price	0.34 <sup>a</sup>		Brester, 1996
$\eta_{KK}$	Own-price elasticity of retail pork demand	-0.79 <sup>a</sup>		Brester, 1996
$\eta_{KY}$	Cross-price elasticity of retail pork demand with respect to poultry price	0.02 <sup>a</sup>		Brester, 1996
$\eta_{YB}$	Cross-price elasticity of retail poultry demand with respect to beef price	0.18 <sup>a</sup>		Brester, 1996
$\eta_{YK}$	Cross-price elasticity of retail poultry demand with respect to pork price	0.04 <sup>a</sup>		Brester, 1996
$\eta_{YY}$	Own-price elasticity of retail poultry demand	-0.29 <sup>a</sup>		Brester, 1996
$\eta_B^w$	Wholesale beef own-price derived demand elasticity	-0.57 <sup>a</sup>		Marsh, 1992
$\eta_B^s$	Slaughter cattle own-price derived demand elasticity	-0.66 <sup>a</sup>		Marsh, 1992
$\eta_B^f$	Farm-level own-price derived demand elasticity	-0.62 <sup>a</sup>		Marsh, 2001
$\eta_K^w$	Wholesale pork own-price derived demand elasticity	-0.71 <sup>a</sup>		calculated <sup>b</sup>
$\eta_K^s$	Slaughter hogs own-price derived demand elasticity	-0.51 <sup>a</sup>		Wohlgenant, 1993
$\eta_Y^w$	Wholesale poultry own-price derived demand elasticity	-0.22 <sup>a</sup>		calculated <sup>b</sup>
$\varepsilon_B^r$	Own-price derived retail beef supply elasticity	0.36	4.62	calculated <sup>b</sup>
$\varepsilon_B^w$	Own-price derived wholesale beef supply elasticity	0.28	3.43	calculated <sup>b</sup>
$\varepsilon_B^s$	Own-price derived slaughter cattle supply elasticity	0.26	3.24	Marsh, 1994
$\varepsilon_B^f$	Own-price farm supply elasticity	0.22	2.82	Marsh, 2003
$\varepsilon_K^r$	Own-price derived retail pork supply elasticity	0.73	3.87	calculated <sup>b</sup>
$\varepsilon_K^w$	Own-price derived wholesale pork supply elasticity	0.44	1.94	calculated <sup>b</sup>
$\varepsilon_K^s$	Own-price slaughter hog supply elasticity	0.41	1.80	Lemieux and Wohlgenant, 1989
$\varepsilon_Y^r$	Own-price derived retail poultry supply elasticity	0.18	13.1	calculated <sup>b</sup>
$\varepsilon_Y^w$	Wholesale own-price poultry supply elasticity	0.14	10.0	Brown, 1997; Hahn, 1997
$\tau_B^{rw}$	Percentage change in wholesale beef quantity given a 1% change in retail beef quantity		1.03 <sup>a</sup>	estimated <sup>c</sup>
$\tau_B^{ws}$	Percentage change in fed cattle quantity given a 1% change in wholesale beef quantity		1.02 <sup>a</sup>	estimated <sup>c</sup>
$\tau_B^{sf}$	Percentage change in feeder cattle quantity given a 1% change in fed cattle quantity		0.78 <sup>a</sup>	estimated <sup>c</sup>

( continued . . . )

Table 2. Continued

Parameter	Definition	Elasticity Estimate		Source
		Short Run	Long Run	
$\tau_K^{rw}$	Percentage change in wholesale pork quantity given a 1% change in retail pork quantity		1.01 <sup>a</sup>	estimated <sup>c</sup>
$\tau_K^{ws}$	Percentage change in hog quantity given a 1% change in wholesale pork quantity		1.00 <sup>a</sup>	estimated <sup>c</sup>
$\tau_Y^{rw}$	Percentage change in wholesale poultry quantity given a 1% change in retail poultry quantity		0.98 <sup>a</sup>	estimated <sup>c</sup>

<sup>a</sup> These elasticity estimates are assumed to be identical for the short run and the long run.

