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Changes in market equilibria resulting from food safety regulation in the meat and poultry industries

H.L. Goodwin Jr.[a,*], Rimma Shiptsova[b]

[a]*Department of Agricultural Economics and Agribusiness, 217 Agriculture Building, University of Arkansas, Fayetteville, AR 72701, USA*
[b]*Department of Economics, Utah State University, Fayetteville, UT, USA*

Abstract

This study presents a unique view on the USDA Food Safety and Inspection Service (USDA FSIS) implementation of the so-called "Mega-Reg" authorizing establishment of regulatory hazard analysis and critical control point (HACCP) procedures. Surveys were sent to plant managers of the 11 firms participating in the HACCP Roundtable at the University of Arkansas. Results of the survey were used to create HACCP implementation cost estimates for poultry kill plants and perform welfare analysis by using equilibrium displacement model (EDM). Results show average welfare losses up to 35 million a year for the broiler industry as well as substantial losses to consumers resulting from the new regulation.

1. Introduction

On July 25, 1996 the United States Department of Agriculture (2001) published the proposed final rule for pathogen reduction; hazard analysis and critical control point (HACCP) systems, 9 CFR Part 304. This final rule, often referred to as the "Mega-Reg" directed the United States Department of Agriculture's Food Safety Inspection Service (2001) (USDA FSIS) to "establish requirements applicable to meat and poultry establishments designed to reduce the occurrence and numbers of pathogenic microorganisms on meat and poultry products, reduce the incidence of foodborne illness associated with the consumption of these products and provide a framework for modernization of the current system of meat and poultry inspection." The "Mega-Reg" was to utilize the HACCP

* Corresponding author. Tel.: +1-501-575-2256; fax: +1-501-575-5306.
E-mail addresses: haroldg@uark.edu (H.L. Goodwin Jr.), rshiptsova@econ.usu.edu (R. Shiptsova).

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approach to achieve its goal of reducing pathogens in food. HACCP represents a new approach to food safety in the meat industry because it focuses on prevention of microbial hazards rather than ex post inspection for contamination (Unnevehr & Jensen, 1996). In addition, there are physical and chemical hazards included in the Mega-Reg.

HACCP implementation for all meat and poultry plants employing more than 500 persons began January 26, 1998. On the same date in 1999, plants with 11 up to 499 employees were added to the HACCP inspection list. Approximately 7,000 inspectors operating from 17 regional USDA FSIS offices are currently dedicated to HACCP implementation and enforcement. The pathogen reduction regulation was expected to have a major impact on the safety of meat and poultry products and on industry production methods.

USDA FSIS conducted an economic impact assessment of the regulation that showed expected benefits would greatly exceed expected costs. In spite of the demonstrated benefits, the assessment was met with controversy. The major reason for controversy was the difficulty in estimating ex ante costs (Unnevehr & Jensen, 1996). For instance, Knutson et al. (1995) (Institute for Food Safety and Engineering) provided much higher cost ($172, $345 and $521 million) estimates than estimates FSIS ($55, $44 and $71 million) for HACCP implementation costs for poultry, pork, and beef, respectively.

Similarly, uncertainty surrounds the methods used to forecast the regulation's ultimate impact on foodborne illness. Current technologies to detect and prevent food related hazards are unable to guarantee a food supply that is 100% safe. Pathogens can enter the food supply at any point from producer to consumer; however, current Federal regulations address only the slaughter and processing portion of the food chain. It is still unclear whether, or to what extent, pathogen reductions in raw meat products will reduce the incidence of foodborne illness.

The economic impact of foodborne illness control and prevention on the food industry has been largely neglected in attempts to place a value on food safety improvements. Current and most recent efforts have focused primarily on improvements in measuring loss of life, loss of productivity due to illness and direct costs of medical treatment (Roberts & Smallwood, 1991). Improved estimates of these very real human and social costs are clearly important in accurately placing a value on food safety improvements and should not be minimized; however, FSIS estimates are only 'unconditional' estimates for costs, i.e., assuming that costs and benefits will happen with certainty. The effects of changing cost structures in food industries directly impacted by new FSIS regulations also need to be refined as new data become available to more effectively assess the on-going costs of this regulation.

