EFFECTS OF COUNTRY-OF-ORIGIN LABELING

(COOL) IN THE U.S. MEAT INDUSTRY

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CHAPTER I

INTRODUCTION

The 2002 Farm Bill (PL 107-171) contains a Country-of-Origin Labeling (COOL) provision that requires retailers to label the country of origin of any covered commodity. The COOL was initially planned to be mandatory from September 30, 2004 but has been delayed for two years. The covered commodities in the COOL provision include whole muscle and ground products of beef, lamb, pork, seafood (wild and farm-raised fish and shell fish), fresh and frozen fruits, vegetables and peanuts. Although the implementation of this provision is expected to affect U.S. agriculture and food industries as well as trade relations with neighboring countries significantly, there is still a great deal of uncertainty regarding the COOL effect. Some producer groups (e.g., R-CALF United Stockgrowers of America) expect that the new provision would increase the demand for U.S. beef by promoting beef born, raised, and processed in the United States. However, producer groups such as National Cattlemen's Beef Association (NCBA) and National Pork Producers Council (NPPC) do not support the mandatory COOL because they expect the cost would outweigh the benefit. Packers and retailers are also concerned about the increased labor and infrastructure cost due to the COOL requirements. A few studies have evaluated the effects of COOL in the livestock industry, but most of them have failed to address the effects of imperfect competition particularly at packing and retailing stages.

The structure of beef packing industry in the United States has become increasingly concentrated within the past decade and there are statistically significant monopoly/monopsony price distortions in slaughter cattle and wholesale beef markets (Schroeter, 1988). Therefore, it is not surprising that non-competitive performance has to be taken into account when evaluating the cost effect caused by COOL. Under this condition, the important but still unanswered question is: will COOL benefit U.S. beef producers? And how will the cost of COOL affect each supply level according to the beef multi-production system?

Problem Statement

The country-original-labeling (COOL) regulation is not only expected to enhance food safety and welfare of domestic consumers, but also expected to increase the producer cost. Opponents of this legislation believe that the cost will harm the producers. Supporters argue that when domestic consumers know the original source of foods, they may be willing to buy more domestic foods (Plain and Grimes). As a result, benefits will offset costs for producers.

In addition, economic theory suggests that if consumers' demand for beef and pork products is more inelastic, consumers will bear more cost of COOL, while if the consumers' demand for beef and pork products is more elastic, producers will bear more cost of COOL. As a result the impacts of COOL on producers and consumers should depend on own and cross price elasticities in the met industry.

Objectives

The general objective of this study is to estimate the effects of Country-of-Origin Labeling policy in the U.S. meat industry. The study analyzes factors that affect the distribution of COOL cost between producers and consumers with consideration of market power and trade. The specific objectives of this study are tow fold: (1) provide theoretical analysis about how domestic producers' derived demand would change under alternative cross price elasticities (cross price elasticities of domestic product demand with respect to the price of imported product); COOL cost (increased marketing and producer cost) and market power (market power in both upstream and downstream markets); and (2) to examine COOL impact on domestic producers with different COOL cost scenarios and cross price elasticities with three-sector equilibrium displacement model (EDM) of the U.S. meat market .

This equilibrium displacement model (EDM) for the U.S. meat industry includes substitution relations between domestic and foreign beef, pork, and poultry products under imperfectly competitive market conditions at both processing and retailing levels. Unlike previous studies, the study examines COOL impact on imperfectly competitive meat industry with variable proportions.

The following chapter summarizes a conceptual framework for the analytical model used in this study. The equilibrium displacement model for the US meat industry and its applicability to the identified study problems are reviewed in Chapter III. Data sources, collection methods and empirical models are presented in Chapter IV. Chapter

V discusses empirical findings and implications. Finally, the last chapter provides concluding remarks, limitations of the current study, and suggestions for future research.

CHAPTER II

LITERATURE REVIEW

The literature reviewed for this study can be divided into four areas: COOL cost estimation and the premium that consumers are willing to pay for the U.S. origin meat, impact of COOL cost on domestic producers and consumers, market power in beef and pork industries, and meat trade between US and foreign countries.

COOL Cost Estimation and Consumers' Willingness-to-Pay Premium

USDA's Agricultural Marketing Service published a Notice (USDA-AMS, 2002) and reported their estimation for the COOL cost. They expected a $1.968 billion for the first year's record-keeping costs. For this cost, $1 billion is born by producers and $340 million by food handlers and $627.75 million by retailers.

Some researchers argue that different assumptions will result in different estimated costs. For example, Van Sickle et al. assume that if all imported products except U.S. origin ones are required to be labeled, the cost will be much less than the cost estimated by USDA. According to their assumption, the record keeping cost associated with COOL will be between $69.86 million and $193.43 million. Compared to other researcher groups, Van Sickle et al. are more optimistic about the COOL impacts. Van Sickle et al. estimate that U.S. consumers will be likely to pay a premium for domestic beef up to $3.0 billion. Therefore, the estimated benefit will offset the expected COOL cost.

On the other hand, some individuals and groups claim that the USDA's result underestimates the COOL cost. More pessimistic estimation was reported by Sparks Companies, Inc. and Cattle Buyers Weekly. They assumes that record keeping systems will be required throughout the whole supply chain and their results show that COOL will contribute to an increase in total cost from $3.66 to $5.60 billion dollars even without cost in the lamb and peanut sectors. Plain and Grimes argue that consumers will not pay a premium for beef since most of beef in retail stores are already the U.S. original products.

Effect of COOL Cost on Domestic Producers and Consumers

The COOL cost will be borne by producers and consumers. Lusk and Anderson (2003) developed an equilibrium displacement model (EDM) for farm, wholesale, and retail markets for beef, pork and poultry. This EDM can be used to analyze the impact of COOL cost on producers and consumers. Empirical results indicate that when consumers' willingness-to-pay increases by 2% to 3%, the producer welfare lost will be offset. Brester and Marsh (2004) used linear equilibrium model to simulate the short-run and long-run changes in equilibrium prices and quantities of livestock products that would result from implementing COOL policy. Their research shows that there will be a significantly large increase in consumer demand for beef and pork in the short run; in the long run, a 0.45% annual increase in consumer demand for beef and a 0.50% annual increase in pork demand.

Market Power in the U.S. Meat Industry

The structure of beef packing and retailing in the United States has become increasingly concentrated within the past decade. Applying Appelbaum's framework (1979), Schroeter estimated the degree of oligopolistic and oligopsonistic performance in the U.S. beef packing market (1988). The results confirmed the presence of small price distortions.

Many studies have typically assumed an integrated processing/retailing sector so that upstream and downstream market power of the integrated sector can be conveniently derived from processor's profit maximization problem (e.g., Azzam; Alston, Sexton, and Zhang; and Kinnucan). However this type of modeling does not take into account of the effect of market power in retailing. Several studies found that the observed food price depends on the relative degree of market power of processors and retailers (e.g., Binkley and Connor; Richards et al.). We improved previous studies by allowing retailer's oligopsony power to separate from processor's market power. To account for the effect of market power at the retail sector, profit maximization conditions for three sectors (retailing, processing, and farm) are simultaneously solved and the equilibrium conditions are incorporated in a multi-equation model.

Based on Azzam (1998) and Holloway (1991)'s work, Kinnucan (2003) extended Muth's (1965) model and analyzed the impact of food industry market power on farmers' incentive to promote the products. Applying the model to the US beef industry, he found that for plausible parameter values market power reduces farmers' incentives to promote the products.

Based on above studies, market power should not be neglect when examine impact of COOL in the U.S. meat industry.

Trade between Domestic and Foreign Products

The United States mainly import lightweight feeder cattle from Mexico, trimmings and ground beef from Australia and New Zealand, and a mix of high-value muscle cuts, manufacturing/trimming beef, fed cattle, feeder cattle, and fed cattle carcasses from Canada. The USDA reported that U.S. imported around 28% of its beef consumption in 2002. In 2002 the United States imported approximately 1.1 billion pounds of pork, which represented about 5.2% of total U.S. pork supplies. Over 80% of those imports originated in Canada.

United States only imports small amount of broilers because U.S. has the largest producers and exporters of poultry in the world. The domestic consumption for poultry is higher than that for beef or pork but less than the total red meat consumption. Since imported beef and pork consumption is relatively large, this study will include them as substitute products for domestic meat, but the poultry import will be neglected in the EDM.

CHAPTER III

CONCEPTUAL FRAMEWORK

This study considers the production of beef, pork and poultry meats from the perspective of three stages: producing, processing and retailing. At the production level, animals are bred into certain weight, sold to processors to be slaughtered and processed. Then the final products are sold to retailers such as major supermarket chains.

As Figure 1 shows, fed cattle, trimmings, ground beef/pork and other meat products can be imported from foreign countries at processing and retail levels. COOL will has effects on the consumption structure of the U.S. meat market, especially on the consumption tendency between domestic and foreign meats. Before COOL, consumers could not differentiate meats from different origins and as a result, meat prices did not change by the country of origin. But after COOL, consumer can differentiate domestic goods from foreign goods. Then, the price of domestic and foreign goods may be different and may move separately like different kinds of products. So this study includes the substitute relationships between domestic and foreign meat.

This study also assumes variable input substitution between farm level input and market input; processors have oligopsony power over farmers while retailers have oligopoly market power over consumers.

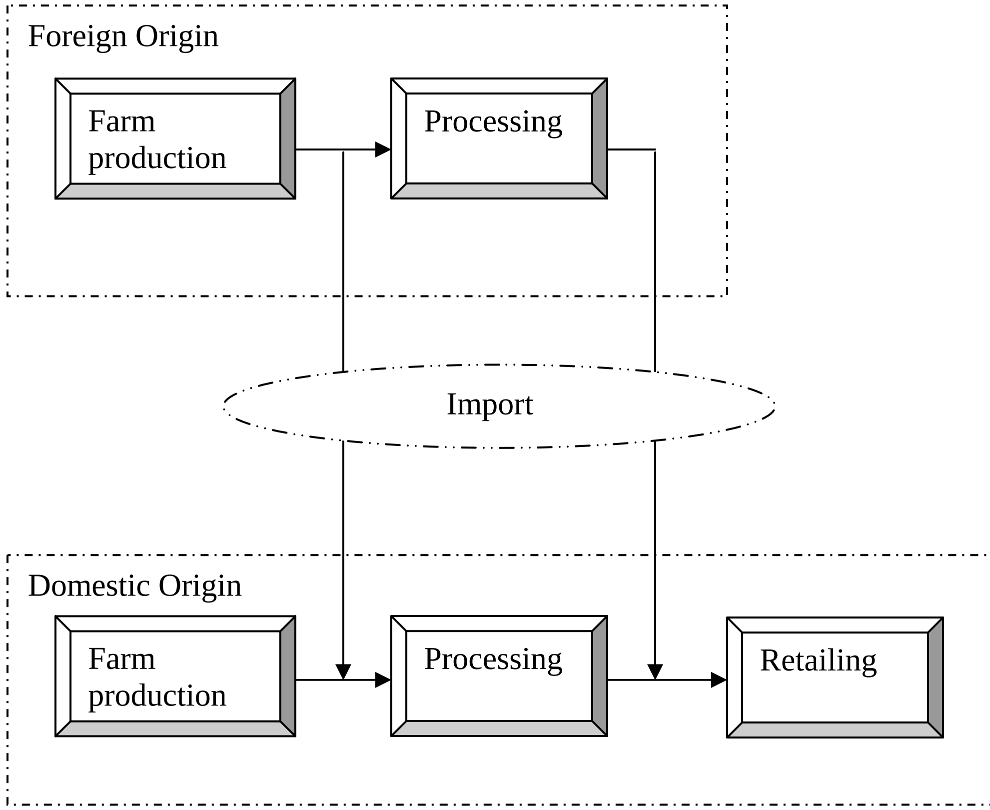

Figure 1. Meat Import by the United State

Once COOL is implemented, the cost increase will affect the action of all participants in meat supply sectors as well as the response of consumers. COOL causes an increase in price at farm, packing and retail levels. After we set up the equilibrium displacement model, we take COOL cost as exogenous supply shifters in different sectors to examine the response of each production level. The supply curve will shift upward because of the COOL cost, and the demand curve for domestic meat will shift right if consumers would like to buy more domestic origin meats.

The COOL effect at retail the level is illustrated in Figure 2.

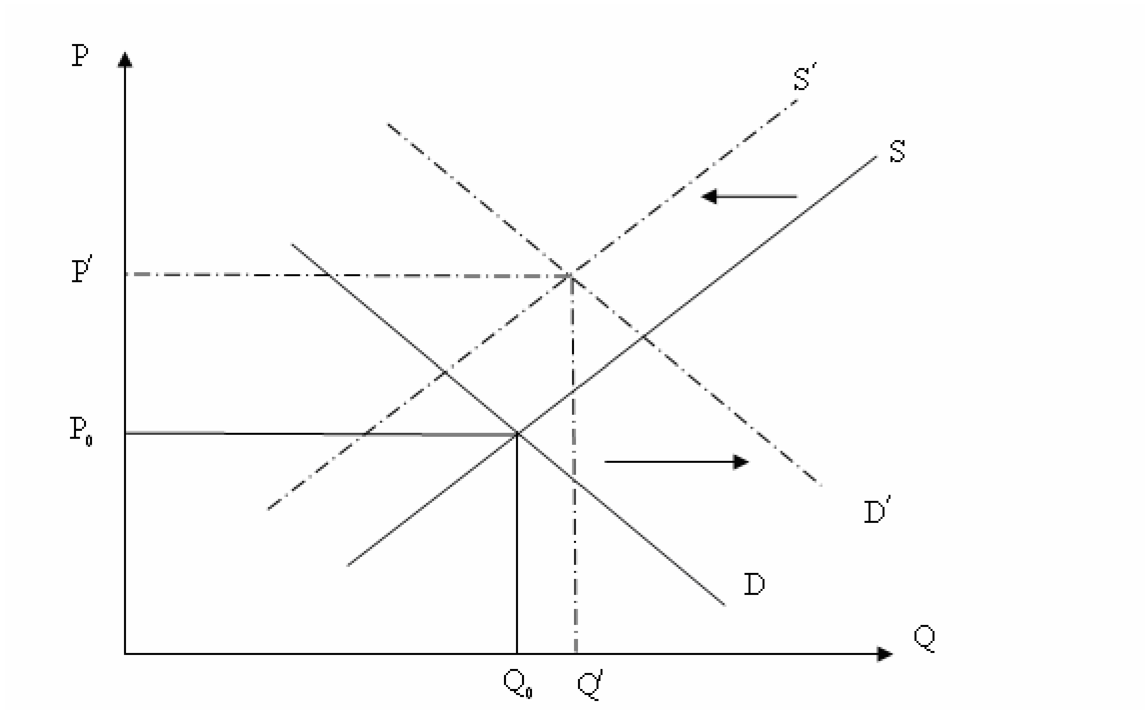

Figure 2. Effects of Imposing COOL Costs on the Retail Level

Here P_0 is the original price of meat. Q_0 is the original consumption quantity of meat. S is the supply curve without cost. S' is the supply curve with cost increase. D is the demand curve before COOL. D' is the demand curve after COOL.