<sup>b</sup> Published elasticities were not available for several derived demand and derived supply functions in the livestock-meat sectors. In these cases, elasticities of price transmission (and the assumption of fixed input proportions) were used to calculate elasticities (Gardner, 1975). The following formula was used to calculate derived demand elasticities for each meat sector:  $E_d^j = E_d^r(\partial \ln(P_r)/\partial \ln(P_d^j))$ , where  $E_d^j$  is the derived demand elasticity at level  $j$  (wholesale or farm level),  $E_d^r$  is the retail (primary) demand elasticity, and  $(\partial \ln(P_r)/\partial \ln(P_d^j))$  is the percentage change in retail price for a 1% change in derived demand price at level  $j$ . The following formula was used to calculate derived supply elasticities for each meat sector:  $E_s^j = E_s^f(\partial \ln(P_f)/\partial \ln(P_s^j))$ , where  $E_s^j$  is the derived supply elasticity at level  $j$  (retail or wholesale level),  $E_s^f$  is the farm (primary) supply elasticity, and  $(\partial \ln(P_f)/\partial \ln(P_s^j))$  is the percentage change in farm price for a 1% change in derived supply price at level  $j$ .

<sup>c</sup> Each quantity transmission elasticity was estimated using annual data from 1970–2000 and double-log functional forms with corrections for first-order autocorrelated errors. Regression results are available from the authors upon request.

Solutions for  $\mathbf{Y}$  in equation (39) require elasticity estimates for elements of the matrix  $\mathbf{A}$ . Obtaining such estimates by econometrically estimating the demand and supply structural equations represented by equations (2)–(19) is problematic. Direct estimation is generally prohibited by the large number of equations in the system and the identification problems which often exist when simultaneously estimating supply and demand equations at each market level. Given that COOL costs represent relatively small shifts in supply functions, another alternative is to use demand and supply elasticity estimates which have been commonly reported in published literature. Therefore, all short-run (1-year) and long-run (10-year) simulations using equation (39) are based on representative published supply and demand elasticities (table 2).

#### Country-of-Origin Labeling Cost Estimates

Exogenous (percentage) changes in COOL costs at each level of the beef and pork industries were obtained from Sparks Companies, Inc. (2003). Although these estimates are smaller than those suggested by Davis (2003) and larger than those suggested by Vansickle et al. (2003), they are similar to recent USDA/AMS (2003) estimates. Sparks Companies estimate that COOL will result in a \$1.653 billion annual increase in operating costs to the beef industry. Furthermore, these cost increases are estimated to be distributed as: \$805 million to the retail sector, \$500 million to the packer (wholesale) sector, \$150 million to the feedlot (fed cattle) sector, and \$198 million to the cow/calf (feeder cattle). Using 2002 average prices and quantities for each market level, these costs estimates represent the following percentage increases in costs relative to total value: 1.24% at the retail level, 1.71% at the wholesale level, 0.50% at the fed cattle level, and 0.96% at the feeder cattle level. Each of these percentage increases in costs

represent upward shifts of the respective supply functions [equations (21), (23), (25), and (27)].

Estimates by Sparks Companies suggest COOL will generate \$713 million of additional costs for the pork industry with \$263 million occurring at the retail level, \$350 million at the wholesale level, and \$100 million at the hog finishing level. Based on 2002 average prices and quantities, these cost increases represent the following percentage increases relative to total value at each level: 0.66% at the retail level, 3.41% at the wholesale level, and 1.08% at the hog finishing level. These percentage increases generate vertical shifts of their respective supply functions [equations (29), (31), and (33)]. Currently, poultry is exempt from COOL legislation. Therefore, we assume no additional costs are incurred by the poultry industry as a result of COOL.

### *Elasticity Estimates*

The elasticities reported in table 2 were generally selected from previously published studies. Davis and Espinoza (1998) demonstrate the importance of examining the sensitivity of changes in prices and quantities (as well as producer and consumer surplus) relative to variations in selected elasticity estimates. Thus, rather than relying solely on these estimates, we assume they represent central tendencies. Following Davis and Espinoza (1998), Monte Carlo simulations of the equilibrium displacement model were conducted by selecting prior distributions for each of the elasticities used in the model. We incorporate diffuse priors with respect to the reported demand and supply elasticities while constraining demand elasticities to be negative and supply elasticities to be positive. A variance for each elasticity is required to parameterize each uniform distribution. However, an estimated variance was not available for every elasticity. Therefore, coefficients of variation were calculated for those elasticity estimates for which variances were available. The average coefficients of variation were 0.16 for demand elasticities and 0.13 for supply elasticities. These coefficients of variation were used to establish endpoints for each uniform distribution that are 3 standard deviations from each mean.

We were unable to find estimates of quantity transmission elasticities ( $\tau_i^{jk}$ ) in the extant literature. Thus, more probability mass was assigned to our own estimates of these elasticities (table 2). Beta(4,4) distributions were used for each transmission elasticity because the Beta distribution is both flexible and amenable to truncation. The average coefficient of variation of the quantity transmission elasticities of 0.08 was used to establish a range of 3 standard deviations for each of these elasticities.