This study focuses on how the incidence of costs from new regulatory action affects the poultry industry after "Mega-Reg" implementation. Antle (2000) developed econometric cost function estimates from secondary Census of Manufacturers data. These estimates indicate that efficiency costs of food safety regulations could realistically exceed FSIS benefit estimates. This is the first study on HACCP implementation that employs primary data obtained from the food industry rather than simulated data to estimate HACCP costs. The equilibrium displacement model (EDM) is employed for the analysis. The model takes into account the costs imposed by the regulation as well as substitution effects in consumption among poultry, pork, and beef. The supply shock for the poultry industry is based on real data, EDM estimates show how pathogen reduction regulation costs affect the poultry industry.

2. Data and methods

Estimates of HACCP costs for the broiler slaughter industry used in this study are based on surveys of plant managers from the 11 firms participating in the HACCP Roundtable, an academic, governmental, and industry group comprised predominantly of representatives of broiler processing firms. This group meets monthly to discuss issues related to HACCP implementation and monitoring. A survey of 56 slaughter plants owned and operated by these firms was conducted to assess costs associated with the first year of HACCP Mega-Reg implementation. The survey focused on additional 1998 capital and capital monitoring costs as well as operational costs incurred since HACCP implementation. Operational costs included water costs, maintenance and monitoring costs, personnel costs and additional training costs related to HACCP monitoring and record keeping. Only broiler slaughter plants were selected for survey inclusion. Surveys were sent to the respective plant managers or their designee for completion and were returned to the University of Arkansas for analysis. Of the 56 surveys sent, 35 were returned in usable form. Total slaughter capacity for these 35 plants represented over 25% of the total U.S. broiler slaughter in 1998, 2.05 billion of the 8 billion total. The results of the survey are presented in Table 1. These survey results are used to estimate HACCP costs for the U.S. broiler industry and to perform benefit/costs analysis for HACCP regulation.

EDM are employed to quantify producer losses/gains resulting from the new regulations. These models allow for the approximation of losses or gains accruing to producers, consumers, or both when market equilibrium is disturbed by an exogenous shock. Within these models, market equilibrium is characterized by functions that are linear in supply and demand elasticities. Such models have been used extensively in the analysis of agricultural and food policies (e.g., Beghin & Chang, 1992; Brown, 1995; Summer & Wohlgenant, 1985; Unnevehr, Gomez, & Garcia, 2001). More specifically, EDM models have been used to analyze food safety policy. Unnevehr et al. (2001) used EDM methods to estimate the incidence of producer welfare loss resulting from HACCP regulations. Their study examines how new regulation to reduce microbial pathogens may influence competitiveness among the beef, pork, and poultry industries. The EDM is used to simulate producer welfare losses taking into account costs imposed by the regulation and substitution effects in consumption. The use of an EDM framework allows for examination of the impact of an exogenous shock on endogenous variables of the model in terms of both direct and indirect effects.

Elasticity estimates are required to implement this type of model. The sensitivity analysis is often conducted by ‘guessing’ plausible elasticity values. Davis and Espinoza (1998) suggested a new sensitivity analysis methodology for the EDM, which is based on prior and posterior distributions of the estimated structural parameters. In this analysis, stochastic simulation of the EDM parameters are conducted to obtain confidence limits around final EDM estimates.

Table 1
Cost increases for poultry slaughter plants incurred since HACCP implementation, responding broiler plants, January 26, 1998 to January 26, 1999