This study assumes that no other demand and supply factors are affected due to COOL other than the price and quantity. We use the equilibrium displacement model to calculate relative changes in price and quantity in response to COOL-induced supply and demand shifters.

Hypotheses

Four hypotheses to be tested in this study include:

(1) The cost of COOL will make domestic producers worse off if there is no demand increase; meanwhile, poultry industry will be better off since consumers will buy more poultry as a substitute of beef and pork.

(2) The cost of COOL would outweigh the overall industry benefit unless COOL leads to less cost increase and an increase in consumers' willingness-to-pay.

(3) The more elastic the own price elasticity of domestic beef and pork, the more COOL cost domestic producers will bear.

(4) The producers would be better off if consumers choose to buy more domestic origin product and/or cross price elasticities to foreign products get more elastic.

CHAPTER IV

PROCEDURES AND DATA SOURCES

The study develops a Muth-type equilibrium displacement model that is able to estimate the impact of COOL on meat production system and its trade relations. The model includes equilibrium conditions of each production stage with consideration of trade and market structure. A unique feature of this model is that it allows retailer's oligopsony power to separate from processor's market power. As stated earlier, a model disaggregated along vertical directions is set up in order to study the COOL costs in different sectors. After the COOL implement, consumers can distinguish domestic beef from imported beef. As the price of these two kinds of beef should be different, we treat them as two different commodities in this study.

First we set up the demand and supply functions for each stage of production system (foreign-origin beef and pork, domestic-origin beef and pork, and domestic poultry). To account for market power in processing and retailing sectors, this study derives imperfect competitive conjecture variables through firm's profit maximization problem. We will develop the model by totally differentiating the structural equations and using log differentials to convert the original functions to elasticity form. Then using the linear elasticity model, we will calculate relative changes in price and quantity in response to COOL-induced supply and demand shifts. The model is also based on the variable proportion technology.

The model will be simulated for three different scenarios of cost increases (low, medium, and high) and four additional scenarios on consumers' willingness to pay for "U. S. Origin" beef (no change, 2%, and 5% increase in willingness to pay) under alternative demand, supply and substitution elasticities. The model will also be simulated for three different scenarios of market structure (perfectly competitive in all sectors, imperfectly competitive in processing sector only, and imperfectly competitive in both retailing and processing sectors). Data for estimation of the cost increase due to COOL are obtained from USDA publications, journal articles, and unpublished reports from consulting companies. Demand, supply and substitution elasticites for the U.S. beef industry are collected from previous studies.

Basic Formulation of the Mathematical Structure Model

First, the model comprises horizontally linked domestic beef, foreign beef, domestic pork, foreign pork, domestic poultry with the vertical linkage of farm, wholesale, and retail sectors. Second, this model permits variable proportions by incorporating the elasticity of substitution between farm and marketing inputs. Third, market power is included in this model. Finally, each industry combines a farm-based input Q^F with a bundle of marketing inputs Q^M to produce retail beef Q^R under conditions of constant returns to scale (CRTS).

Processors take the price of marketing services P^M as given, but they have sufficient market presence to influence the price of the farm-based input P^F, and the price of the retail beef P_B^R. That is, downstream processors/retailers exercise oligopoly power in the retail beef market and oligopsony power in the cattle market, but are individually too small in relation to the total food economy to influence market input price P^M. Consumer demand for domestic beef is separated from foreign beef sold at domestic market. That is because as COOL policy issues, consumer can distinguish domestic beef from foreign beef, so these two different original beef can be regarded as different goods in the retail market and the prices will not move together. After COOL policy issues, the farmer and marketers will bear a cost increase.

Under these assumptions a structural model is represented by:

Retail (Demand)

Beef

(4. 1) $$Q_{BD}^R = Q_{BD}^R\,(P_{BD}^R, P_{PD}^R, P_C^R, P_{BF}^R, P_{PF}^R)$$

(4. 2) $$Q_{BF}^R = Q_{BF}^R\,(P_{BD}^R, P_{PD}^R, P_C^R, P_{BF}^R, P_{PF}^R)$$

Pork

(4. 3) $$Q_{PD}^R = Q_{PD}^R\,(P_{BD}^R, P_{PD}^R, P_C^R, P_{BF}^R, P_{PF}^R)$$

(4. 4) $$Q_{PF}^R = Q_{PF}^R\,(P_{BD}^R, P_{PD}^R, P_C^R, P_{BF}^R, P_{PF}^R)$$

Poultry

(4. 5) $$Q_C^R = Q_{BD}^R\,(P_{BD}^R, P_{PD}^R, P_C^R, P_{BF}^R, P_{PF}^R)$$

Retail (Supply)

Beef

(4. 6) $$Q_{BD}^R = f^B\,(Q_{BD}^F, Q_{BD}^M)$$

(4. 7) $$Q_{BF}^{R} = g^{B}\ (Q_{BF}^{F}, Q_{BF}^{M})$$

Pork

(4. 8) $$Q_{PD}^{R} = f^{P}\ (Q_{PD}^{F}, Q_{PD}^{M})$$

(4. 9) $$Q_{PF}^{R} = g^{P}\ (Q_{PF}^{F}, Q_{PF}^{M})$$

Poultry

(4. 10) $$Q_{C}^{R} = f^{C}\ (Q_{C}^{F}, Q_{C}^{M})$$

Farm-level derived demand

Beef

(4. 11) $$P_{BD}^{F}(1+\Omega_{B}) = P_{BD}^{R}\ f_{Q_{BD}^{F}}^{B}(1+\psi_{B})$$

(4. 12) $$P_{BF}^{F}(1+\Omega_{B}) = P_{BF}^{R}\ g_{Q_{BF}^{F}}^{B}\ (1+\psi_{B})$$

(4. 13) $$P_{BD}^{M} = P_{BD}^{R}\ f_{Q_{BD}^{M}}^{B}\ (1+\psi_{B})$$

(4. 14) $$P_{BF}^{M} = P_{BF}^{R}\ g_{Q_{BF}^{M}}^{B}(1+\psi_{B})$$

Pork

(4. 15) $$P_{PD}^{F}(1+\Omega_{P}) = P_{PD}^{R}\ f_{Q_{PD}^{F}}^{P}(1+\psi_{P})$$

(4. 16) $$P_{PF}^{F}(1+\Omega_{P}) = P_{PF}^{R}\ g_{Q_{PF}^{F}}^{P}\ (1+\psi_{P})$$

(4. 17) $$P_{PD}^{M} = P_{PD}^{R}\ f_{Q_{PD}^{M}}^{P}\ (1+\psi_{P})$$

(4. 18) $$P_{PF}^{M} = P_{PF}^{R}\ g_{Q_{PF}^{M}}^{P}$$

Poultry

(4. 19) $$P_{C}^{F}\ (1+\Omega_{C}) = P_{C}^{R}\ f_{Q_{C}^{F}}^{C}\ (1+\psi_{C})$$

(4. 20) $$P_C^M = P_C^R \; f_{Q_C^M}^C \; (1+\psi_C)$$

Farm-level supply

Beef

(4. 21) $$P_{BD}^F = P_{BD}^F \; (Q_{BD}^F, \mu_{BD})$$

(4. 22) $$P_{BF}^F = P_{BF}^F \; (Q_{BF}^F, \mu_{BF})$$

Pork

(4. 23) $$P_{PD}^F = P_{PD}^F \; (Q_{PD}^F, \mu_{PD})$$

(4. 24) $$P_{PF}^F = P_{PF}^F \; (Q_{PF}^F, \mu_{PF})$$

Poultry

(4. 25) $$P_C^F = P_C^F \; (Q_C^F)$$

Market Input Supply

(4. 26) $$Q_{BD}^M = Q_{BD}^M (P_{BD}^M, \gamma_B)$$

(4. 27) $$Q_{BF}^M = Q_{BF}^M (P_{BF}^M, \gamma_B)$$

(4. 28) $$Q_{PD}^M = Q_{PD}^M (P_{PD}^M, \gamma_P)$$

(4. 29) $$Q_{PF}^M = Q_{PF}^M (P_{PF}^M, \gamma_P)$$

(4. 30) $$Q_{CF}^M = Q_{CF}^M (P_{CF}^M)$$

Superscripts R, F, M denote retail, farm, market prices and quantities respectively; the subscripts B, P, C denotes beef, pork and poultry respectively; subscripts D and F denote domestic and foreign origin separately.

Equations (4.1) to (4.5) are retail demand for domestic origin and foreign origin beef, pork and poultry in the U. S. meat market. In this model domestic origin beef, pork, and poultry, and foreign origin beef and pork are substitute goods. This model does not consider poultry import issue; instead, it only includes domestic poultry demand and supply. Q_{BD}^{R}, Q_{BF}^{R}, Q_{PD}^{R}, Q_{PF}^{R}, and Q_{BF}^{R} are retail demand; P_{BD}^{R}, P_{BF}^{R}, P_{PD}^{R}, P_{PF}^{R} and P_{C}^{R} are retail prices for domestic and foreign origin beef, pork and poultry.

Equations (4.6) to (4.10) are supply functions. The industry combines farm-based inputs Q_{ij}^{F} (i =beef, pork, poultry; j =domestic, foreign) with a bundle of marketing inputs Q_{ij}^{M} to produce retail products Q_{ij}^{R} under conditions of constant returns to scale (CRTS). Equations (4.11) to (4.20) are farm level derived demand functions. Firms in the industry take the price of marketing services P_{ij}^{M} as given, but they have sufficient market presence to influence the price of the farm-based inputs P_{ij}^{F} and the price of the retail products P_{ij}^{R}. That is, downstream firms exercise oligopoly power in the Q_{ij}^{R} market and exercise oligopsony power in the Q_{ij}^{F} market. $f_{Q_{iD}^{F}}^{i} = \dfrac{\partial f^{i}}{\partial Q_{iD}^{F}}$ (i =beef, pork, poultry) are domestic farm level input quantity Q_{iD}^{F}'s marginal product function; $g_{Q_{iF}^{F}}^{i} = \dfrac{\partial g^{i}}{\partial Q_{iF}^{F}}$ (i =beef, pork, poultry) are foreign farm level input quantity Q_{iF}^{F}'s marginal product function. $\psi_{i} = \dfrac{\xi_{i}}{\eta_{ij}}$ (i = beef, pork, poultry; j =domestic, foreign) are the Lerner index that denotes oligopoly power, where η_{ij} are the retail demand elasticity of j original meat i, and ξ_{i} are the output conjectural elasticity ($\xi_{i} \in [0, \quad 1]$, $\xi = 0$ for perfect competition and $\xi = 1$ for pure monopoly). $\Omega_{ij} = \dfrac{\theta_{ij}}{\varepsilon_{ij}}$ are the Lerner index to denote oligopsony power in i^{th} meat market, where ε_{ij} is the supply elasticity for Q_{ij}^{F}, and θ is the input conjectural elasticity ($\theta \in [0,\ 1]$, $\theta = 0$ for perfect competition and $\theta = 1$ for pure monopoly).

Equations (4.21) to (4.25) are farm level supply functions and (4.26) to (4.30) are marketing input supply functions. μ_{ij} and γ_{ij} are COOL caused increasing in cost for meat i of origin j at farm level and market level respectively.

The model contains 25 endogenous variables ($Q_{BD}^{R}, Q_{BD}^{F}, P_{BD}^{F}, P_{BD}^{R}, Q_{BF}^{R}, Q_{BF}^{F}, P_{BF}^{F}, P_{BF}^{R}, Q_{BD}^{M}, Q_{BF}^{M}, Q_{PD}^{R}, Q_{PD}^{F}, P_{PD}^{F}, P_{PD}^{R}, Q_{PF}^{R}, Q_{PF}^{F}, P_{PF}^{F}, P_{PF}^{R}, Q_{PD}^{M}, Q_{PF}^{M}, Q_{C}^{R}, Q_{C}^{F}, P_{C}^{F}, P_{C}^{R}, Q_{C}^{M}$), 8 exogenous variables($P_{BD}^{M}, P_{BF}^{M}, P_{PD}^{M}, P_{PF}^{M}, P_{C}^{M}, \mu_{BD}, \mu_{BF}, \mu_{PD}, \mu_{PF}, \gamma_{BD}, \gamma_{BF}, \gamma_{PD}, \gamma_{PF}$). Following the standard assumptions of this type of model (Muth, 1964; Gardner, 1975), the parameters are treated as exogenous variables.