A sensitivity analysis of an equilibrium displacement model should consider both variations of elasticity estimates and correlations among these estimates (Davis and Espinoza, 1998). Our selected demand elasticities are assumed to be uncorrelated with supply elasticities, and demand and supply elasticity estimates are assumed to be uncorrelated between meat sectors. We further assume both primary and derived demand elasticities and primary and derived supply elasticities are correlated within meat sectors. We were only able to obtain correlation coefficients among elasticity estimates within the beef sector. Correlation coefficients among elasticity estimates for nearby demand levels (e.g., feeder and fed cattle sectors) averaged 0.43. Correlation coefficients among elasticity estimates for one-level-away demand levels (e.g., feeder cattle and wholesale beef sectors) averaged 0.18. A correlation coefficient of 0.08 was used for the only two-levels-away sectors (i.e., feeder cattle and retail beef sectors).

Correlation coefficients among elasticity estimates for nearby supply levels averaged 0.33, and 0.11 for one-level-away supply sectors. A correlation coefficient of 0.04 was used for the only two-levels-away sector. These correlation coefficients were also applied to the pork and poultry sectors.

At the retail level, marginal samples of own-price elasticities of demand are selected from uniform distributions. However, it is assumed that cross-price elasticities of demand remain proportional to own-price elasticities of demand. Furthermore, the correlation coefficients among the quantity transmission elasticities were each assumed to be 0.80 within each meat sector.

The simulation requires sampling from the selected distributions. However, the existence of correlated elasticities distorts marginal distributions. Rather than sampling from an intractable multivariate distribution, we use a variant of the Iman and Conover (1982) procedure for generating a correlated multivariate sample. Distortions of marginal distribution samples caused by correlations among elasticities are accounted for by reordering individually and independently generated marginal samples. The Iman-Conover procedure for generating correlated samples using rank order procedures is presented in the appendix. All of the following Monte Carlo simulations are the result of 1,000 iterations. Empirical distributions are generated for each endogenous variable and for all estimates of changes in consumer and producer surplus. These empirical distributions are used to develop reported means, confidence intervals, and  $p$ -values for our results (Davis and Espinoza, 1998).

## Simulation Results

### *Price and Quantity Effects of COOL Assuming No Change in Consumer Demand*

Short- and long-run impacts of the above percentage cost changes are initially simulated using equation (39), assuming COOL has no effects on consumer demand for beef and pork. Short-run percentage changes in prices and quantities are presented in the first column of table 3. Ninety-five percent confidence intervals are reported based upon the empirical distributions generated by the Monte Carlo procedure. All short-run mean estimates are significantly different from zero at the  $\alpha = 0.05$  level with the exception of retail pork quantity ( $p$ -value of 0.07). Beef, pork, and poultry prices increase at the retail and wholesale levels, and feeder cattle prices increase at the farm level. But, all beef and pork quantities decline. These results are theoretically consistent in that COOL-induced additional marketing costs reduce derived retail supplies and derived demands. Poultry prices and quantities increase because poultry demand increases as consumers substitute away from relatively more expensive beef and pork products.

The first column of table 4 presents short-run changes in producer surplus for each market level and consumer surplus at the retail levels of each industry. Except for retail beef, retail pork, and wholesale pork producer surplus, all other estimates of economic surplus changes are statistically significant. In the absence of demand increases, producer surplus declines at all levels of the beef and pork industries. Producer surplus declines by \$647.8 million in the beef industry and by \$220.4 million in the pork industry. Increased poultry demand generates increases in producer surplus at every level of the poultry industry and an aggregate increase of \$198.3 million. Across all meat sectors,