Costs category		Sum	Mean (SD)
I. Capital costs	Change in equipment	$5,260,194	$154,712 (201,142)
II. Capital monitoring costs	Machinery	$247,764	$9,911 (27,260)
	Chemicals	$463,750	$18,550 (65,028)
	Product loss	$8,700	$2,000 (7,187)
	Packaging	$48,000	$363 (1,138)
	Other	$275,500	$11,479 (33,229)
	Total capital monitoring costs	$1,043,714	$30,697 (92,060)
	Total change in capital costs	$6,303,907	$180,112 (214,246)
III. Operational costs			
A. Water costs	Change in annual water costs[a]	$3,153,412	$98,544 (90,314)
	Change in annual waster water treatment costs	$6,192,243	$213,526 (496,217)
	Change in gallons	$2,102,274,632	$65,696,082 (60,209,451)
	Total change in water costs	$9,345,655	$292,052 (491,570)
B. Maintenance and monitoring costs	Costs of plant manager time spent on HACCP monitoring, appeals and compliance[b]	$251,604	$7,862 (10,146)
	Additional preventive maintenance	$1,402,934	$43,842 (120,197)
	Costs of additional preventive management personnel since HACCP began	$7,653,080	$255,103 (527,930)
	Total HACCP maintenance and monitoring costs	$9,307,618	$273,753 (600,339)
C. Personnel costs	Additional personnel costs[c]	$4,898,963	$148,453 (119,861)
	Consulting expertise costs	$117,129	$3,549 (6,259)
	HACCP training costs	$706,895	$21,421 (19,340)
	Loss of management	$62,390	$3,889 (4,928)
	Total HACCP personnel costs	$5,785,377	$165,296 (128,790)
D. Additional training costs		$1,000,000	$500,000
Total operational costs		$25,438,650	
Total fixed and variable costs		$31,742,557	

[a] Calculated as $1.50/1,000 gallons of water.
[b] Estimated at wage rate of $20/h.
[c] Assumed that 30% of managers quit since HACCP began.

This study employs supply and demand elasticities estimated from supply and demand systems. Wholesale supply elasticities from Sullivan, Wainio, and Roningen (1990) and retail demand elasticity estimates from Huang (1993) have been used in the estimation (Table 2). The results using alternative elasticity estimates, including wholesale demand elasticity estimates from Sullivan and retail demand from Lemiex and Wohlgenant (1989) and Eales and Unnevehr (1993) are available from the authors. The shock in supply is derived from the estimated actual HACCP costs for the U.S. broiler industry and ex ante FSIS estimates of HACCP costs for pork and beef industries.

Table 2
Elasticity estimates

	Beef	Pork	Chicken
Sullivan wholesale elasticities of supply			
Beef	0.65	−0.01	–
Pork	−0.02	1.00	−0.01
Chicken	–	−0.02	0.65
Huang retail elasticities of demand			
Beef	−0.6088	0.1214	0.0207
Pork	0.2130	−0.7162	0.0167
Chicken	0.1054	0.0484	−0.3718

Fig. 1 shows the hypothesized impact of HACCP on meat industries. First wholesale supply (S_W) shifts, which, in turn, affects a retail supply (S_R) shift. The magnitude of the retail supply shift depends on the elasticity of price transmission. The substitution effect takes place when consumers start to substitute among the three meat products depending on supply shifts. The consumer demand and supply equations for each industry are

$$Q_i^s = f_i^s(W_i, C_i), \qquad Q_i^d = f_i^d(P_{br}, P_p, P_b), \qquad Q_i^d = Q_i^s = Q_i, \quad i = b, br, p \tag{1}$$

where b is beef, br the broilers, p the pork, W_i the wholesale price for good i, P_i the retail price for good i, C_i the HACCP cost per unit produced to industry, and Q_i is the quantity produced by industry i.

Differentiating the supply and demand equations above and rearranging terms yields

$$\mathrm{d}\ln(Q_i) = \varepsilon_i(\mathrm{d}\ln(W_i) - c_i), \qquad \mathrm{d}\ln(Q_i) = \sum_j \eta_{ij}\,\mathrm{d}\ln(P_j),$$
$$\mathrm{d}\ln(W_i) = \tau_i\,\mathrm{d}\ln(P_i), \quad i, j = b, br, p \tag{2}$$

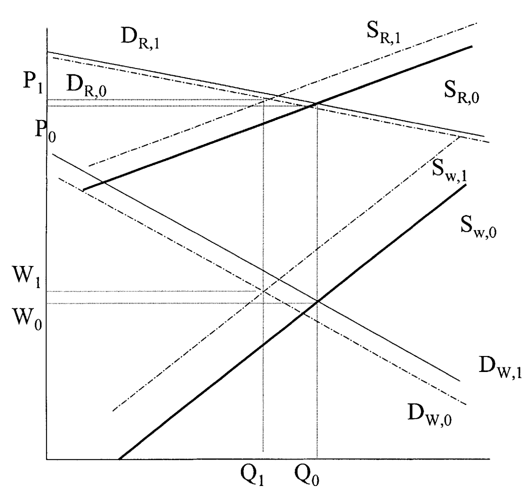

Fig. 1. A shock in wholesale supply and its effects on retail demand and supply and consumption.

where τ_i, ε_i, and for good i, respectively; and η_{ij} is the demand elasticity for product i with respect to product j.