The EDM Model

Following Muth (1964), structural equations, (4. 1) - (4. 25), are expressed in percentage changes as:

<u>Retail (Demand)</u>

Beef

(4. 31) $\quad \mathrm{E}\,Q_{BD}^{R} = \eta_{(BD,BD)}(\mathrm{E}\,P_{BD}^{R} - \delta_B) + \eta_{(BD,PD)}(\mathrm{E}\,P_{PD}^{R} - \delta_P) + \eta_{(BD,C)}\mathrm{E}\,P_{C}^{R} + \eta_{(BD,BF)}\mathrm{E}\,P_{BF}^{R} + \eta_{(BD,PF)}\mathrm{E}\,P_{PF}^{R}$

(4. 32) $\quad \mathrm{E}\,Q_{BF}^{R} = \eta_{(BF,BD)}(\mathrm{E}\,P_{BD}^{R} - \delta_B) + \eta_{(BF,PD)}(\mathrm{E}\,P_{PD}^{R} - \delta_P) + \eta_{(BF,C)}\mathrm{E}\,P_{C}^{R} + \eta_{(BF,BF)}\mathrm{E}\,P_{BF}^{R} + \eta_{(BF,PF)}\mathrm{E}\,P_{PF}^{R}$

Pork

(4. 33) $\mathrm{E}\,Q_{PD}^{R} = \eta_{(PD,BD)}(\mathrm{E}\,P_{BD}^{R} - \delta_B) + \eta_{(PD,PD)}(\mathrm{E}\,P_{PD}^{R} - \delta_P) + \eta_{(PD,C)}\,\mathrm{E}\,P_{C}^{R} + \eta_{(PD,BF)}\,\mathrm{E}\,P_{BF}^{R} + \eta_{(PD,PF)}\,\mathrm{E}\,P_{PF}^{R}$

(4. 34) $\mathrm{E}\,Q_{PF}^{R} = \eta_{(PF,BD)}(\mathrm{E}\,P_{BD}^{R} - \delta_B) + \eta_{(PF,PD)}(\mathrm{E}\,P_{PD}^{R} - \delta_P) + \eta_{(PF,C)}\,\mathrm{E}\,P_{C}^{R} + \eta_{(PF,BF)}\,\mathrm{E}\,P_{BF}^{R} + \eta_{(PF,PF)}\,\mathrm{E}\,P_{PF}^{R}$

Poultry

(4. 35) $\mathrm{E}\,Q_{C}^{R} = \eta_{(C,BD)}(\mathrm{E}\,P_{BD}^{R} - \delta_B) + \eta_{(C,PD)}(\mathrm{E}\,P_{PD}^{R} - \delta_P) + \eta_{(C,C)}\,\mathrm{E}\,P_{C}^{R} + \eta_{(C,BF)}\,\mathrm{E}\,P_{BF}^{R} + \eta_{(C,PF)}\,\mathrm{E}\,P_{PF}^{R}$

Retail (Supply)

Beef

(4. 36) $\mathrm{E}\,Q_{BD}^{R} = \kappa_B\,\mathrm{E}\,Q_{BD}^{F} + (1-\kappa_B)\,\mathrm{E}\,Q_{D}^{M}$

(4. 37) $\mathrm{E}\,Q_{BF}^{R} = \kappa_B\,\mathrm{E}\,Q_{BF}^{F} + (1-\kappa_B)\,\mathrm{E}\,Q_{F}^{M}$

Pork

(4. 38) $\mathrm{E}\,Q_{PD}^{R} = \kappa_P\,\mathrm{E}\,Q_{PD}^{F} + (1-\kappa_P)\,\mathrm{E}\,Q_{D}^{M}$

(4. 39) $\mathrm{E}\,Q_{PF}^{R} = \kappa_P\,\mathrm{E}\,Q_{PF}^{F} + (1-\kappa_P)\,\mathrm{E}\,Q_{F}^{M}$

Poultry

(4. 40) $\mathrm{E}\,Q_{C}^{R} = \kappa_C\,\mathrm{E}\,Q_{C}^{F} + (1-\kappa_C)\,\mathrm{E}\,Q_{D}^{M}$

Derived Demand for Farm-level Input

Beef

(4. 41) $\mathrm{E}\,P_{BD}^{F} = \mathrm{E}\,P_{BD}^{R} - \frac{1-\kappa_B}{\sigma_B}\,\mathrm{E}\,Q_{BD}^{F} + \frac{1-\kappa_B}{\sigma_B}\,\mathrm{E}\,Q_{D}^{M} + \eta_{B\psi}\,\mathrm{E}\,\psi_B - \varepsilon_{B\Omega}\,\mathrm{E}\,\Omega_B$

(4. 42) $\mathrm{E}\,P_{BF}^{F} = \mathrm{E}\,P_{BF}^{R} - \frac{1-\kappa_B}{\sigma_B}\,\mathrm{E}\,Q_{BF}^{F} + \frac{1-\kappa_B}{\sigma_B}\,\mathrm{E}\,Q_{F}^{M} + \eta_{B\psi}\,\mathrm{E}\,\psi_B - \varepsilon_{B\Omega}\,\mathrm{E}\,\Omega_B$

Pork

(4. 45) $\mathrm{E}\,P_{PD}^{F} = \mathrm{E}\,P_{PD}^{R} - \frac{1-\kappa_P}{\sigma_P}\,\mathrm{E}\,Q_{PD}^{F} + \frac{1-\kappa_P}{\sigma_P}\,\mathrm{E}\,Q_{D}^{M} + \eta_{P\psi}\,\mathrm{E}\,\psi_P - \varepsilon_{P\Omega}\,\mathrm{E}\,\Omega_P$

(4. 46) $$\mathrm{E}\,P_{PF}^{F} = \mathrm{E}\,P_{PF}^{R} - \frac{1-\kappa_P}{\sigma_P}\,\mathrm{E}\,Q_{PF}^{F} + \frac{1-\kappa_P}{\sigma_P}\,\mathrm{E}\,Q_{D}^{M} + \eta_{P\psi}\,\mathrm{E}\,\psi_P - \varepsilon_{P\Omega}\,\mathrm{E}\,\Omega_P$$

Poultry

(4. 49) $$\mathrm{E}\,P_{C}^{F} = \mathrm{E}\,P_{C}^{R} - \frac{1-\kappa_C}{\sigma_C}\,\mathrm{E}\,Q_{C}^{F} + \frac{1-\kappa_C}{\sigma_C}\,\mathrm{E}\,Q_{D}^{M} + \eta_{C\psi}\,\mathrm{E}\,\psi_C - \varepsilon_{C\Omega}\,\mathrm{E}\,\Omega_C$$

Derived Demand for Marketing Input

Beef

(4. 43) $$EP_{MD} + \frac{E\gamma_B}{1-\kappa_B} = \mathrm{E}\,P_{BD}^{R} + \frac{\kappa_B}{\sigma_B}\,\mathrm{E}\,Q_{BD}^{F} - \frac{\kappa_B}{\sigma_B}\,\mathrm{E}\,Q_{D}^{M} + \eta_{B\psi}\,\mathrm{E}\,\psi_B$$

(4. 44) $$EP_{MF} + \frac{E\gamma_B}{1-\kappa_B} = \mathrm{E}\,P_{BF}^{R} + \frac{\kappa_B}{\sigma_B}\,\mathrm{E}\,Q_{BF}^{F} - \frac{\kappa_B}{\sigma_B}\,\mathrm{E}\,Q_{F}^{M} + \eta_{B\psi}\,\mathrm{E}\,\psi_B$$

Pork

(4. 47) $$\mathrm{E}\,P_{MD} + \frac{E\gamma_P}{1-\kappa_P} = \mathrm{E}\,P_{PD}^{R} + \frac{\kappa_P}{\sigma_P}\,\mathrm{E}\,Q_{PD}^{F} - \frac{\kappa_P}{\sigma_P}\,\mathrm{E}\,Q_{D}^{M} + \eta_{P\psi}\,\mathrm{E}\,\psi_P$$

(4. 48) $$\mathrm{E}\,P_{MF} + \frac{E\gamma_P}{1-\kappa_P} = \mathrm{E}\,P_{PF}^{R} + \frac{\kappa_P}{\sigma_P}\,\mathrm{E}\,Q_{PF}^{F} - \frac{\kappa_P}{\sigma_P}\,\mathrm{E}\,Q_{F}^{M} + \eta_{P\psi}\,\mathrm{E}\,\psi_P$$

Poultry

(4. 50) $$\mathrm{E}\,P_{MD} = \mathrm{E}\,P_{C}^{R} + \frac{\kappa_C}{\sigma_C}\,\mathrm{E}\,Q_{C}^{F} - \frac{\kappa_C}{\sigma_C}\,\mathrm{E}\,Q_{D}^{M} + \eta_{C\psi}\,\mathrm{E}\,\psi_C$$

Beef

(4. 51) $$\mathrm{E}\,Q_{BD}^{F} = \varepsilon_{BD}^{F}\,(EP_{BD}^{F} - E\mu_B)$$

(4. 52) $$\mathrm{E}\,Q_{BF}^{F} = \varepsilon_{BF}^{F}\,(EP_{BD}^{F} - E\mu_B)$$

Pork

(4. 53) $$\mathrm{E}\;Q_{PD}^{F} = \varepsilon_{PD}^{F}\,(EP_{PD}^{F} - E\mu_P)$$

(4. 54) $\quad \mathrm{E}\,Q_{PF}^{F} = \varepsilon_{PF}^{F}\ (EP_{PF}^{F} - E\mu_P)$

Poultry

(4. 55) $\quad \mathrm{E}\,Q_{C}^{F} = \varepsilon_{C}^{F}\ EP_{C}^{F}$

<u>Marketing Input Supply</u>

(4. 56) $\quad \mathrm{E}\,Q_{BD}^{M} = \varepsilon_{BD}^{M}\,(EP_{BD}^{M} - \frac{E\gamma_B}{1-\kappa_B})$

(4. 57) $\quad EQ_{BF}^{M} = \varepsilon_{BF}^{M}(EP_{BF}^{M} - \frac{E\gamma_B}{1-\kappa_B})$

(4. 58) $\quad \mathrm{E}\,Q_{PD}^{M} = \varepsilon_{PD}^{M}\,(EP_{PD}^{M} - \frac{E\gamma_P}{1-\kappa_P})$

(4. 59) $\quad \mathrm{E}\,Q_{PF}^{M} = \varepsilon_{PF}^{M}\,(EP_{PF}^{M} - \frac{E\gamma_P}{1-\kappa_P})$

(4. 60) $\quad \mathrm{E}\,Q_{C}^{M} = \varepsilon_{C}^{M}\ EP_{C}^{M}$,

where $\eta_{B\psi} = \frac{\psi_B}{1+\psi_B}$, $\varepsilon_{B\Omega} = \frac{\Omega_B}{1+\Omega_B}$, $\eta_{(BD,BD)}^{F} = \frac{\partial f_{Q_{BD}^F}}{\partial Q_{BD}^F}\,\frac{Q_{BD}^F}{f_{Q_{BD}^F}}$. EQ_{ij}^{n} and EP_{ij}^{n} are percentage changes in quantity and price of the i^{th} meat with j^{th} origin at the n^{th} level, respectively, where $EQ_{ij}^{n} = d\ln Q_{ij}^{n} \approx \frac{dQ_{ij}^{n}}{Q_{ij}^{n}}$. Demand elasticities are represented by η_{ij}. S_i is the farmers' share of the retail dollar for the i^{th} meat, σ_i is the elasticity of substitution between meat i and marketing inputs, and ε_{ij} is the supply elasticity of i^{th} meat of j^{th} origin.

Exogenous shocks to the system of equations are given by $E\delta_B$, $E\mu_{BD}$ and $\frac{E\gamma_{BD}}{1-\kappa}$, $E\delta_P$, $E\mu_{PD}$ and $\frac{E\gamma_{PD}}{1-\kappa}$. $E\delta_i$ represents the percentage change in initial equilibrium price for i^{th} domestic meat due to an exogenous demand shift (e.g., the percentage increase in consumers' willingness-to-pay for the initial quantity of meat i due to the new labeling policy). Parameters $E\mu_{ij}$ and $\frac{E\gamma_{ij}}{1-\kappa}$ represent exogenous shocks, expressed in percentage terms, to marketing and farm supply, respectively. The assumptions of the model include: the meat processing and retailing industries are characterized by constant returns to scale; the supply curve of marketing inputs is perfectly elastic; the products (beef, pork, and poultry) are independent in production with no specialized factors in common; and the displacement of supply and demand curves are parallel.

Once parameter values have been assigned, 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 price and quantity of beef, pork, and poultry at the retail and farm level. Once these values have been determined, changes in producer surplus ΔPS_{iD}^{F} for i^{th} domestic meat can be calculated is:

(4. 61) $$\Delta PS_{iD}^{F} = P_{iD}^{F} Q_{iD}^{F} (EP_{iD}^{F^*} - E\mu_{iD})(1 + 0.5EQ_{iD}^{F^*}) \quad i = beef, pork, poultry$$

Here the asterisks in the superscripts denote the solutions to the system of solved equations.

Since in domestic retailing market, consumption contains foreign origin meat and domestic meat, the consumer surplus change should include changes of both of them. So the consumer surplus ΔCS_i for different meat as:

(4. 62) $$\Delta CS_i = -P_{iD}^{R} Q_{iD}^{R} (EP_{iD}^{R^*} - E\delta)(1 + 0.5EQ_{iD}^{R^*}) - P_{iF}^{R} Q_{iF}^{R} (EP_{iF}^{R^*} - E\delta)(1 + 0.5EQ_{iF}^{R^*})$$

Derived Demand Analysis with Beef Sector Only Model

Because the system equations, (4. 31) – (4. 60), are too complex to show analytically results about welfare effects of exogenous shocks in detail,, this study considers a simple one-sector model of the beef industry for the analysis of derived demand. Although ignoring important issues such as substitutability between meats at the retail level and international trade, the simpler model provides better insights about how analytical solutions are obtained. The single sector model for the beef industry is represented by:

Retail Demand

(4. 63) $EQ_{BD}^{R} = \eta_{DD}(EP_{BD}^{R} - E\delta_{B}) + \eta_{DF} EP_{BF}^{R}$

(4. 64) $EQ_{BF}^{R} = \eta_{FD}(EP_{BD}^{R} - E\delta_{B}) + \eta_{FF} EP_{BF}^{R}$

Retail (Supply)

(4. 65) $EQ_{BD}^{R} = \kappa_{B} EQ_{BD}^{F} + (1-\kappa_{B}) EQ_{BD}^{M}$

(4. 66) $EQ_{BF}^{R} = \kappa_{B} EQ_{BF}^{F} + (1-\kappa_{B}) EQ_{BF}^{M}$

Farm-level derived demand

(4. 67) $EP_{BD}^{F} = EP_{BD}^{R} - \frac{1-\kappa_{B}}{\sigma_{B}} EQ_{BD}^{F} + \frac{1-\kappa_{B}}{\sigma_{B}} EQ_{D}^{M} + \eta_{\psi B} E\psi_{B} - \varepsilon_{\Omega B} E\Omega_{B}$

(4. 68) $EP_{BF}^{F} = EP_{BF}^{R} - \frac{1-\kappa_{B}}{\sigma_{B}} EQ_{BF}^{F} + \frac{1-\kappa_{B}}{\sigma_{B}} EQ_{F}^{M} + \eta_{\psi B} E\psi_{B} - \varepsilon_{\Omega B} E\Omega_{B}$

Here, $\eta_{\psi} = \frac{\psi}{1+\psi}$, $\varepsilon_{\Omega} = \frac{\Omega}{1+\Omega}$

Farm-level supply

(4. 69) $EQ_{BD}^{F} = \varepsilon_{D}^{F}(EP_{BD}^{F} - E\mu_{B})$

(4. 70) $EQ_{BF}^{F} = \varepsilon_{F}^{F}(EP_{BF}^{F} - E\mu_{B})$

Non Farm-level derived demand

(4. 71) $EP_{BD}^{M} + \frac{E\gamma_{B}}{1-\kappa_{B}} = EP_{BD}^{R} + \frac{\kappa_{B}}{\sigma_{B}}EQ_{BD}^{F} - \frac{\kappa_{B}}{\sigma_{B}}EQ_{BD}^{M} + \eta_{\psi B}E\psi_{B}$

(4. 72) $EP_{BF}^{M} + \frac{E\gamma_{B}}{1-\kappa_{B}} = EP_{BF}^{R} + \frac{\kappa_{B}}{\sigma_{B}}EQ_{BF}^{F} - \frac{\kappa_{B}}{\sigma_{B}}EQ_{BF}^{M} + \eta_{\psi B}E\psi_{B}$

According to previous assumptions, price of marketing inputs do not change, which means both EP_{BD}^{M} and EP_{BF}^{M} are equal to zero. Therefore, equations (4. 53) and (4. 54) are eliminated while solving the beef only EDM model.