**Table 3. Percentage Changes in the Endogenous Variables for Each Simulation**

Endogenous Variables	No Demand Increase		4.05% Beef Demand Increase 4.45% Pork Demand Increase	
	Short Run	Long Run	Short Run	Long Run
<b>Beef Sector:</b>				
<i>Retail Beef Price</i>	1.39 (1.01, 2.04)	0.25 (0.18, 0.36)	6.20 (4.60, 9.02)	1.08 (0.78, 1.56)
<i>Retail Beef Quantity</i>	-0.75 (-0.94, -0.54)	-0.14 (-0.25, -0.07)	0.95 (0.15, 1.86)	3.53 (3.09, 3.83)
<i>Wholesale Beef Price</i>	1.15 (0.71, 1.88)	0.41 (0.29, 0.58)	3.32 (1.83, 5.76)	1.39 (0.99, 1.98)
<i>Wholesale Beef Quantity</i>	-1.39 (-1.54, -1.17)	-0.37 (-0.58, -0.21)	-0.79 (-1.29, -0.05)	2.86 (2.10, 3.44)
<i>Fed Cattle Price</i>	-1.09 (-1.86, -0.54)	0.04 <sup>†</sup> (-0.04, 0.10)	-0.34 <sup>†</sup> (-1.12, 0.58)	1.02 (0.62, 1.65)
<i>Fed Cattle Quantity</i>	-0.74 (-0.91, -0.61)	-0.40 (-0.60, -0.25)	-0.57 (-0.75, -0.37)	2.26 (1.40, 3.23)
<i>Feeder Cattle Price</i>	0.46 (0.14, 0.84)	0.18 (0.10, 0.27)	0.61 (0.30, 1.06)	0.74 (0.44, 1.18)
<i>Feeder Cattle Quantity</i>	-0.85 (-0.93, -0.74)	-0.42 (-0.61, -0.27)	-0.81 (-0.89, -0.68)	1.34 (0.51, 2.46)
<b>Pork Sector:</b>				
<i>Retail Pork Price</i>	0.77 (0.58, 1.01)	0.16 (0.12, 0.23)	4.89 (3.74, 6.59)	1.22 (0.90, 1.73)
<i>Retail Pork Quantity</i>	-0.12 <sup>†</sup> (-0.24, 0.04)	-0.05 <sup>†</sup> (-0.12, 0.01)	2.82 (1.80, 3.67)	3.86 (3.32, 4.23)
<i>Wholesale Pork Price</i>	2.98 (2.11, 4.37)	1.31 (0.95, 1.88)	5.65 (3.79, 8.47)	2.85 (2.00, 4.09)
<i>Wholesale Pork Quantity</i>	-2.13 (-2.64, -1.53)	-0.96 (-1.46, -0.53)	-0.97 <sup>†</sup> (-2.03, 0.32)	1.92 (0.57, 3.22)
<i>Hog Price</i>	-1.17 (-2.27, -0.37)	0.05 <sup>†</sup> (-0.24, 0.27)	0.16 <sup>†</sup> (-1.12, 1.76)	1.36 (0.68, 2.47)
<i>Hog Quantity</i>	-1.54 (-1.99, -1.22)	-0.98 (-1.46, -0.60)	-1.00 (-1.50, -0.35)	1.29 (0.08, 2.79)
<b>Poultry Sector:</b>				
<i>Retail Poultry Price</i>	0.59 (0.37, 0.91)	0.004 (0.002, 0.008)	2.76 (1.74, 4.15)	0.02 (0.01, 0.04)
<i>Retail Poultry Quantity</i>	0.10 (0.06, 0.17)	0.05 (0.02, 0.09)	0.49 (0.30, 0.79)	0.24 (0.12, 0.41)
<i>Poultry Price</i>	0.29 (0.15, 0.53)	0.005 (0.002, 0.010)	1.36 (0.73, 2.39)	0.02 (0.01, 0.05)
<i>Poultry Quantity</i>	0.04 (0.02, 0.08)	0.05 (0.02, 0.09)	0.19 (0.09, 0.35)	0.23 (0.10, 0.40)

Note: Percentage changes are based upon average 2002 quantities and prices for livestock and meat.

<sup>†</sup> Indicates that the estimate was not significantly different from zero at the  $\alpha = 0.05$  level.

**Table 4. Changes in Producer Surplus for Each Market Level and Consumer Surplus at the Retail Level Assuming No Demand Increase (\$ millions)**