The price variable in the demand equations reflects retail price. Price in the supply equations may reflect either wholesale or farm commodity price, depending on the method of estimation. Within the system of Eq. (2), relative change of wholesale price is assumed proportional to relative change in retail price. The multiplier τ_i is the elasticity of price transmission between wholesale and retail prices. The linear shift assumption of the EDM has the advantage of simplicity in the estimation procedure; however, it imposes restrictions on the shocks. A linear shift in supply implies the same additional cost per unit for the whole industry. That is, increases in marginal costs would be considered to be constant. This is supported by Antle's (2000) finding that costs of regulation per pound of meat are found to be size neutral for all but the smallest plants (10 or fewer employees) or the period of this analysis, only large poultry and meat plants had to be compliant with the pathogen reduction regulation specified in the Mega-Reg in 1998. Therefore, HACCP compliance costs per production unit were accounted as approximately the same for each plant in the sample. Thus, the shock c in the model is assumed to be total HACCP costs as a percent of average total production value by industry i. In the long-run competitive equilibrium, a change in the cost per unit produced is approximately equal to the change in marginal costs. The change in marginal cost c_i for product i is

$$c_i = \frac{C_i \bar{Q}_i}{W_i \bar{Q}_i} = \frac{C_i}{W_i} \tag{3}$$

where $\bar{Q}_i$ is average quantity produced by industry i. Costs as a percentage of industry sales are given in Table 3.

The other limitation of the model is the assumption that quantity supplied at the wholesale and retail level is the same, which may not always be true. However, this might be a better way to estimate welfare changes as a result of the regulation because EDM requires elasticity estimates. Elasticities of demand are usually estimated at the retail level, and elasticities of supply are estimated at farm or wholesale level. Therefore, an assumption of same quantity supplied for both retail and wholesale levels was made. Price transmission elasticity will be used to derive wholesale price percentage change from retail price percentage change. Bernard and Willett (1996) argued that elasticity of price transmission

Table 3
Total annual costs and production by industry

	Broilers	Pork	Beef
HACCP costs[a] (million $)	124	345	521
Total production (million lb)	27612	19001	25760
Total retail sales	66045.12	46172.43	71355.20
Industry sales (million $)	17745.31	18487.97	39412.80
HACCP costs as percent of industry sales	0.7	1.87	1.32

[a] HACCP costs are estimated for broiler industry only, Institute for Food Science and Engineering at Texas A&M University (IFSE) simulated estimates are used for beef and pork industries.

change depends on shifts in retail food demand. This study focuses on average price transmission elasticity, and, therefore, Gardner's (1975, p. 403) formula is used

$$\tau_i = \frac{\sigma_i + e_b}{\sigma_i + S_i^p e_b + (1 - S_i^p) e_a} \tag{4}$$

where σ is the elasticity of substitution between producer and marketing inputs, e_a the elasticity of supply of producer inputs, e_b the elasticity of supply of marketing inputs, and S^p is the producer share of retail dollar.

Endogenous variables of the model are the proportional changes in quantities and prices of pork, beef, and chicken. The exogenous shocks are change in prices received by the producer due to additional costs. It is necessary to form estimates of producer and consumer surplus as well as the change in social welfare so that some measure of welfare impact from the aforementioned endogenous and exogenous changes. Producer welfare changes are estimated following the procedure outlined in Unnevehr et al. (2001). Consumer and social welfare changes are estimated in a similar manner utilizing classic welfare theory. The concept of consumer and producer surplus can be found in a *Microeconomic* textbook and was derived by the authors based on the concept.