In the model, retail demands are downward sloping ($\eta_{DD} < 0, \eta_{DF} < 0$); the input supply curves are upward-sloping ($\varepsilon_{D}^{F} > 0, \varepsilon_{F}^{F} > 0, \varepsilon_{MD}^{F} > 0, \varepsilon_{MF}^{F} > 0$); the COOL cost shifts the supply curves to the left ($\frac{E\gamma_{B}}{1-\kappa_{B}}$>0, $E\mu_{B}$>0); market power change shifts derived demand left (η_{ψ}<0, ε_{Ω}>0); and meat industry technology exhibits variable proportions (σ_{B}>0). Importantly, the farm-share term S_{B}^{F} ($S_{B}^{F} = S_{BD}^{F} = S_{BF}^{F} = P_{BD}^{F}Q_{BD}^{F} / P_{BD}^{R}Q_{BD}^{R}$) is evaluated 'at the initial equilibrium point', thus, the value-share term κ_{B} in this model is properly interpreted as a constant. Solutions for the above model are determined by using matrix algebra.

<u>Farm level Derived Demand Equation</u>

The derived 'demand' curve for farm output is obtained by dropping Equations (4.43) and (4.44) (since we want to treat farm price as temporarily exogenous), and solving the remaining equations simultaneously for EQ_{BD}^{F} yields:

(4. 73)

$$
\begin{aligned}
EQ_{BD}^{F} = & -\frac{D2\cdot\left(\lambda\cdot\varepsilon_{MD,MD}^{F}-\sigma\cdot\eta_{(BD,BD)}\right)-(1-\kappa)\cdot\left(\varepsilon_{MD,MD}^{F}\cdot\kappa+\sigma\right)\cdot\eta_{(BF,BD)}\cdot\eta_{(BD,BF)}}{D}\cdot EP_{BD}^{F} \\
& +\frac{\kappa\eta_{(BD,BF)}\cdot\left(\sigma+\varepsilon_{MF,MF}^{F}\right)\cdot\left(\sigma+\varepsilon_{MD,MD}^{F}\right)}{D}\cdot EP_{BF}^{F} \\
& +\frac{[(\eta_{(BD,BD)}+\eta_{(BD,BF)})D2+(1-\kappa)\eta_{(BD,BF)}(\eta_{(BF,BF)}+\eta_{(BF,BD)}](\varepsilon_{MD,MD}^{F}+\sigma)\cdot\eta_{\psi}\cdot}{D}E\Psi \\
& +\frac{\{(\varepsilon_{MD,MD}^{F}[-\sigma\lambda D2+(D12+(1-\kappa)\sigma)\kappa\eta_{(BD,BF)}]+[(\eta_{(BD,BD)}+\eta_{(BD,BF)})(\varepsilon_{MF,MF}^{F}+\sigma)+(1-\kappa)M]\sigma\}\varepsilon_{\Omega}}{D}\cdot E\Omega \\
& -\frac{\left[D2\cdot\eta_{(BD,BD)}+(1-\kappa)\eta_{(BF,BD)}\eta_{(BD,BF)}\right]\cdot\left(\varepsilon_{MD,MD}^{F}+\sigma\right)}{D}\cdot E\delta \\
& +\frac{D2(\lambda\varepsilon_{MD,MD}^{F}-\sigma\eta_{(BD,BD)})-[D12+(1-\cdot\kappa)]\cdot\eta_{(BD,BF)}\kappa\sigma\cdot\varepsilon_{MD,MD}^{F}}{D}\cdot E\gamma
\end{aligned}
$$

Where

$\lambda=-\eta_{(BD,BD)}\cdot\kappa+(1-\kappa)\cdot\sigma>0$;

$\lambda 22=-\eta_{(BF,BF)}\cdot\kappa+(1-\kappa)\cdot\sigma$ >0;

$\lambda 12=-\eta_{(BD,BF)}\cdot\kappa+(1-\kappa)\cdot\sigma$;

$D1=\varepsilon_{MD,MD}^{F}-(1-\kappa)\cdot\eta_{(BD,BD)}+\kappa\cdot\sigma$ >0

$D12=\varepsilon_{MF,MF}^{F}+(1-\kappa)\cdot\eta_{(BF,BD)}+\kappa\cdot\sigma$ >0

$D2=\varepsilon_{MF,MF}^{F}-(1-\kappa)\cdot\eta_{(BF,BF)}+\kappa\cdot\sigma$ >0

$D=D2\cdot D1-(1-\kappa)^{2}\cdot\eta_{(BF,BD)}\cdot\eta_{(BD,BF)}$ >0[1]

Equation (4. 73) can be rewritten as:

(4. 74) $EQ_{BD}^{F}=-\Phi EP_{BD}^{F}+\Pi EP_{BF}^{F}-\Gamma E\Psi_{B}-\mathrm{H}E\Omega_{B}+\Delta E\delta-\mathrm{M}E\gamma$

Here $\Phi>0$, $\Pi>0$, $\Gamma>0$, $\mathrm{H}>0$, $\Delta>0$, $\mathrm{M}>0$.

Let $\Phi=\frac{\Gamma}{D}$, here

[1] According to Lusk & Anderson, own price elasticities are larger than cross price elastisities, that is $\eta_{ii}>\eta_{ij}$, then D>0.

$$
\begin{aligned}
\Gamma &= D2\cdot\left(\lambda\cdot\varepsilon^{F}_{MD,MD} - \sigma\cdot\eta_{(BD,BD)}\right) - (1-\kappa)\cdot\left(\varepsilon^{F}_{MD,MD}\cdot\kappa + \sigma\right)\cdot\eta_{(BF,BD)}\cdot\eta_{(BD,BF)} \\
&= (\varepsilon^{F}_{MF,MF} - (1-\kappa)\cdot\eta_{(BF,BF)} + \kappa\cdot\sigma)\cdot(\lambda\varepsilon^{F}_{MD,MD} - \sigma\cdot\eta_{(BD,BD)}) \\
&\quad -(1-\kappa)\cdot\left(\varepsilon^{F}_{MD,MD}\cdot\kappa+\sigma\right)\cdot\eta_{(BF,BD)}\cdot\eta_{(BD,BF)} \\
&= \kappa\cdot\sigma\cdot(\lambda\varepsilon^{F}_{MD,MD} - \sigma\cdot\eta_{(BD,BD)}) + (\varepsilon^{F}_{MF,MF} - (1-\kappa)\cdot\eta_{(BF,BF)})\cdot(\lambda\varepsilon^{F}_{MD,MD} - \sigma\cdot\eta_{(BD,BD)}) \\
&\quad -(1-\kappa)\cdot\left(\varepsilon^{F}_{MD,MD}\cdot\kappa+\sigma\right)\cdot\eta_{(BF,BD)}\cdot\eta_{(BD,BF)} \\
&= a+b-c
\end{aligned}
$$

here, $a = \kappa\cdot\sigma\cdot(\lambda\varepsilon^{F}_{MD,MD} - \sigma\cdot\eta_{(BD,BD)})$,

$b = (\varepsilon^{F}_{MF,MF} - (1-\kappa)\cdot\eta_{(BF,BF)})\cdot(\lambda\varepsilon^{F}_{MD,MD} - \sigma\cdot\eta_{(BD,BD)})$, and

$c = (1-\kappa)\cdot\left(\varepsilon^{F}_{MD,MD}\cdot\kappa+\sigma\right)\cdot\eta_{(BF,BD)}\cdot\eta_{(BD,BF)}$.

Since the coefficient of EP^{F}_{BD} is negative, the derived ‘demand’ curve is downward sloping, as expected. The second part of Γ and b, which contains farm level supply elasticity $\varepsilon^{F}_{MF,MF}$ and retail demand $\eta_{(BF,BF)}$ in foreign market, reinforces the effect of increasing in price of domestic beef because of the substitution relationship. The third part of Γ and c, which contains cross price elasticities $\eta_{(BD,BF)}$ and $\eta_{(BF,BD)}$, weakens the effect of b.

Also, the coefficient of EP^{F}_{BF} is positive, which means foreign origin beef is a substitute of domestic beef in the retail market. Equation (4.73) also shows that trade effect (cross price elasticity) shifts the derived demand up, market power shifts the derived demand down, and increased marketing cost shifts the derived demand down.

Several previous studies (Van Sickle et al.) show that labeling policy will make domestic consumers buy more domestic origin meats. Here we try to analyze how much consumer demand would have to increase in order to offset any producer surplus losses that would be incurred from COOL. To determine this value analytically, it is important to note that in Equation (4. 73), changes in producer surplus can be characterized by investigating changes in ($EP_{BF}^{F} - E\mu$). ΔPS_{BD}^{F} is set to zero (meaning producers are neither benefited nor harmed by COOL), and δ^{*} is solved as:

$$(4.\ 75)\quad \delta^{*} = \frac{\{(\eta_{(BD,BD)} + \eta_{(BD,BF)})[\varepsilon_{(MF,MF)}^{F} + (1-\kappa)\sigma] + \kappa M\}\eta_{\psi}}{\kappa M + [\varepsilon_{(MF,MF)}^{F} + (1-\kappa)\sigma]\eta_{(BD,BD)}} E\psi$$

$$+ \frac{[(\kappa\eta_{(BD,BF)} - \lambda)\varepsilon_{(MF,MF)}^{F} + (1-\kappa)\sigma(\kappa\eta_{(BF,BF)} - \lambda) + \kappa^{2}M]\varepsilon_{\Omega}}{\kappa M + [\varepsilon_{(MF,MF)}^{F} + (1-\kappa)\sigma]\eta_{(BD,BD)}} E\Omega$$

$$+ \frac{(\kappa\eta_{(BD,BF)} - \lambda)\varepsilon_{(MF,MF)}^{F} + (1-\kappa)\sigma(\kappa\eta_{(BF,BF)} - \lambda) + \kappa^{2}M}{\kappa M + [\varepsilon_{(MF,MF)}^{F} + (1-\kappa)\sigma]\eta_{(BD,BD)}} E\mu$$

$$+ \frac{(\eta_{(BD,BD)} + \eta_{(BF,BF)})(\varepsilon_{(MF,MF)}^{F} + \sigma) + \sigma(\lambda + \varepsilon_{(BF,BF)} - \kappa\eta_{(BF,BF)}) + \kappa M}{\kappa M + [\varepsilon_{(MF,MF)}^{F} + (1-\kappa)\sigma]\eta_{(BD,BD)}} E\gamma$$

Here, $M = \eta_{(BF,BD)} \cdot \eta_{(BD,BF)} - \eta_{(BD,BD)} \cdot \eta_{(BF,BF)}$; $\lambda = -\kappa \cdot \eta_{(BD,BD)} + (1-\kappa) \cdot \sigma$; δ^{*} is the percentage change in price in retail level.

If market price is exogenous, $EP_{BMD} = EP_{BMF}$ =0, as assumed by Zhang and Sexton (2000) and Wohlgenant (1993), Equation. (4.75) reduces to :

$$(4.\ 76)\quad \begin{aligned} EQ_{BD}^{F} &= -\lambda EP_{BD}^{F} + \eta_{(BD,BF)}\kappa EP_{BF}^{F} + (\eta_{(BD,BD)} + \eta_{(BD,BF)}) \cdot \eta_{\psi} E\Psi + \varepsilon_{\Omega}(\eta_{(BD,BF)}\kappa - \lambda)E\Omega \\ &\quad - \eta_{(BD,BD)}E\delta + (\eta_{(BD,BF)} + \sigma + \eta_{(BD,BD)})E\gamma \end{aligned}$$

From the equation (4.76), the coefficient of EP_{BD}^{F} $\lambda = -\eta_{(BD,BD)} \cdot \kappa + (1-\kappa) \cdot \sigma$ >0, domestic beef price increases will cause farm level demand to decrease; the coefficient of EP_{BF}^{F} $\eta_{(BD,BF)}\kappa$ >0 means that foreign origin beef is a substitute good and the price increase of the foreign beef will cause an increase in domestic beef consumption ; the coefficient of COOL cost shifter $E\gamma$ is $(\eta_{(BD,BF)} + \sigma + \eta_{(BD,BD)})$, when

$\left|\eta_{(BD,BD)}\right| > \eta_{(BD,BF)} + \sigma$, COOL cost increase decreases the derived demand in farm level; the coefficient of demand shifter $E\delta$ coefficient is $-\eta_{(BD,BD)}$>0, which indicate that consumer demand increase will always increase the farm level demand.

In this case, when there is no substitution between domestic beef and foreign beef, that is $\eta_{(BD,BF)}$ =0, and there are no supply and demand shifter, Equation (4. 73) reduces to:

(4. 77) $$EQ_{BD}^{F} = -\lambda EP_{BD}^{F} + \eta_{(BD,BD)}\eta_{\psi} E\Psi - \varepsilon_{\Omega}\lambda E\Omega$$

Which is equivalent to Kinnucan's expression of derived demand without considering advertising (Kinnucan, 2002, p. 146).

Interpretation of the Coefficients

The coefficient of EP_{BF}^{F} in Equation (4. 76) is $\eta_{(BD,BF)}\kappa$, which indicates domestic beef and foreign beef are substitute goods, In beef market, market power won't change after the issuing of COOL. Therefore, both $E\Psi$ and $E\Omega$ equal to zero. Then, change in derived demand is reduced to :

(4. 78) $$EQ_{BD}^{F} = -\lambda EP_{BD}^{F} + \eta_{(BD,BF)}\kappa EP_{BF}^{F} - \eta_{(BD,BD)} E\delta + (\eta_{(BD,BF)} + \sigma + \eta_{(BD,BD)}) E\gamma$$

Here, $\eta_{(BD,BD)}$ <0, $\kappa = Sa\dfrac{1+\Omega}{1+\Psi} > 0$, $Sa = \dfrac{P_{BD}^{F} Q_{BD}^{F}}{P_{BD}^{R} Q_{BD}^{R}}$, $\eta_{(BD,BF)}$ >0, σ >0, and $\lambda = -\eta_{(BD,BD)} \cdot \kappa + (1-\kappa)\cdot\sigma$ >0.