Industry/Market Level	No Demand Increase			Cumulative Present Value
	Short Run	Long Run	Cumulative	
<b>Beef Producer Surplus:</b>				
Retail Level	0.0 <sup>a†</sup>	-22.2	-893.7	-678.0 <sup>†</sup>
Wholesale Level	-168.3	-34.8	-1,487.7	-1,197.4
Slaughter (Fed Cattle) Level	-461.4	-39.7	-2,272.8	-1,904.6
Farm (Feeder Cattle) Level	-101.3	-32.7	-999.4	-795.6
<i>Total Beef Industry Producer Surplus:</i>	-647.8	-129.4	-5,653.6	-4,575.6
<b>Pork Producer Surplus:</b>				
Retail Level	0.0 <sup>a†</sup>	-5.6	-50.3 <sup>†</sup>	-28.9 <sup>†</sup>
Wholesale Level	-53.3 <sup>†</sup>	-55.5	-877.1	-682.7
Slaughter (Hog) Level	-207.5	-53.6	-1,275.4	-1,037.3
<i>Total Pork Industry Producer Surplus:</i>	-220.4	-114.7	-2,212.8	-1,749.0
<b>Poultry Producer Surplus:</b>				
Retail Level	146.8	1.0	420.4	372.5
Wholesale Level	51.5	0.9	208.0	180.1
<i>Total Poultry Industry Producer Surplus:</i>	198.3	1.9	628.4	552.6
<b>Total Meat Industry Producer Surplus:</b>	<b>-670.0</b>	<b>-242.2</b>	<b>-7,238.0</b>	<b>-5,771.9</b>
<b>Retail Consumer Surplus:</b>				
Retail Beef	-795.5	-187.8	-4,874.6	-3,981.8
Retail Pork	-181.3	-51.6	-1,097.0	-893.0
Retail Poultry	89.3	54.0	906.7	713.3
<i>Total Retail Consumer Surplus:</i>	-887.5	-185.4	-5,064.9	-4,161.5

Note: Producer surplus is calculated relative to 2002 quantities and prices for livestock and meat.

<sup>†</sup> Indicates that the estimate was not significantly different from zero at the  $\alpha = 0.05$  level.

<sup>a</sup> The simulation model indicated a slight increase in retail-level producer surplus for beef and pork. However, such an improvement is not possible given the assumption of no increase in consumer demand. The slight increase was attributable to highly inelastic short-run supply elasticities which caused the linear supply functions to have relatively large negative price intercepts. In addition, these estimates were not significantly different from zero. Hence, the beef and pork retail estimates are set to zero.

retail-level consumer surplus declines by \$887.5 million. Although consumer surplus in the poultry sector increases by \$89.3 million, consumer surplus declines by \$795.5 million in the beef sector and by \$181.3 million in the pork sector (table 4).

The second column of table 3 reports long-run percentage changes in prices and quantities. These results are generated from equation (39) by replacing short-run supply elasticities in matrix **A** with long-run supply elasticities. All long-run price and quantity changes have the same signs as those reported for the short-run simulation. However, the more elastic long-run supply elasticities reduce the size of all of the percentage changes in prices and quantities. All price and quantity changes are statistically significant except for fed cattle price, retail pork quantity, and hog price.

Long-run changes in producer surplus are reported in the second column of table 4. In the absence of increases in consumer demand, producer surplus at each level of the beef and pork industries declines in the long run. Conversely, the poultry industry gains



producer surplus at each level. Nonetheless, all of the long-run estimates are quite small because of highly elastic long-run supply functions.

Changes in producer welfare contain a dynamic element—increases or decreases in producer surplus occur over time. Therefore, it is appropriate to consider *cumulative* changes in producer surplus that accrue as an industry adjusts from a short-run to a long-run equilibrium.<sup>1</sup> To simulate these cumulative effects, we assume it takes 10 years to adjust from the short run to the long run in the meat industry. A 10-year adjustment period was selected because beef cattle inventories have been characterized by 8–12 year cycles (Rosen, Murphy, and Scheinkman, 1994). Although hog cycles are of shorter duration and poultry cycles may be nonexistent, we use the beef industry average cycle length because of linkages among the meat sectors. Ten years of producer surplus are simulated for every market level by multiplicatively increasing supply elasticities between the short-run estimates (year 1) and long-run estimates (year 10). The third column of table 4 presents the simple summation of producer and consumer surplus changes over 10 years for each market level. The fourth column gives the present value of these changes in producer and consumer surplus assuming a 5% discount rate. Over the 10-year adjustment period, producer surplus declines at every market level of the beef and pork industries. In addition, retail-level consumer surplus declines in both the beef and pork industries. Although the poultry industry gains producer surplus and retail-level consumer surplus, the entire meat industry loses producer surplus and retail-level consumer surplus if COOL does not increase consumer demand for beef and pork.

#### *Price and Quantity Effects of COOL Resulting from Changes in Consumer Demand*

A second Monte Carlo simulation was conducted to determine COOL-induced beef and pork demand increases required so that farm-level cattle and hog producers do not lose cumulative (present value) producer surplus over the 10-year adjustment period. The model predicts a one-time, permanent increase of 4.05% in beef demand and 4.45% in pork demand would be necessary for the present value of gains and losses in the feeder cattle and hog production sectors to be zero. Columns 3 and 4 of table 3 present the short-run and long-run price and quantity impacts of these demand increases. With the exception of fed cattle and hog prices (which are not statistically significant), all other prices increase in the short run. In the long run, all prices and quantities increase.