Change in producer surplus for commodity i without the substitution effect is

$$\Delta \mathrm{PS}_i = W_i Q_i (\mathrm{d}(\ln W_i) - c_i)(1 + 0.5\,\mathrm{d}(\ln Q_i)) \tag{5}$$

and with substitution is

$$\Delta \mathrm{PS}_{i,\mathrm{s}} = W_i Q_i (\mathrm{d}(\ln W_{i,\mathrm{s}}) - c_i)(1 + 0.5\,\mathrm{d}(\ln Q_i^*)) \tag{6}$$

Change in consumer surplus without substitution is

$$\Delta \mathrm{CS}_i = -P_i Q_i\,\mathrm{d}(\ln P_i)(1 + 0.5\,\mathrm{d}(\ln Q_i)) \tag{7}$$

and with substitution is

$$\Delta \mathrm{CS}_{i,\mathrm{s}} = -P_i Q_i\,\mathrm{d}(\ln P_i)(1 + 0.5\,\mathrm{d}(\ln Q_{i,\mathrm{s}}))\frac{\mathrm{d}(\ln Q_{i,\mathrm{s}})}{\mathrm{d}(\ln Q_i)} \tag{8}$$

where the subscripts i, s indicates substitution. Total consumer surplus change is difficult to assess because of the lack of information on human health improvement.

Welfare change for the retailer without the substitution effects is

$$\Delta \mathrm{RS}_i = -W_i Q_i\,\mathrm{d}(\ln W_i)(1 + 0.5\,\mathrm{d}(\ln Q_i)) + P_i Q_i (\mathrm{d}(\ln P_i) - c_i^r)(1 + 0.5\,\mathrm{d}(\ln Q_i)) \tag{9}$$

where c_i^r is percent of HACCP costs of retail sales.

Welfare change for the retailer with substitution effects is

$$\Delta \mathrm{RS}_{i,\mathrm{s}} = -W_i Q_i\,\mathrm{d}(\ln W_i)(1 + 0.5\,\mathrm{d}(\ln Q_{i,\mathrm{s}}))\frac{\mathrm{d}(\ln Q_{i,\mathrm{s}})}{\mathrm{d}(\ln Q_i)} + P_i Q_i (\mathrm{d}(\ln P_{i,\mathrm{s}}) - c_i^r)(1 + 0.5\,\mathrm{d}(\ln Q_i)) \tag{10}$$

Finally, change in total social welfare for industry i is

$$\Delta \mathrm{SW}_i = \Delta \mathrm{PS}_i + \Delta \mathrm{RS}_i + \Delta \mathrm{CS}_i \tag{11}$$

3. Results

Estimated results are derived from Huang retail elasticity of demand and Sullivan wholesale elasticity of supply estimates and two alternative values for price transmission elasticities. The elasticity estimates were derived by simulating distributions for the EDM parameter estimates. The parameters were repeatedly drawn from their respective distributions over 1,000 replications and 95% confidence bounds were constructed to generate the empirical distributions of the welfare measures. The results are presented in Tables 4–6. Initial elasticity estimate are presented in Table 2. The elasticity of price

Table 4
Change in producer, retailer, and consumer surplus for broiler industry (millions of dollars)

	Mean	Lower limit	Upper limit
$\tau = 1.26$			
Producer (without substitution)	−34.71	−37.15	−32.28
Producer substitution (with substitution)	−13.57	−16.04	−11.09
Consumer (without substitution)	−210.39	−216.77	−204.01
Consumer substitution (with substitution)	−86.68	−118.87	−54.49
Retailer (without substitution)	−167.96	−174.84	−161.09
Retailer (with substitution)	−76.29	−90.62	−61.95
$\tau = 1.41$			
Producer (without substitution)	−32.03	−33.95	−30.11
Producer substitution (with substitution)	−12.16	−14.75	−9.56
Consumer (without substitution)	−197.08	−201.73	−192.43
Consumer substitution (with substitution)	−84.33	−114.65	−54.02
Retailer (without substitution)	−151.99	−157.05	−146.94
Retailer substitution (with substitution)	−65.15	−79.03	−51.27

Table 5
Change in producer, retailer, and consumer surplus for pork industry (millions of dollars)