To apply the model to the beef, pork, and poultry industries, we need to assign values to the model parameters. Table 1 reports model parameters and sources for the parameter values. The three-sector model outlined in equations (4. 31)-(4. 55) makes use of all the parameters related to beef or pork. Following Lemieux and Wohlgenant, this study sets the foreign elasticities of supply at 10.

The remaining values needed to implement the model are cost estimates. In the subsequent analysis, we simulate several scenarios under different cost estimates. These scenarios vary by the magnitude of the cost estimate in addition to who bears the cost. To determine the potential costs of COOL, we use the estimates reported by VanSickle et al. to get a low estimate of COOL costs, and use the estimates reported by Sparks Companies, Inc, to get a high estimate of COOL costs.

CHAPTER V

EMPIRICAL RESULTS

Chapter IV discusses theoretical results about how changes in domestic and foreign prices, market power, COOL cost, and retail demand affect the farm level derived demand of one sector model. In Chapter V, we first apply the conceptual framework derived in Chapter IV to the U.S. beef industry. Then, the single sector model derived in Chapter IV will be extended to the U.S. meat industry to examine substitution effects across beef, pork, and poultry industries. The three-sector model is simulated with alternative scenarios about COOL costs and premium that U.S. consumers are willing to pay for the U.S. origin products.

COOL Effects with Beef Sector Only Model

In this chapter, we examine the impact of COOL on the U.S. domestic beef producers and consumers under alternative own price elasticities, while assuming cross price elasticities (domestic beef demand respect to foreign beef price, $\eta_{(BD,BF)}$; and foreign beef demand respect to domestic beef price, $\eta_{(BF,BD)}$) are fixed. Then the model is first simulated with different cross price elasticities where $\eta_{(BD,BF)}$ and $\eta_{(BF,BD)}$ move together. Finally, the model is simulated for cases where $\eta_{(BD,BF)}$ and $\eta_{(BF,BD)}$ move independently.

In this analysis, we consider medium COOL cost increase (3% of current price) and no demand change (Lusk, 2004). We assume 80% of the cost is borne by processors and retailers while 20% is borne by producers (Lusk, 2004). The farm supply elasticity is set at ε =0.15 (Wohlgenant, 1993) and the farm cost-share parameter is set to S_a =0.472 (ERS/USDA, 2001). Other parameter values used for simulation are listed in Table A1. Equations (4.61) and (4.62) can be used to calculate producer surplus and consumer surplus. δ^* in Equation (4.75) is the magnitude of demand increase that would be required to exactly offset the loss in producer surplus due to cost increase. [2]

Results with Alternative Own Price Elasticities

Assuming there are no market power changes (Ψ =0, Ω =0) and no retail demand change (δ =0), results of the producer surplus change and consumer surplus change under different price elasticities scenarios are shown in Table 1. In this part we assume that cross price elasticities, $\eta_{(BD,BF)}$ and $\eta_{(BF,BD)}$, are the same and both equal to 0.5. Other parameters used are listed in Table A1.

According to Table 1, for all scenarios, an increase in COOL cost decreases consumer surplus and producer surplus. When own price elasticity $\eta_{(BD,BD)}$ becomes more elastic (from –0.45 to –0.98), cost increase is borne more by producers and as a result, change in producer surplus declines from –\$131.76 million to –\$237.04 million, while change in consumer surplus increases from -\$542.14 million to -\$415.64 million.

We also estimate how much consumers' demand increase will offset the producers' loss by calculating δ^* using Equation (4.75). Results in Table 1 show that

[2] Equations are derived in Chapter IV.

in order to offset the producer loss from COOL cost, consumer demand for beef, δ^* , needs to increase from 1.20% to 1.30%.

Results with Alternative Cross Price Elasticities

Table 2 shows how COOL effects change under different cross price elasticities. In the simulation, we use the same condition as Table 1, except that own price elasticity is fixed at a medium value -0.78 and $\eta_{(BD,BF)}$ and $\eta_{(BF,BD)}$ move together.

Results show that when cross price elasticities are all equal to zeros, both producers and consumers are worse off from COOL policy, and producers lose -\$521.88 million and consumers lose -\$247.72 million. As $\eta_{(BD,BF)}$ and $\eta_{(BF,BD)}$ increase, producers will hurt less, but consumers will pay more for the cost increasing from COOL. When cross price elasticities become more elastic and equal to 1, beef producers' loss decreases to -\$138.50 million; meanwhile, consumers' loss increases to -\$708.99 million. These results show that when cross price elasticities become more elastic, COOL cost is shifted from producers to consumers. Especially, when cross price elasticities increase to 1.5, producers will gain instead of loss from COOL policy.

When cross price elastiticies are equal to zero, consumer demand needs to increase by 2.90% to offset the impact of COOL cost increase on producers; however, when $\eta_{(BD,BF)}$ is equal to 1, the consumer demand needs to be increased by only 0.8%

Table 3 shows how COOL affects producers and consumers under different $\eta_{(BF,BD)}$ when $\eta_{(BD,BF)}$ is fixed at 0.2. The result shows that both producers and consumers are worse off from COOL under different $\eta_{(BF,BD)}$. When $\eta_{(BF,BD)}$ gets more elastic from 0.5 to 2, domestic producers will loss from -$448.73 million to -$445.48 million and consumers will lose from -$355.56 million to -$339.46 million; the retail demand needs to increase from 2.49% to 2.52% to offset the producer loss. The more elastic of $\eta_{(BF,BD)}$ is, the less producers lose and the more consumers lose, but not significantly. The result indicates that foreign retail demand cross price elasticity respect to domestic price has little effect on domestic producers and consumers welfare.

Table 4 shows how COOL affect producers and consumers when $\eta_{(BF,BD)}$ equal 0.2 under different $\eta_{(BD,BF)}$. The result shows that both producers and consumers are worse off from COOL when $\eta_{(BD,BF)}$ equals from 0.5 to 1. But when $\eta_{(BD,BF)}$ is more elastic at 2.0, the increase in cost will be borne more by consumers and producers will not be worse off. When $\eta_{(BD,BF)}$ equal 0.5, producers and consumers will lose -$337.76 and -$468.97 million dollars respectively and retail demand needs to increase by 1.88% to offset the producer loss. When $\eta_{(BD,BF)}$ gets more elastic, the cost from COOL will be transferred from producers to consumers, and the producer loss and consumer loss will be -$152.16 and -$692.53, respectively.

<u>Results with Alternative Market Power Parameters</u>

In his study of captive beef supplies, Azzam (1998) uses 0.06 as an upper-limit value for θ, and seems to prefer a value of 0.03 for this parameter. Based on Azzam (1998), as well as Sexton's (2000) view that empirical estimates of market power parameters are probably understated, we set θ with three scenarios: 0.0178, 0.03 and 0.05. As for oligopoly power, the empirical literature suggests that oligopoly power ξ in the beef marketing channel is probably less than oligopsony power θ, especially when successive oligopsony is considered (Schroeter et al., 2000). In this study we assume that $\xi \leq \theta$, and set the scenarios for ξ from lower value 0.01, medium value 0.0223 to upper value 0.05, and market power ratio θ from 0.0178, 0.03 to upper limit 0.05.

Table 5 to Table 7 indicate that if processors have the oligopoly and oligopsony market powers, both producers and consumers will lose from COOL policy. But when market power effects become more significant, the increasing in cost by COOL will be borne more by consumers than by producers.

Table 5 shows the result of the impact of COOL under different market power values. Here, we set the low market power ratios at ξ=0.01 and θ=0.0178, medium value at ξ=0.0223 and θ=0.03 and upper value at ξ=0.05 and θ=0.05.

With lower market power parameters, producers lose -$527.29 million and consumers lose -$440.45 million, and then producers pay less than consumers. But when ξ increases to 0.05, the change of producer surplus is -$557.57 million, a little more than that under lower market power condition, and consumers' loss is as high as -$1507.73 million, nearly three fold more than producers' loss. This means that when processors become more imperfectly competitive, the cost increase will hurt consumers more than producers. Retail demand needs to increase from 3.01% to 3.75% to offset the cost increase.

Table 6 and Table 7 show how COOL affects the beef industry under alternative oligopoly and oligopsony parameters. In Table 6, when the parameter of oligopsony market power θ is fixed at the medium value 0.03, the impact of COOL under different oligopoly market power is presented with changing ξ from 0.01 to 0.05.

Results in Table 6 and Table 7 show that when the extent of market power becomes more significant, both producers and consumers will be worse off. But the processors' oligopsony power over farmers show lager effect than processors' oligopoly power over retailers

Impacts of COOL Cost in the U.S. Meat Industry

Now we use three-sector model to consider COOL effect on the U.S meat industry. First, we assume same cross price elasticities ($\eta_{iD,iF} = \eta_{iF,iD}$, i =beef, pork, poultry) for each livestock industry. Since poultry is not required by COOL regulation, only red meats (beef and pork) face cost increase by COOL in the simulation. Then we estimate the COOL effect on producers and consumers for each meat product in the U.S meat market in different COOL cost scenarios. Second, we will compare the COOL effect on U.S meat producers under different cross price elasticities.

To apply the model, Equations (4.31) – (4.55), to the U.S. beef, pork, and poultry industries, we use parameter values in Table A1[3]. The COOL effects are examined in different elasticity scenarios, and elasticities of supply for foreign-origin meats are set at 10 following Lemieux and Wohlgenant.

Statistics reported by VanSickle et al. imply that reoccurring annual costs from COOL would range from about \$36 million to \$132 million (depending upon whether producers bear any COOL costs) 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

[3] The complete set of values is provided in the Table A1 in appendix A

that COOL would increase cost by about 0.5% for beef and about 0.25% for pork. These values are taken to represent the lower-bound cost estimates of COOL.

To obtain an upper bound on COOL cost estimates, we use the statistics reported by Sparks Companies, Inc. Sparks reports that COOL would cost the beef sector approximately $1.620 billion and the pork sector approximately $452 million. Dividing these statistics by the revenue figures reported in Table 1 implies that COOL would increase costs by about 6.5% for beef and about 3% for pork and COOL costs are borne 80% by producers and 20% by marketers (processors and retailers).

Finally, according to USDA/NASS's estimates, the total farm revenue for beef, pork and poultry are $24,394 million, $12,883 million and $15,341 million dollars respectively in 2001 to 2002. This study will use these data to calculate producer surplus.

COOL Effects in the U.S Meat Market

This study assumes that the cross price elasticities between domestic and foreign countries are the same for both beef and pork. Table 9 presents results of simulations under different COOL cost and retail demand change scenarios. Figures 1 -3, drawn from Table 9, illustrate effects of COOL in alternative scenarios of consumers' willingness to pay for the U.S.-origin beef and pork.

The results show that when there is no demand increase for domestic beef and pork, 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 poultry industry. Table 9 shows that decline in producer surplus in beef industry ranges from -$12.91 million (when cost increases are at low end of estimates) to -$152.96 million (when cost increases are at the high end of estimates); decline in producer surplus in pork industry ranges from -$8.10 million to -$95.61 million and increase in producer surplus in poultry industry ranges from $15.18 million to $183.74 million in the U.S. meat market. In the three cost scenarios, producer surplus decline but producer surplus increase in poultry industry while cost increases in beef and pork industry. The more increase in cost, the more loss for beef and pork producers and the more gain for poultry producers.

If consumers prefer domestic to foreign beef and pork, retail demand increases are expected for domestic beef and pork. Therefore, the model is simulated with several scenarios about demand increase in domestic beef and pork. Here demand increase is assumed as 2% and 5%.

Table 10 reports the producer surplus of the U.S. meat producers in different COOL cost scenarios when there is a 2% retail demand increase for domestic beef and pork. Unlike Table 9, Table 10 shows that a 2% retail demand increase results in gain for beef and pork producers even at the high cost increase from COOL. The pork producers gain from around $395.71 million to $228.89 million dollars under low to high COOL cost increase, and this gain is higher than beef producers' gain ($222.84 million to $81.85 million dollars). Poultry producers are worse off when increase in cost is low and medium. When the COOL cost is high, poultry producers' surplus increases. The trend of change in producer surplus is the same as Table 9. When the cost increases, beef and pork producer surplus decreases while poultry producer surplus increases.

When the demand increases by 5% for domestic beef and pork in the U.S market, the overall trend of change in producer surplus is the same as the result with a 2% demand increase. The difference is that the beef and pork producers will gain more in each scenario while poultry producers will lose more in the low and medium COOL cost scenario and gain less under the high COOL cost scenario.

As Table 11 shows, beef producers will gain from $579.44 million dollars to $437.03 million dollars, pork producers gain a little less than beef producers in each cost scenario. Poultry producers will loss from -$167.87 million dollars to -$115.95 million dollars when cost increases from COOL are low and medium. When cost increase is high, poultry producers gain only $2.08 million dollars.

From Table 10 and Table 11, it can be concluded that if consumers prefer domestic beef and pork by paying higher premium to domestic beef and pork, domestic producers of beef and pork will benefit after COOL regulation, while domestic poultry producers will be worse off unless the cost increase as high as around 6.5%.

COOL Effects with Different Cross Price Elasticities

Previous results were obtained under the assumption that cross price elasticities of foreign product with respect to price of domestic meat, $\eta_{(iF,iD)}$ (*i*=beef, pork) are inelastic at 0.2. But what would happen if consumers are price elastic in consumption of foreign product in response to change in domestic price (or elasticity of domestic demand is elastic in response to change in price of foreign product), for example, at 0.6. The following discussion compares the COOL effect in alternative scenarios about price elasticities of foreign product with respect to price of domestic meat.

Table 12 shows when there is no demand change, which means δ is zero, how COOL affects the U.S. meat industry under different cross price elasticities. For the scenario of inelastic cross price elasticity, we set $\eta_{(iD,iF)}$ and $\eta_{(iF,iD)}$ as the same and equal to 0.20; own price elasticities $\eta_{(BD,BD)}$ and $\eta_{(PD,PD)}$ are -0.56 and -0.69, respectively. For the scenario of elastic cross price elasticity, we set $\eta_{(iD,iF)}$ and $\eta_{(iF,iD)}$ are the same and equal to 0.60, own price elasticities $\eta_{(BD,BD)}$ and $\eta_{(PD,PD)}$ are -0.56 and -0.45, respectively. The results illustrate the COOL effects under inelastic and elastic cross price elasticities, respectively. Both of these two simulations were performed under the assumption of no demand change.

Table 12 shows that when there are no demand changes and if consumers are more sensitive to the price of foreign meat, the U.S beef and pork producers will lose less and poultry producers will gain more in each COOL cost scenarios. This result is consistent with the results in one-sector model.