The short-run, long-run, and cumulative changes in producer surplus and retail-level consumer surplus resulting from these demand increases are reported in table 5. The slaughter and farm sectors of the beef industry lose producer surplus in the short run. The change in producer surplus at the pork slaughter level is not significantly different from zero. All other sectors gain producer surplus and retail-level consumer surplus increases. In the long run (year 10), all sectors gain producer surplus.

Over the 10-year period, the discounted present value of gains and losses of producer surplus is positive for each of the meat sectors. Changes in producer surplus for fed cattle producers are not significantly different from zero. The simulation was conducted whereby feeder cattle and hog producers neither gain nor lose producer surplus. All other market levels of the meat industry gain producer surplus.

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<sup>1</sup> The authors thank Ted Schroeder for this insight.

**Table 5. Changes in Producer Surplus for Each Market Level and Consumer Surplus at the Retail Level Assuming a 4.05% Beef Demand Increase and a 4.45% Pork Demand Increase (\$ millions)**

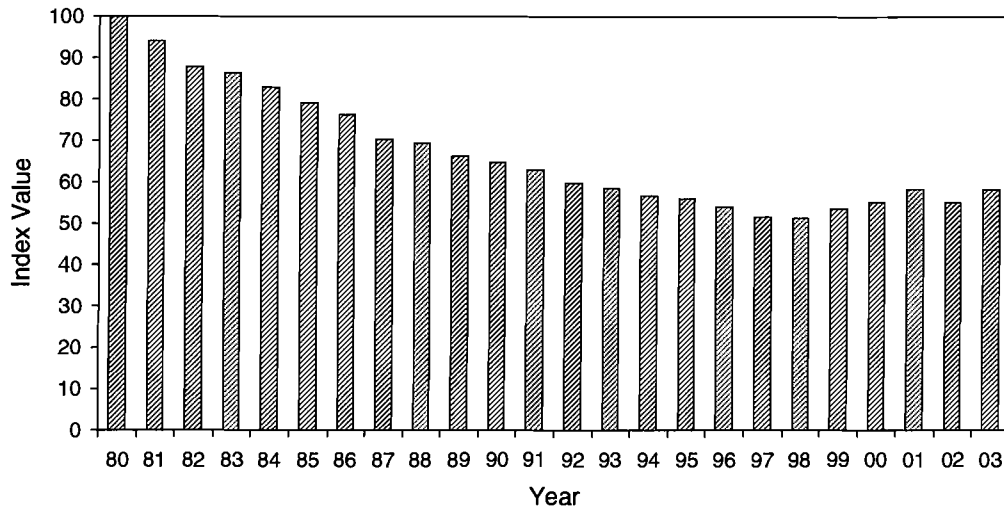
Industry/Market Level	4.05% Beef Demand Increase 4.45% Pork Demand Increase		Cumulative	Cumulative Present Value
	Short Run	Long Run		
<b>Beef Producer Surplus:</b>				
Retail Level	3,211.9	527.6	15,662.9	13,011.9
Wholesale Level	459.4	256.5	3,809.1	3,017.9
Slaughter (Fed Cattle) Level	-248.4	221.1	812.3 <sup>†</sup>	458.7 <sup>†</sup>
Farm (Feeder Cattle) Level	-68.4	101.4	85.4 <sup>†</sup>	0.0 <sup>†</sup>
<i>Total Beef Industry Producer Surplus:</i>	<b>3,354.5</b>	<b>1,106.6</b>	<b>20,369.8</b>	<b>16,488.5</b>
<b>Pork Producer Surplus:</b>				
Retail Level	1,703.1	422.0	9,457.3	7,740.6
Wholesale Level	216.3	102.9	1,348.5	1,083.1
Slaughter (Hog) Level	-85.4 <sup>†</sup>	67.8	67.7 <sup>†</sup>	0.0 <sup>†</sup>
<i>Total Pork Industry Producer Surplus:</i>	<b>1,834.0</b>	<b>592.8</b>	<b>10,873.4</b>	<b>8,823.7</b>
<b>Poultry Producer Surplus:</b>				
Retail Level	689.4	4.8	1,970.7	1,746.4
Wholesale Level	241.4	4.3	974.1	843.4
<i>Total Poultry Industry Producer Surplus:</i>	<b>930.8</b>	<b>9.1</b>	<b>2,944.8</b>	<b>2,589.8</b>
<b>Total Meat Industry Producer Surplus:</b>	<b>6,119.3</b>	<b>1,708.4</b>	<b>34,188.0</b>	<b>27,901.9</b>
<b>Retail Consumer Surplus:</b>				
Retail Beef	882.0	3,174.6	20,311.9	14,861.4
Retail Pork	1,438.3	1,944.2	17,090.7	13,019.9
Retail Poultry	419.5	254.1	4,248.6	3,342.2
<i>Total Retail Consumer Surplus:</i>	<b>2,739.8</b>	<b>5,372.9</b>	<b>41,651.3</b>	<b>31,223.5</b>

Note: Producer surplus is calculated relative to 2002 quantities and prices for livestock and meat.