	Mean	Lower limit	Upper limit
$\tau = 1$			
Producer (without substitution)	−134.09	−140.05	−128.14
Producer substitution (with substitution)	−120.89	−125.96	−115.82
Consumer (without substitution)	−475.66	−490.09	−461.23
Consumer substitution(with substitution)	−414.92	−568.92	−260.91
Retailer (without substitution)	−516.78	−532.49	−501.07
Retailer (with substitution)	−515.04	−580.97	−449.11
$\tau = 1.28$			
Producer (without substitution)	−115.14	−120.14	−110.15
Producer substitution (with substitution)	−101.18	−106.94	−95.42
Consumer (without substitution)	−377.76	−513.66	−241.86
Consumer substitution (with substitution)	−432.78	−443.7	−421.86
Retailer (without substitution)	−421.43	−432.48	−410.39
Retailer (with substitution)	−398.12	−467.77	−328.48

Table 6
Change in producer, retailer, and consumer surplus for beef industry (millions of dollars)

	Mean	Lower limit	Upper limit
τ = 1.18			
Producer (without substitution)	−209.85	−218.29	−201.42
Producer substitution (with substitution)	−167.28	−175.06	−159.49
Consumer (without substitution)	−412.29	−424.8	−399.79
Consumer substitution (with substitution)	−343.82	−471.49	−216.16
Retailer (without substitution)	−581.75	−596.97	−566.53
Retailer (with substitution)	−546.12	−634.24	−458
τ = 1.28			
Producer (without substitution)	−200.54	−207.19	−193.89
Producer substitution (with substitution)	−162.49	−170.67	−154.32
Consumer (without substitution)	−399.56	−408.99	−390.13
Consumer substitution (with substitution)	−359.52	−488.81	−230.24
Retailer (without substitution)	−549.08	−560.69	−537.48
Retailer (with substitution)	−493.66	−584.63	−402.68

transmission of $T_1 = 1.26$ for the poultry industry was estimated by utilizing Gardner's formula (4) assuming plausible values for the elasticity of supply of marketing services e_b (1.00) and the elasticity of substitution between farm and marketing inputs σ (0.0) (Gardner, 1975; Richards & Patterson, 1998). Davis and Espinoza (1998) argued that alternative values e_b of 2.00 and σ of 0.74 (p. 874) might be more appropriate. Their argument was based on generating posterior distributions for the elasticity estimates and finding a mode for the generated dataset (p. 875).

This study is concerned with shifts in demand and supply only in domestic markets. Therefore, the exported quantities were subtracted from the respective industry's total production. For the broiler industry, the export prices are generally considerably lower than domestic broiler meat prices, because mostly dark meat is being exported. A new domestic price index was calculated to adjust for that difference.

The results are given for the three participating agents: producer, retailer, and consumer. For the broiler industry, producer welfare changes for both with and without substitution effects and for the alternative price transmission elasticity values are presented in Table 4. The results are robust with respect to different values of price transmission elasticity. The results indicate that without substitution effects, estimated annual mean broiler producer surplus losses are over $34 million if the Gardner price transmission elasticity estimates are applied, and $32 million when Davis and Espinoza estimates are applied. However, with substitution effects, producer mean loss is $13 million for Gardner estimates and $12 million for Davis and Espinoza estimates. The difference in estimated producer welfare changes demonstrates the importance of both consumer behavior as reflected and the elasticity of price transmission. Higher own-price elasticity of demand results in greater producer welfare losses when substitution effects are not considered. When demand is inelastic, a small decrease in quantity demanded leads to a large increase in price, which offsets a large part of producer losses. Hence, smaller demand elasticity is associated with a smaller producer loss. When no substitution occurs, the total adjustment to shifts in supply is reflected by movement along the demand curve. When the substitution effect occurs, producer losses are smaller with the magnitude of the reduction depending on the direction and magnitude of the demand shift. The comparison of losses with and without substitutability again emphasizes the importance of consumer behavior on producer welfare losses. When consumers substitute among different commodities, price increase causes inward shift in demand that sometimes might lead to a greater producer loss (see Tables 4–6).