Under the high cost scenario, beef producers lose by \$26.58 and pork producers lose \$11.44 million when $\eta_{(iD,iF)} = \eta_{(iF,iD)} = 0.60$. This is compared to beef and pork producer loss at\$152.96 and \$95.61 million when $\eta_{(iD,iF)} = \eta_{(iF,iD)} = 0.20$ respectively. The result indicates that if consumers are more sensitive to the foreign product price, the loss from COOL will be much less than the case with inelastic cross price elasticities. Lusk and Anderson's results are estimated with inelastic cross price elasticities ($\eta_{(iD,iF)} = \eta_{(iF,iD)} = 0.20$) only, which indicates that if both cross price elasticities ($\eta_{(iD,iF)}$ and $\eta_{(iF,iD)}$) are larger than 0.2, their results may overestimate the loss from the COOL regulation .

Next, the three-sector model is simulated with the assumptions of demand increase Table 13 shows if there is a 5% retail demand increase, how COOL would affect the U.S. meat market under different cross elasticites ($\eta_{(iD,iF)}$ and $\eta_{(iF,iD)}$).

Inelastic condition represents results with inelastic conditions, $\eta_{(iD,iF)} = \eta_{(iF,iD)} = 0.20$, while elastic condition shows results from $\eta_{(iD,iF)} = \eta_{(iF,iD)} = 0.60$. Both simulations assume a 5% demand increase for domestic beef and pork. The result in Table 13 shows that when there is a 5% demand increase for domestic beef and pork, producers in these two sectors will be better off. This result is consistent with the results in one-sector model. Table 13 shows that under inelastic condition, beef producers gain $940.98 million to $719.64 million and pork producers gain $870.81 million to $613.98 million, which are higher than gains ranging from $579.44 to $437.03 million and from $537.33 to $448.35 million under elastic condition. This means that when cross price elasticites get more elastic, the producers will gain more than the cases with inelastic cross price elasticities. This conclusion is consistent with the result shown in Table 12.

Results from Table 12 and Table 13 indicate that the cross price elasticites have important effect on the estimated results of the COOL effects. The more elastic of the cross price elasticiities, the less beef and pork producers will lose due to COOL when there is no demand increase, and they will gain more if there are a 5% demand increase.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study uses an equilibrium displacement model to examine impacts of COOL cost increase on producer and consumer welfare in the U.S. meat industry. The model includes substitution relationships not only between different meats such as beef, pork and poultry, but also between domestic and foreign original products. Unlike previous studies, this paper considers imperfectly competitive market structure in the meat processing industry. In order to give a detailed view of the COOL effects on the meat industry, a single sector model was employed to give a theoretical analysis about how COOL affect on the derived demand of domestic farm level producers. Then, empirical simulation results are presented. The study results indicate that farm level producers for beef and pork will be worse off unless consumer demand increases for the U.S. "COOL" product when there is no demand increase for domestic beef and pork. Poultry industry will benefit from COOL because consumers will substitute higher-priced beef and pork for poultry. When own price elasticity becomes more elastic, producers are expected to lose more while consumers will lose less.   When cross price elasticities between domestic and foreign products are more inelastic, producers will lose less while consumers will lose more.

The results also show that if processors have the oligopoly and oligopsony market powers, both producers and consumers are likely to lose from COOL. But when the extent of market powers becomes more significant, the COOL cost will be borne more by consumers than by producers. However, market power effects seemes to be weak due to the offsetting effects from more inelastic derived demand and inward shifting of derived demand.

If COOL can make U.S. consumers more loyal to the U.S. "COOL" products, own elasticity more inelastic and cross price elasticity more elastic, it may enhance producer benefit substantially. According to the simulation results, a 2% demand increase for domestic beef and pork will offset the potential producer loss from the COOL cost. And if domestic demand increases by 5% for beef and pork, farm level producers of beef and pork will benefit from COOL significantly.

This study used a three-sector model to examine the COOL effects on the U.S meat industry. First, assuming same cross price elasticities between domestic and foreign market this study estimated the change in producer surplus due to the COOL regulation. Second, the COOL effect was compared on U.S meat producers under different cross price elasticities.

The results show that when there is no demand increase for domestic beef and pork, the effect of cost increase due to COOL has negative impacts on producer surplus in domestic beef and pork industries but positive impacts on the poultry industry. In alternative scenarios of low, medium and high COOL cost increase, producer surplus declines as the cost increases in beef and pork industries, but increases in the poultry industry. The more cost increase, the more loss for beef and pork producers and more gain for poultry producers. If consumers are more sensitive to the price of foreign meat, the U.S. beef and pork producers will lose less and poultry producers will gain more in each COOL cost scenarios when there are no demand changes.

This study also found that the more elastic the cross price demand elasticiities between domestic and foreign meat, the less beef and pork producers will lose from the COOL regulation when there is no demand increase. Obviously, beef and pork producers will gain more when there is a 5% demand increase.

Table 1. COOL Effects with Different Own Price Elasticity[a]

	Scenarios		
$\eta_{(BD,BD)}$	-0.45	-0.78	-0.98
ΔPS (million dollars)	-131.76	-203.64	-237.04
ΔCS (million dollars)	-542.14	-455.77	-415.64
δ^*	1.20%	1.28%	1.30%

[a] Computed using Equations (4.63) - (4.72), $\eta_{(BF,BF)} = \eta_{(BD,BD)}$ and $\eta_{(BD,BF)} = \eta_{(BF,BD)}$=0.50 and other values of parameters are in Table A1 in appendix A.

Table 2. COOL Effects with Different Cross Price Elasticities

	Scenarios			
$\eta_{(BD,BF)}$	0	0.2	1	1.5
ΔPS (million dollars)	-521.88	-448.41	-138.50	80.78
ΔCS (million dollars)	-247.72	-335.94	-708.99	-973.83
δ^{*}	2.90%	2.50%	0.80%	

Results are calculated with conditions in Table 1 except $\eta_{(BD,BF)}$ and $\eta_{(BF,BD)}$ while holding $\eta_{(BD,BD)}$ = -0.78 and $\eta_{(BD,BF)} = \eta_{(BF,BD)}$.

Table 3. COOL Effects with Different Cross Price Elasticity

	Scenarios			
	$\eta_{(BF,BD)}$ =0.5	$\eta_{(BF,BD)}$ =0.75	$\eta_{(BF,BD)}$ =1	$\eta_{(BF,BD)}$ =2
ΔPS (million dollars)	-448.73	-447.52	-447.11	-445.48
ΔCS (million dollars)	-355.56	-337.01	-337.50	-339.46
δ^{*}	2.49%	2.50%	2.50%	2.52%

Results are calculated with conditions in Table 1 except $\eta_{(BF,BD)}$ while holding

$\eta_{(BD,BF)}$ =0.2, $\eta_{(BD,BD)} = \eta_{(BF,BF)}$ -0.78

Table 4. COOL Effects with Different Cross Price Elasticity

	Scenarios			
	$\eta_{(BD,BF)}$ =0.5	$\eta_{(BD,BF)}$ =0.75	$\eta_{(BD,BF)}$ =1	$\eta_{(BD,BF)}$ =2
ΔPS (million dollars)	-337.76	-245.14	-152.16	223.58
ΔCS (million dollars)	-468.97	-580.46	-692.53	-1146.67
δ^*	1.88%	1.37%	0.85%	

Results are calculated with conditions in Table 1 except $\eta_{(BD,BF)}$ while holding

$\eta_{(BF,BD)}$ = 0.2, $\eta_{(BD,BD)}$ = $\eta_{(BF,BF)}$ = -0.78.

Table 5. COOL Effect with Different Market Power

	Scenarios		
	ξ=0.01, θ=0.0178	ξ=0.0223, θ=0.03	ξ=0.05, θ=0.05
ΔPS (million dollars)	-530.21	-533.29	-548.60
ΔCS (million dollars)	-544.15	-653.44	-1193.09
δ^*	3.07%	3.14%	3.50%

Results are calculated with conditions in the foot note of Table 1 except θ and ξ.

Table 6. COOL Effect with Different Upstream Oligopoly Power

	Scenarios		
	ξ=0.01	ξ=0.0223	ξ=0.05
ΔPS (million dollars)	-530.21	-533.29	-548.60
ΔCS (million dollars)	-544.15	-653.44	-1193.09
δ^*	3.07%	3.14%	3.50%

Results are calculated with conditions in foot note of Table 5 except θ and ξ.

$\eta_{(BF,BF)} = \eta_{(BD,BD)}$ = -0.78, $\eta_{(BD,BF)} = \eta_{(BF,BD)}$ = 0 and holding θ = 0.03.

Table 7. COOL Effect with Different Downstream Oligoposony Power

	Scenarios		
	θ=0.0178	θ=0.03	θ=0.05
ΔPS (million dollars)	-529.82	-533.29	-538.73
ΔCS (million dollars)	-530.33	-653.44	-845.75
δ^{*}	3.06%	3.14%	3.26%

Results are calculated with conditions in foot note of Table 5 except θ while holding ξ=0.223.

Table 8. COOL Effect with Different Decoposition of Aggregate Price Elasticity

	Scenarios	
	$\eta_{(BD,BD)} = \eta_{(BF,BF)} = -0.56$ $\eta_{(BD,BF)} = \eta_{(BF,BD)} = 0.20$	$\eta_{(BD,BD)} = -0.776$ $\eta_{(BF,BF)} = -1.774$ $\eta_{(BD,BF)} = 0.216$ $\eta_{(BF,BD)} = 1.224$
ΔPS (million dollars)	-305.24	-335.56
ΔCS (million dollars)	-653.71	-617.73
δ^*	2.17%	2.23%

Results are calculated with conditions in the foot note of Table 5 except $\eta_{(BD,BD)}$, $\eta_{(BF,BF)}$ and κ_B=0.35.

Table 9. COOL Effect on the Meat Industry with No Demand Change

	Scenarios					
	Beef		Pork		Poultry	
	ΔPS	ΔCS	ΔPS	ΔCS	ΔPS	ΔCS
Low Cost Estimate	-12.91	-74.28	-15.34	-72.68	24.14	-25.24
Medium Cost Estimate	-65.14	-338.84	-50.57	-396.68	105.91	-110.71
High Cost Estimate	-152.96	-900.26	-181.04	-872.24	291.74	-304.88

Computed using Equations (4.31) - (4.55) with value of parameters in Table A1 with $\delta_B = \delta_P = 0$.

Table 10. COOL Effect on the Meat Industry with 2% Demand Increase

	Scenarios					
	Beef		Pork		Poultry	
	ΔPS	ΔCS	ΔPS	ΔCS	ΔPS	ΔCS
Low Cost Estimate	222.84	702.83	395.71	718.48	-91.70	95.88
Medium Cost Estimate	170.26	436.75	360.24	493.39	-9.63	10.06
High Cost Estimate	81.85	-127.78	228.89	-85.26	176.95	-184.96

Computed using Equations (4.31) - (4.55) with value of parameters in Table A1 with $\delta_B = \delta_P = 2\%$.

Table 11. COOL Effect on the Meat Industry with 5% Demand Increases

	Scenarios					
	Beef		Pork		Poultry	
	ΔPS	ΔCS	ΔPS	ΔCS	ΔPS	ΔCS
Low Cost Estimate	579.44	1878.54	537.33	1715.79	-167.87	279.18
Medium Cost Estimate	526.34	1610.16	518.42	1589.06	-115.95	192.83
High Cost Estimate	437.03	1040.99	448.35	985.79	2.08	-3.47

Computed using Equations (4.31) - (4.55) with value of parameters in Table A1 with $\delta_B = \delta_P = 5\%$.

Table 12. COOL Effects with Different Cross Price Elasticities and No Demand Change

		Scenarios		
	Cross price elasticities	Beef	Pork	Poultry
		ΔPS	ΔPS	ΔPS
Low Cost Estimate	Inelastic	-12.91	-15.34	24.14
	Elastic	-5.43	-0.13	27.70
Medium Cost Estimate	Inelastic	-65.14	-50.57	105.91
	Elastic	-19.86	-1.16	79.37
High Cost Estimate	Inelastic	-152.96	-181.04	291.74
	Elastic	-26.58	-11.44	166.48

1) Computed using Equations (4.31) - (4.55) with same value of parameters in Table A1.

2) $\delta_B = \delta_P = 0$.

3) When cross price is inelastic, $\eta_{(BD,BF)} = \eta_{(BF,BD)}$ =0.2; other wise $\eta_{(BD,BF)}$ = $\eta_{(BF,BD)}$ = 0.6.

Table 13. COOL Effects with Different Cross Price Elasticities and 5% Demand Increase

		Scenarios		
	Cross price elasticities	ΔPS	ΔPS	ΔPS
		Beef	Pork	Poultry
Low Cost Estimate	Inelastic	579.44	537.33	-167.87
	Elastic	940.98	870.81	-59.29
Medium Cost Estimate	Inelastic	526.34	518.42	-115.95
	Elastic	882.83	735.28	-61.85
High Cost Estimate	Inelastic	437.03	448.35	2.08
	Elastic	718.64	613.98	494.02

Computed using Equations (4.31) - (4.55) with conditions in Table 12 except $\delta_B = \delta_P = 5\%$.