<sup>†</sup> Indicates that the estimate was not significantly different from zero at the  $\alpha = 0.05$  level.

### A Discussion of the Simulation Results

The above simulation results are contingent upon the relative costs of COOL at each market level across industries. Overall, the price, quantity, and producer surplus changes are relatively small; however, COOL-induced marketing costs are also small relative to revenues generated at each market level. Furthermore, if actual COOL costs are smaller or larger than those used in this simulation, the model's estimates of price, quantity, and producer and consumer surplus changes will be proportionally smaller or larger. Nonetheless, the critical result of the simulations is that livestock producers lose producer surplus if the implementation of COOL fails to increase consumer demand for domestically produced beef and pork products. If one-time, permanent demand increases do occur, they need to exceed 4.05% for beef and 4.45% for pork if the lowest levels of the beef and pork production sectors (feeder cattle and hog producers) are to be no worse off in the long run.



Source: Livestock Marketing Information Center, 2003.

**Figure 4. U.S. beef demand index, 1980–2003 (1980 = 100)**

Whether such demand changes are considered small or large is a matter of opinion. For example, figure 4 illustrates that the demand for beef (represented by an index) declined approximately 50% between 1980 and 1998. From 1998 to 2003, beef demand increased (measured in terms of vertical shifts) an average of 4% per year. Economists have attributed this increase to higher domestic and foreign consumer incomes, higher quality beef products, and more convenient beef products (Schroeder, Marsh, and Mintert, 2000). A one-time, permanent 4.05% increase in beef demand is within the range of recent demand changes. However, it should be noted that COOL applies only to beef and pork muscle cuts and ground products sold through grocery stores. According to the National Cattlemen's Beef Association (2001), only 52% of beef volume is sold through retail outlets. Therefore, an industry-wide 4.05% increase in beef demand would have to be generated by approximately one-half of the beef market.<sup>2</sup>

### Conclusions

If COOL-induced demand increases do not occur, then all sectors of the beef and pork industries lose producer surplus. In addition, retail beef and pork consumers lose consumer surplus. To determine the ultimate effects of COOL on producer- and retail-level consumer surplus, the discounted present value of cumulative effects of producer and consumer surplus gains and losses should be calculated over a sufficiently long period to allow for gradual changes in supply responses. Retail beef and pork demand would have to experience one-time, permanent increases of 4.05% and 4.45%, respectively, if feeder cattle and hog producers were to experience no loss of producer surplus. Because COOL applies only to beef and pork muscle cuts and ground products sold through retail outlets, this sector of the beef and pork industries must generate the

<sup>2</sup> We appreciate this insight provided by Don Seifert, bass player for the "Ringling 5."

entire demand increase. These results are, of course, specific to our assumptions regarding the size and distribution of marketing costs resulting from the implementation of COOL.

The poultry industry is the only unequivocal winner of the implementation of COOL. It was assumed here that the poultry industry's cost structure was unaffected by COOL because poultry is currently excluded from COOL legislation. Consequently, increased COOL marketing costs in the beef and pork sectors which increase retail beef and pork prices encourage consumers to substitute toward poultry products. This demand increase causes subsequent increases in equilibrium poultry prices, quantities, and producer and consumer surplus in the poultry industry.

COOL is receiving a chilly reception by some market participants primarily because of the uncertainty regarding potential increases in demand and costs resulting from the legislation. Interestingly, the most vocal proponents of COOL have been groups principally representing feeder cattle producers. Yet, if COOL-induced demand increases are relatively small, upstream market participants may gain producer surplus while feeder cattle producers will lose producer surplus. Thus, the strong support of COOL provided by some feeder cattle producers either suggests those producers expect COOL-induced beef demand increases to more than offset additional marketing costs, or they are unaware that the incidence of both costs and benefits is largely the result of relative supply and demand elasticities among market levels.