Retailers usually incur a greater loss in absolute terms than do producers. From Table 4, mean producer losses for the broiler industry are up to $35 million without the substitution effects when using Gardner price transmission elasticity, consumer losses are up to $210 million and the retailer losses are up to $168 million. Estimated mean losses are, in general, higher for beef and pork industries (Tables 5 and 6). Mean producer welfare loss is up to $134 million (without substitution) and $120 (with substitution) for the pork industry and up to $209 million (without substitution) and $167 million (with substitution) for the beef industry. Retailer losses for pork and beef follow a similar pattern (pork: $517 million vs. $515 million, beef: $582 vs. $546 million). Consumer surplus losses are smaller for both pork and beef with substitution effects (pork: $476 million vs. $415 million, beef: $412 million vs. $344 million); substitution between different commodities helps the consumer to reduce losses.

The results for change in producer and retailer for all meat products combined are given in Table 7. Mean producer losses range from $347 to $378 million without substitution effects, and from $276 to $301 with substitution effects. Retailer losses are up to $1,267 without substitution and up to $1,191 with substitution. Mean consumer losses are up to $1,122 without substitution effects and $956 with substitution effects. For all the results, the effect of using different price transmission elasticities is substantial. Also, when the substitution effect is added, retail demand elasticities have a great effect on the direction and magnitude of surplus change for all the three participating parties (producers, retailers, and consumers). Therefore, one may infer that the most competitive industry(ies) might ‘‘benefit’’ on behalf of others as a result of the regulation.

Table 7
Change in producer, retailer, and consumer surplus for all meat products (millions of dollars)

Transmission elasticity		Mean	Lower limit	Upper limit
Gardner elasticity estimates	Producer (without substitution)	−378.66	−395.49	−361.83
	Producer (with substitution)	−301.73	−317.06	−286.41
	Retailer (without substitution)	−1266.49	−1304.1	−1228.88
	Retailer (with substitution)	−1137.45	−1305.15	−969.74
	Consumer (without substitution)	−1098.34	−1131.66	−1065.02
	Consumer (with substitution)	−821.62	−1117.12	−526.12
Davis and Espinoza elasticity estimates	Producer	−347.71	−361.28	−334.15
	Producer substitution	−275.83	−292.36	−259.3
	Retailer	−1122.51	−1150.11	−1094.91
	Retailer substitution	−956.93	−1130.78	−783.08
	Consumer (without substitution)	−1011.12	−1034.99	−987.26
	Consumer (with substitution)	−821.62	−1117.12	−526.12

Table 8
Change in producer and retailer surplus as a percent of total sales

Transmission elasticity	Participating party	Mean	Lower limit	Upper limit
Gardner elasticity estimates	Producer (without substitution)	−0.58	−0.6	−0.56
	Producer (with substitution)	−0.46	−0.48	−0.44
	Retailer (without substitution)	−0.45	−0.47	−0.43
	Retailer (with substitution)	−0.55	−0.57	−0.54
Davis and Espinoza elasticity estimates	Producer	−0.55	−0.57	−0.53
	Producer substitution	−0.45	−0.47	−0.43
	Retailer	−0.59	−0.62	−0.55
	Retailer substitution	−0.49	−0.53	−0.42

Table 8 presents results for percentage welfare loss for producers (as a percent of industry sales) and for retailers (as a percent of retail sales). In general, producers incur a higher loss as a percent of all sales because of a lower product value. Finally, Table 9 presents social welfare losses for the meat industry as a result of pathogen reduction regulation. Mean losses range from $2,054 to $2,260 million with substitution effects.

Projected consumer health benefits were estimated to exceed greatly the costs of the regulation (Buzby, Roberts, Lin, & MacDonald, 1996). Actual consumer health benefits are yet difficult to assess because it has been only 3 years since the regulation was implemented, and there have not been sufficient statistics accumulated to test whether a statistically significant decrease in foodborne illness has occurred. FoodNet data of the Center for Disease Control (CDC) indicate that there were no significant changes in human health in 1998 (see Table 10). *Salmonella enteritidis* went down, but this is associated with egg quality assurance programs, not with HACCP plans in meat and poultry processing plants.