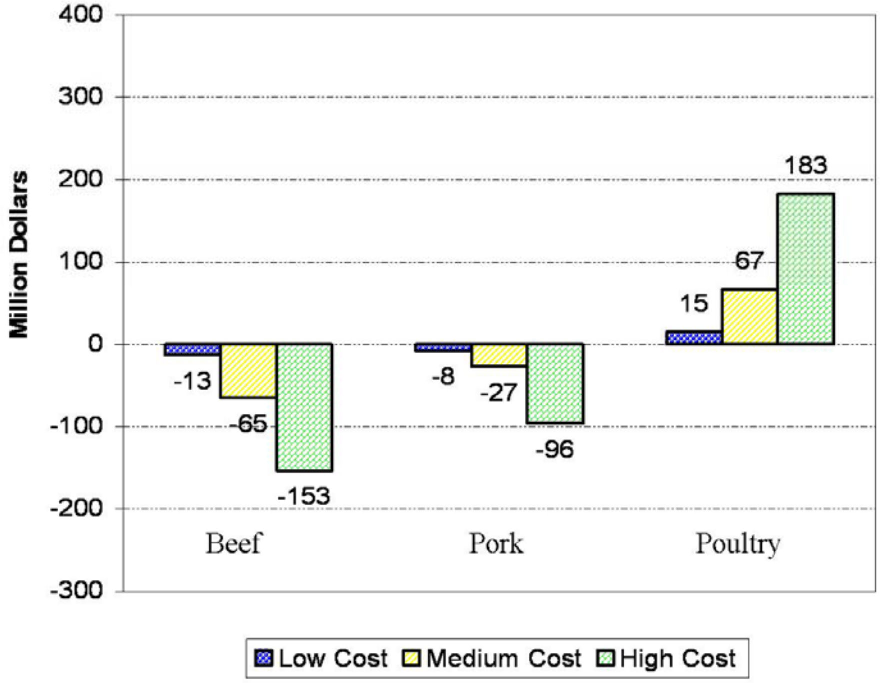

Figure 3. COOL effects with no demand change for domestic beef and pork

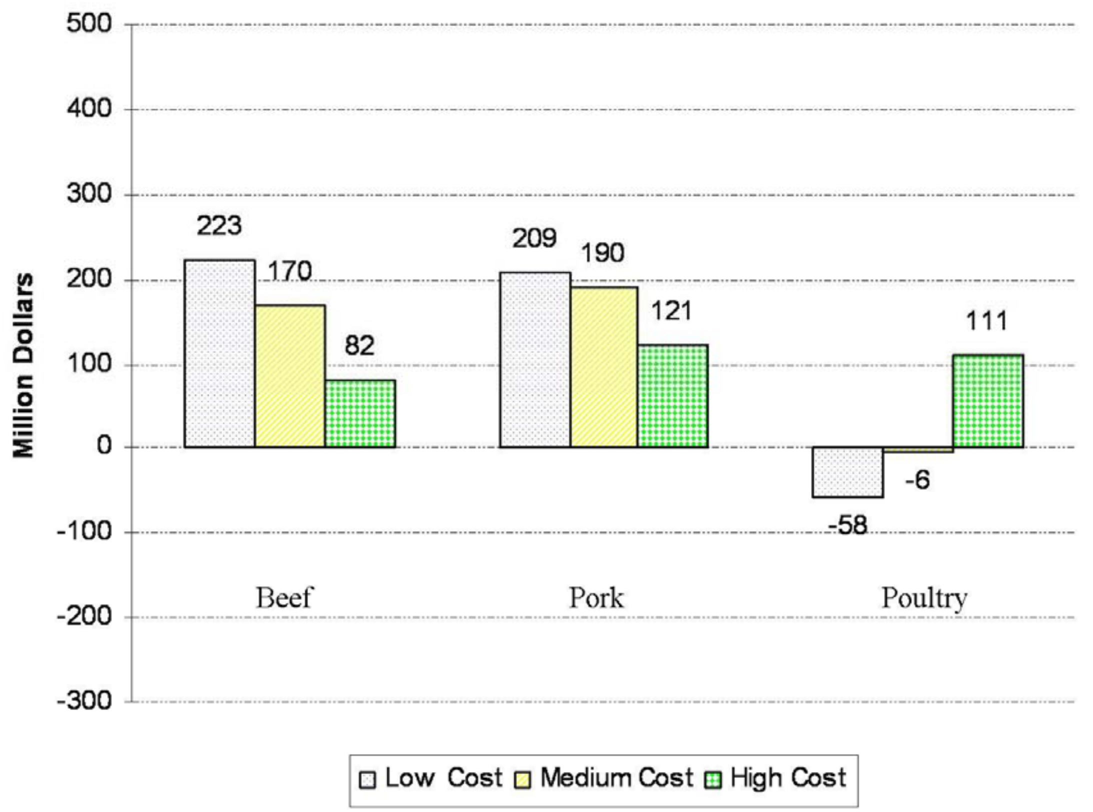

Figure 4. COOL effects with 2% demand change for domestic beef and pork

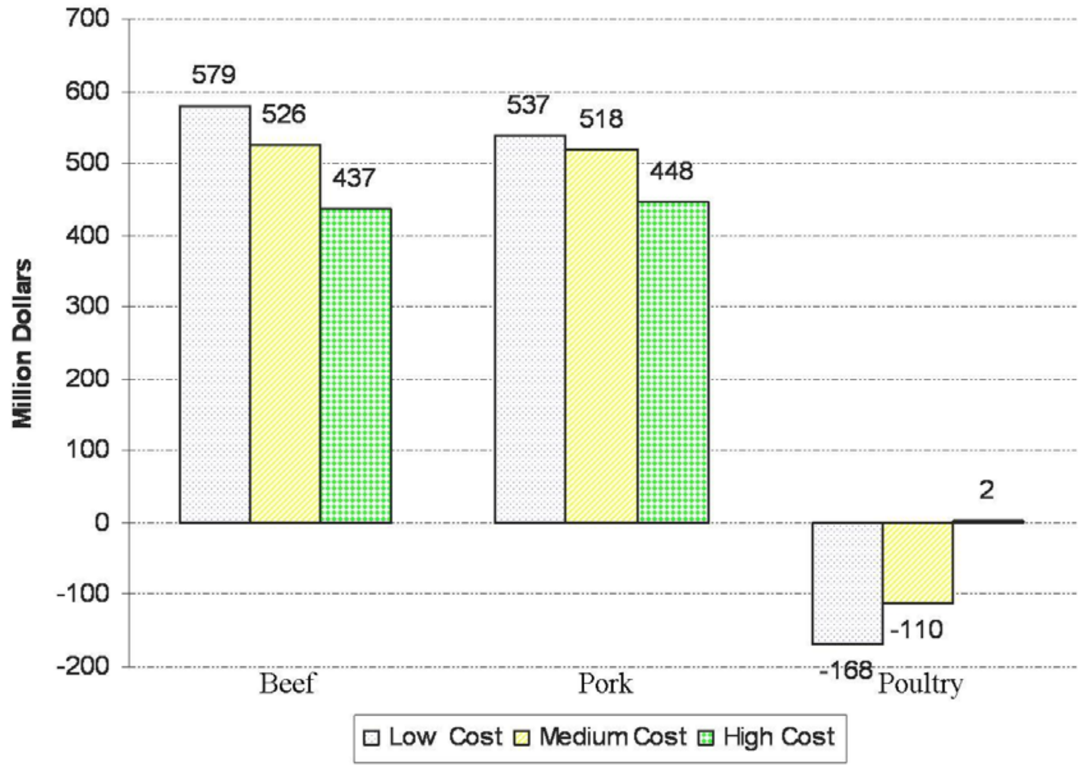

Figure 5. COOL effects with 5% demand increases for domestic beef and pork

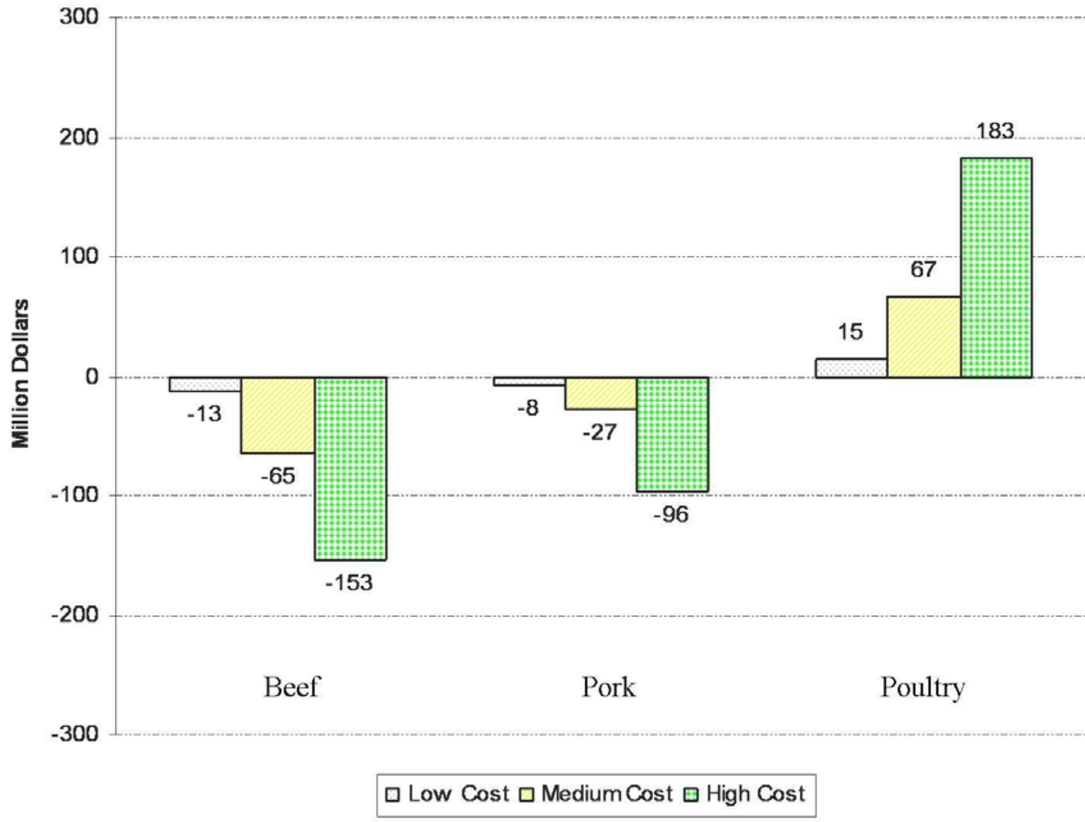

Figure 6. COOL effects with low cross price elasticities and no demand change

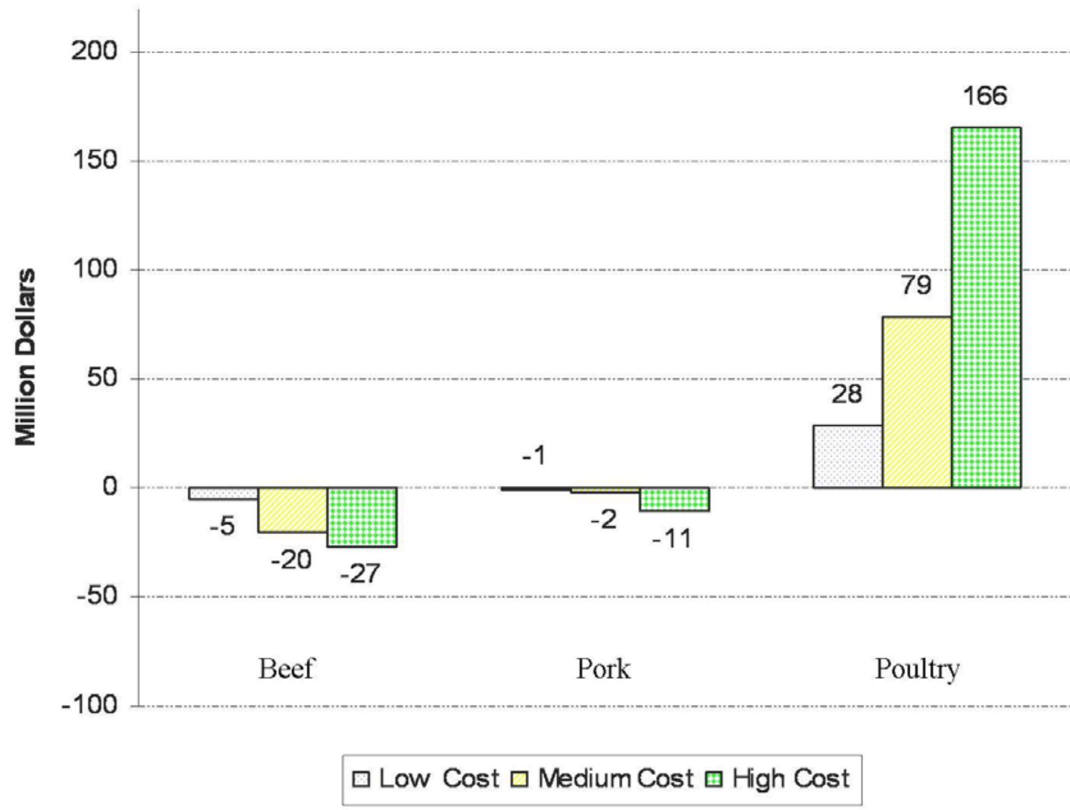

Figure 7. COOL effects with high cross price elasticities and no demand change

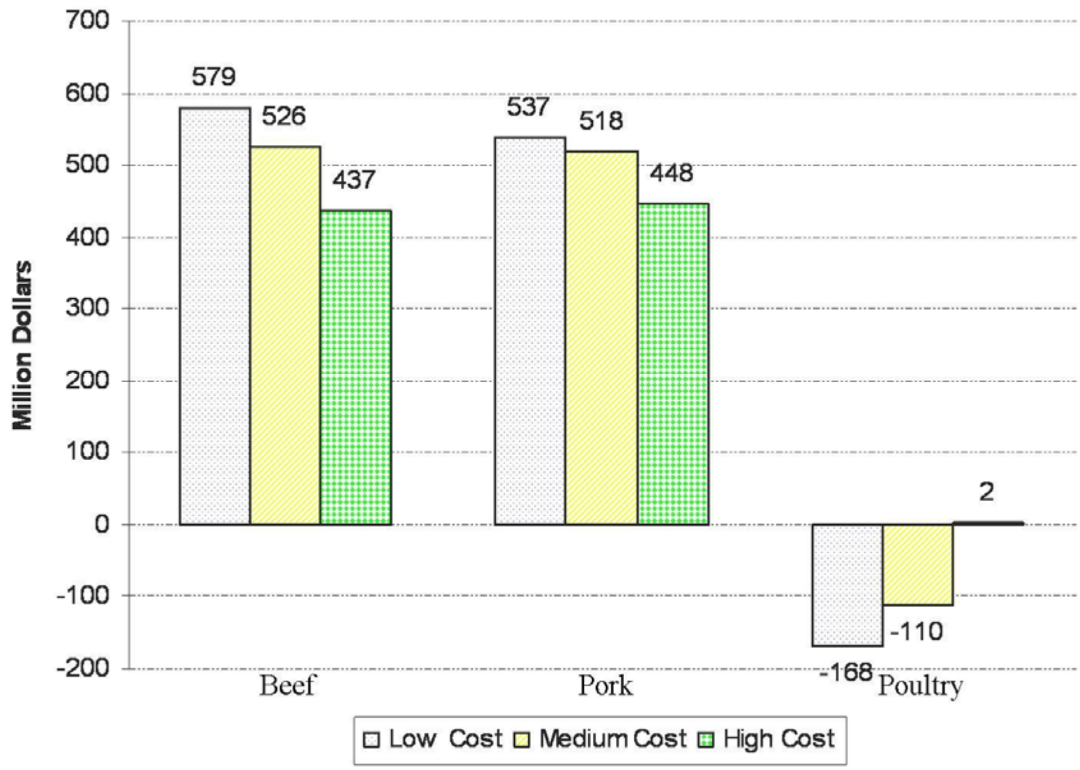

Figure 8. COOL effects with low cross price elasticities and 5% demand increase

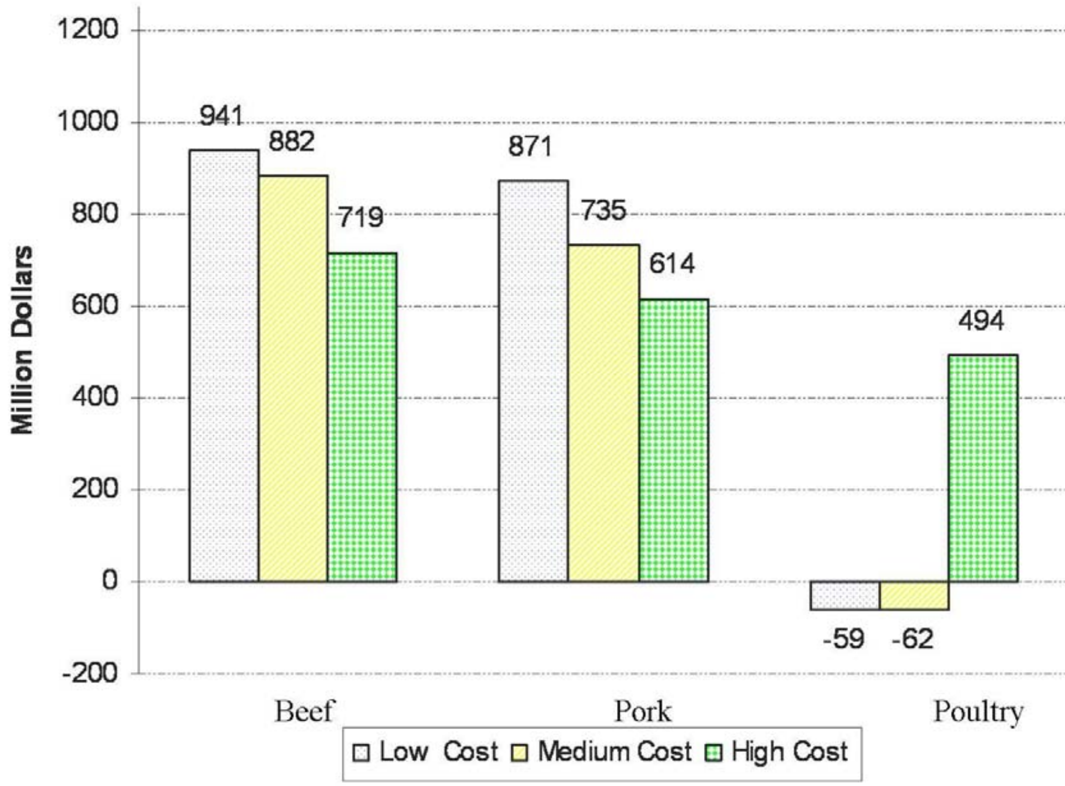

Figure 9. COOL effects with high cross price elasticities and 5% demand increase

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APPENDICES

APPENDIX A-DESCRIPTION OF VARIABLES IN THE MODEL

Table A1. Description of the Parameters in the Models

Parameter	Definition	Value
$\eta^R_{(BD,BD)}$	Retail level own-price demand elasticity for domestic beef	-0.56
$\eta^R_{(BD,PD)}$	Retail level cross-price demand elasticity for domestic beef with respect to domestic pork	0.10
$\eta^R_{(BD,C)}$	Retail level cross-price demand elasticity for domestic beef with respect to poultry	0.05
$\eta^R_{(BD,BF)}$	Retail level cross-price demand elasticity for domestic beef with respect to foreign beef	0.20
$\eta^R_{(BD,PF)}$	Retail level cross-price demand elasticity for domestic beef with respect to foreign pork	0.05
$\eta^R_{(BF,BD)}$	Retail level cross-price demand elasticity for foreign beef with respect to domestic beef	0.20
$\eta^R_{(BF,PD)}$	Retail level cross-price demand elasticity for foreign beef with respect to domestic pork	0.05
$\eta^R_{(BF,C)}$	Retail level cross-price demand elasticity for foreign beef with respect to poultry	0.05
$\eta^R_{(BF,BF)}$	Retail level own-price demand elasticity for foreign beef	-0.56
$\eta^R_{(BF,PF)}$	Retail level cross-price demand elasticity for foreign beef with respect to foreign pork	0.10
$\eta^R_{(PD,BD)}$	Retail level cross-price demand elasticity for domestic beef with respect to domestic beef	0.10
$\eta^R_{(PD,PD)}$	Retail level own-price demand elasticity for domestic pork	-0.69
$\eta^R_{(PD,C)}$	Retail level cross-price demand elasticity for domestic pork with respect to poultry	0.04
$\eta^R_{(PD,BF)}$	Retail level cross-price demand elasticity for domestic pork with respect to foreign beef	0.10
$\eta^R_{(PD,PF)}$	Retail level cross-price demand elasticity for domestic pork with respect to foreign pork	0.20
$\eta^R_{(PF,BD)}$	Retail level cross-price demand elasticity for foreign pork with respect to domestic beef	0.10
$\eta^R_{(PF,PD)}$	Retail level cross-price demand elasticity for foreign pork with respect to domestic pork	0.20
$\eta^R_{(PF,C)}$	Retail level cross-price demand elasticity for foreign pork with respect to poultry	0.04
$\eta^R_{(PF,BF)}$	Retail level cross-price demand elasticity for foreign pork with respect to foreign beef	0.23
$\eta^R_{(PF,PF)}$	Retail level own-price demand elasticity for foreign pork	-0.69
$\eta^R_{(C,BD)}$	Retail level cross-price demand elasticity for poultry respect to domestic beef	0.21
$\eta^R_{(C,PD)}$	Retail level cross-price demand elasticity for poultry with respect to domestic pork	0.07
$\eta^R_{(C,C)}$	Retail level own-price demand elasticity for poultry	-0.33
$\eta^R_{(C,BF)}$	Retail level cross-price demand elasticity for poultry with respect to foreign beef	0.21
$\eta^R_{(C,PF)}$	Retail level cross-price demand elasticity for poultry with respect to foreign pork	0.07

$\varepsilon^{R}_{BD,BD}$	Retail level own-price derived supply elasticity for domestic beef	0.15
$\varepsilon^{R}_{BF,BF}$	Retail level own-price derived supply elasticity for foreign beef	10.00
$\varepsilon^{R}_{PD,PD}$	Retail level own-price derived supply elasticity for domestic pork	0.40
$\varepsilon^{R}_{PF,PF}$	Retail level own-price derived supply elasticity for foreign pork	10.00
$\varepsilon^{R}_{C,C}$	Retail level own-price derived supply elasticity for domestic poultry	0.65
σ_{BD}	Elasticity of substitution between domestic beef and marketing inputs	0.72
σ_{BF}	Elasticity of substitution between foreign beef and marketing inputs	0.72
σ_{PD}	Elasticity of substitution between domestic pork and marketing inputs	0.35