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### **Appendix: Generating Correlated Samples Using Rank Order Procedures**

This appendix presents a variation of Iman and Conover's (1982) procedures for generating a correlated multivariate sample by reordering individually and independently generated marginal samples. (A slightly different variation is utilized by Hart, Hayes, and Babcock, 2003.) The Iman-Conover procedures preserve all marginal samples, and thus are especially useful when the marginal distributions are distorted by traditional correlation generating procedures.

Algebraically, a variation of the Iman-Conover procedure can be described as follows:

- Generate a multivariate sample  $\mathbf{X}_{n \times p}$  with  $n$  realizations on each of  $p$  random variables. The marginal sample in column  $j$  (i.e.,  $\mathbf{x}_j$ ) may be independently generated and need not be from the same distributional family as any of the remaining  $p - 1$  random variables. Denote  $\tilde{\mathbf{X}}$  as a matrix in which the elements in each column of  $\mathbf{X}$  have been reordered. Let the desired or “target” Pearson correlation matrix for  $\tilde{\mathbf{X}}$  be  $\Sigma_X$ . The following procedures involve the derivation of a matrix  $\tilde{\mathbf{R}}_{n \times p}$  whose sample Pearson covariance matrix exactly equals  $\Sigma_X$ . The column elements of  $\mathbf{X}$  are then reordered so that each element of each column in  $\tilde{\mathbf{X}}$  has the same column rank as the corresponding element in  $\tilde{\mathbf{R}}$ .
- Generate a sample  $\mathbf{R}_{n \times p}$  from the normal or some other continuous distribution. For our application, we generate  $r_{ij} \sim$  i.i.d. normal  $(0, 1)$  using a standard pseudo-random number generator.
- Compute the sample covariance matrix of  $\mathbf{R}$ :

$$(A1) \quad \hat{\Sigma}_{\mathbf{R}} = \mathbf{R}' \left[ \left( \frac{1}{n-1} \right) \left( I_n - \left( \frac{1}{n} \right) \mathbf{1}_n \mathbf{1}_n' \right) \right] \mathbf{R} = \mathbf{R}' \mathbf{C} \mathbf{R},$$

where  $\hat{\Sigma}_{\mathbf{R}}$  is the sample covariance matrix,  $\mathbf{1}_n$  is an  $\{n \times 1\}$  column vector with each element equal to one, and  $\mathbf{C}$  is the sample covariance operator. Note that, for finite samples,  $\hat{\Sigma}_{\mathbf{R}}$  may not equal  $I_p$  even if all  $r_{ij}$  are generated independently from normal  $(0, 1)$ .

- Use the Cholesky or other decomposition algorithm to decompose  $\hat{\Sigma}_{\mathbf{R}}$  as:

$$(A2) \quad \hat{\Sigma}_{\mathbf{R}} = \mathbf{U}' \mathbf{U},$$

where  $\mathbf{U}$  is an invertable matrix.

- Similarly, decompose the target correlation matrix  $\Sigma_X$  as:

$$(A3) \quad \Sigma_X = \mathbf{V}' \mathbf{V}.$$

- Construct the transformed matrix:

$$(A4) \quad \tilde{\mathbf{R}}_{n \times p} = \mathbf{R} \mathbf{U}^{-1} \mathbf{V},$$

for which:

$$\hat{\Sigma}_{\tilde{\mathbf{R}}} = \tilde{\mathbf{R}}' \mathbf{C} \tilde{\mathbf{R}} = \mathbf{V}' (\mathbf{U}^{-1})' (\mathbf{R}' \mathbf{C} \mathbf{R}) \mathbf{U}^{-1} \mathbf{V} = \mathbf{V}' (\mathbf{U}')^{-1} (\mathbf{U}' \mathbf{U}) \mathbf{U}^{-1} \mathbf{V} = \mathbf{V}' \mathbf{V} = \Sigma_X,$$

or

$$(A5) \quad \hat{\Sigma}_{\tilde{\mathbf{R}}} = \Sigma_X.$$

By construction,  $\tilde{\mathbf{R}}$  has sample covariance and correlation matrix  $\Sigma_X$ .

- $\tilde{\mathbf{X}}$  is obtained by reordering the columns of  $\mathbf{X}$  to have the same rank order as the columns of  $\tilde{\mathbf{R}}$ . By construct,  $\tilde{\mathbf{R}}$  and  $\tilde{\mathbf{X}}$  have identical Spearman rank correlations. For most continuous distributions, the sample Pearson correlation of  $\tilde{\mathbf{X}}$  will approach  $\Sigma_X$  as  $n$  gets larger.