σ_{PF}	Elasticity of substitution between foreign beef and marketing inputs	0.35
σ_{C}	Elasticity of substitution between domestic poultry and marketing inputs	0.11

APPENDIX B-MAPLE CODE FOR SIMULATING MODEL

Beef Sector Model Maple Program Code

```
> Restart;
> With(linalg);
> cool_cost_share:=0.2;
> Epsi:=0;Eomiga:=0;Egamma:=(1-cool_cost_share)*Cost*(1-kappa);Emu:=cool_cost_share*Cost;

> Eq := {
-EQ_R_BD+(eta11*(EP_R_BD-Edelta)+eta12*EP_R_BF),
-EQ_R_BF+(eta21*(EP_R_BD-Edelta)+eta22*EP_R_BF),
-EQ_R_BD+0.57*EQ_F_BD+(1-kappa)*EQ_MD,
-EQ_R_BF+kappa*EQ_F_BF+(1-kappa)*EQ_MF,
-EP_F_BD+(EP_R_BD-((1-kappa)/sigma)*EQ_F_BD+((1-kappa)/sigma)*EQ_MD+eta1*Epsi-epsilon1*Eomiga),
-EP_F_BF+(EP_R_BF-((1-kappa)/sigma)*EQ_F_BF+((1-kappa)/sigma)*EQ_MF+eta1*Epsi-epsilon1*Eomiga),
-Egamma/(1-kappa)+EP_R_BD+(kappa/sigma)*EQ_F_BD-(kappa/sigma)*EQ_MD+eta1*Epsi, -Egamma/(1-
kappa)+EP_R_BF+(kappa/sigma)*EQ_F_BF-(kappa/sigma)*EQ_MF+eta1*Epsi,
-EQ_F_BD+epsilon11*(EP_F_BD-Emu),
-EQ_F_BF+epsilon12*(EP_F_BF-Emu)          };

>A_1:=genmatrix(Eq,[EQ_R_BD,EQ_R_BF,EP_F_BD,EP_F_BF,EP_R_BD,EP_R_BF,EQ_F_BD,EQ_MD,EQ_F_BF
,EQ_MF]);
>B:=matrix(10,1,[EQ_R_BD,EQ_R_BF,EP_F_BD,EP_F_BF,EP_R_BD,EP_R_BF,EQ_F_BD,EQ_MD,EQ_F_BF,EQ
_MF]);
> C:=genmatrix(Eq,[Edelta, Cost]);
> E:=matrix(2,1,[Edelta,Cost]);
> F_1:=multiply(C,-E);

> result_3:=linsolve(A_1,F_1);

> EP_F_BD:=matrix(1,1,row(result_3,3));
> EP_F_BD:=det(EP_F_BD);
> EP_F_BD_Emu:=EP_F_BD-Emu;
> delta_star:=solve(EP_F_BD_Emu,Edelta);
>B:=matrix(10,1,[EQ_R_BD,EQ_R_BF,EP_F_BD,EP_F_BF,EP_R_BD,EP_R_BF,EQ_F_BD,EQ_MD,EQ_F_BF,EQ
_MF]);
>EQ_R_BD:=matrix(1,1,row(result_3,1));EQ_R_BF:=matrix(1,1,row(result_3,2));EP_F_BD:=matrix(1,1,row(result_3
,3));EP_R_BD:=matrix(1,1,row(result_3,5));EP_R_BF:=matrix(1,1,row(result_3,6));EQ_F_BD:=matrix(1,1,row(result
_3,7));EQ_MD:=matrix(1,1,row(result_3,8));
```

For the thearetical solutions of CS and PS change.

(1) For CS change;

```
> EP_F_BD_Emu;
> EP_F_BD_Emu :=
collect(EP_F_BD_Emu,[Epsi,Eomiga,Egamma,Emu,EP_F_BD,EP_F_BF,epsilon32,epsilon31,eta22,eta11,sigma,epsil
on1,kappa]);
> EQ_F_BD:=det(EQ_F_BD);
> EQ_F_BD :=
collect(EQ_F_BD,[Epsi,Eomiga,Egamma,Emu,EP_F_BD,EP_F_BF,epsilon32,epsilon31,eta22,eta11,sigma,epsilon1,k
appa]);
Error, (in collect) cannot collect 0
> PS:=EP_F_BD_Emu*(1+0.5*EQ_F_BD);
```

(2) For PS change;

```
> EP_R_BF:=det(EP_R_BF);EQ_R_BF:=det(EQ_R_BF);
```

```
> EP_F_BD_0:=det(EP_F_BD);EP_R_BD_0:=det(EP_R_BD);
>EQ_R_BD:=det(EQ_R_BD);EP_F_BD:=det(EP_F_BD);EP_R_BD:=det(EP_R_BD);EQ_F_BD;
> P_F_BD_Q_F_BD:=24394;   P_R_BD_Q_R_BD:=51002;
> Edelta:=0;epsilon11:=0.7; epsilon12:=10.00;
> PS_change:=P_F_BD_Q_F_BD*(EP_F_BD-Emu)*(1+0.5*EQ_F_BD);
> collect(PS_change,[Edelta,Cost]);
> eta11:=-0.78; eta22:=eta11;
> Edelta:=0; eta12:=0; eta21:=0;kappa:=a;sigma:=0.005;Cost:=0.003;
> PS_change;
> plot(PS_change,a=0..3,y=-100..100);
> Edelta:=0; EP_MD:=0;EP_MF:=0;
> eta12:=0; eta21:=0;
> zeta_change:=2;
> theta_change:=3;

---------------COOL caused Shifter-------------------------------------------------------------------

> Egamma:=0.024*(1-kappa);Emu:=0.006;
-----Parameters--------------------
> sigma:=0.35; Sa:=0.57;
> epsilon11:=0.7; epsilon12:=10.00;
> eta_own:=matrix(3,1,[-0.45,-0.78,-0.98]);
> eta11_1:=matrix(1,1,row(eta_own,2));
> eta11:=det(eta11_1);eta22:=eta11;
---cross demand elasticity-----
> eta_cross:=matrix(5,1,[0.5,0,0.2,1,1.5]);
> eta21_1:=matrix(1,1,row(eta_cross,2));
> eta21:=det(eta21_1);
> eta12:=eta21;

----Market power----

----------------------/*Oligopoly power*/------
> zeta_own:=matrix(4,1,[0,0.1,0.15,0.3]);
> zeta_1:=matrix(1,1,row(zeta_own,zeta_change));zeta:=det(zeta_1); psi:=zeta/eta11;
--------------------/*theta, relative to oligopsony power*/------
> theta_own:=matrix(4,1,[0,0.1,0.15,0.3]);
> theta_1:=matrix(1,1,row(theta_own,theta_change)); theta:=det(theta_1);  omega:=theta/epsilon11;
> kappa:=Sa*(1+omega)/(1+psi);
> Epsi:=0; Eomiga:=0;

-----------------PS & CS------------------------------------------------------------------------
>EQ_R_BD:=det(EQ_R_BD);EP_F_BD:=det(EP_F_BD);EP_R_BD:=det(EP_R_BD);EQ_F_BD;
> P_F_BD_Q_F_BD:=24394;   P_R_BD_Q_R_BD:=51002;
> PS_change:=P_F_BD_Q_F_BD*(EP_F_BD-Emu)*(1+0.5*EQ_F_BD);
> CS_change:=-P_R_BD_Q_R_BD*((EP_R_BD-Edelta)*(1+0.5*EQ_R_BD)+(EP_R_BF-
Edelta)*(1+0.5*EQ_R_BF));

> D22:=kappa*sigma-(1-kappa)*eta22+epsilon12;
> D11:=kappa*sigma-(1-kappa)*eta11+epsilon11;
> DD:=D22*D11-(1-kappa)^2*eta12*eta21;restart;
```

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