Table 9
Change in social welfare (millions of dollars)

Transmission elasticity	Substitution	Mean	Lower limit	Upper limit
Gardner elasticity estimates	Without substitution	−2743.49	−2743.71	−2743.28
	With substitution	−2260.8	−2599.94	−1921.66
Davis and Espinoza elasticity estimates	Without substitution	−2481.35	−2481.49	−2481.21
	With substitution	−2054.38	−2517.7	−1591.06

Table 10
Rate[a] of selected pathogens detected by FoodNet[b] at the five original sites, by year and pathogen, 1996–2000

Pathogen	1996	1997	1998	1999	2000
Campylobacter	23.5	25.2	21.4	17.5	18.1
E. coli O157	2.7	2.3	2.8	2.1	2.0
Salmonella	14.5	13.6	12.3	14.8	14.1
Salmonella enteritidis	2.5	2.3	1.4	1.3	1.2

[a] Per 100,000 population.
[b] Source: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5115a3.htm

Rates of occurrence of *Campylobacter* went down slightly in 1998–1999. However, consumer reports indicate a higher occurrence of *Campylobacter* in 1998 than in 1997, which indicates that presence of bacteria in raw meats may well not directly translate into human illness. Bacteria in raw meats and human illness might be negatively correlated, especially when consumer awareness rises. Furthermore, data for human illness were collected for selected counties in five states in 1996 and in 1997 and in seven states in 1998 and 1999. Therefore, any difference in the results might occur as a result of different samples. This suggests that consumers might have lost over $1,000 million annually over the first 3 years of Mega-Reg implementation without achieving a statistically significant improvement in food safety benefits.

4. Analysis limitations and conclusions

This is the first study that employed real cost estimates of HACCP Mega-Reg implementation to analyze welfare losses resulting from the new regulation. Overall, the results show that producer welfare losses are substantial for the broiler industry. The cost estimates are based on data of the year of 1998; small plants were not yet introduced to implementing the HACCP Mega-Reg. Costs to small plants are expected to be greater than to the large ones. Further, HACCP costs for broiler plants were underestimated because most pathogen reduction compliance costs were not included. Also costs for poultry further-processing plants were not included. The other limitation of the study is that only world wholesale supply elasticity estimates were available. Due to the nature of the markets, the supply response of the U.S. domestic market might be stronger and quicker than the one of the world. Because of more imperfections and distortion, the rest of the world supply may not be as sensitive to change in price as U.S. meat and poultry. Therefore, elasticity of the world's wholesale supply is probably smaller than that of U.S. supply, a result that may also lead to underestimated producer welfare losses.

However, even these underestimated costs of HACCP compliance result in a substantial decrease in social welfare. Mean welfare losses for the broiler industry may be as high as $35 million per year. Consumer mean welfare losses are even much higher than for producers (up to $197 million per year) but are contingent on reduction in foodborne illness. More information on human health improvement has to be gathered to assess total consumer gains and losses. Results of this study indicate that social welfare loss (a sum of consumer, producer, and retailer surplus changes) for all meat products exceed $2 billion per year (Table 9).

According to the FoodNet data, there has been no significant reduction in the incidence of foodborne illnesses in the original five sample states during the period 1996 through 2000. There have been minor and nominal changes in occurrences of three primary pathogens—*Campylobacter*, *E. coli* O157 and *Salmonella*; *E. coli* and *Salmonella* are two pathogens directly targeted by the Mega-Reg (see Table 10). Based upon this data, it can be said that producer, retailer, and consumer welfare losses are not offset by the benefits of health improvement. These observations suggest that consumers (and society) are paying not for statistically verified food safety improvements but for improved food quality—not by choice but rather as a result of regulation. The intent of the "Mega-Reg" was to significantly decrease occurrences of human illness. Despite reported reductions of pathogenic contamination on meat and poultry carcasses, this reduction does not necessarily result in a decrease in human illness due to the high likelihood of contamination during handling and preparation of food.

Although much of the fear surrounding food safety focuses on meat and poultry, the General Accounting Office estimates that 85% of foodborne illness comes from the fruits, vegetables, seafood, and cheeses that are regulated by the FDA. These foods claim a larger share of the American diet each year. ‘‘Poisoning’’ from those foods can be every bit as serious as that from meat and poultry. Still, the FDA has less than 10% of the inspectors of the USDA FSIS, the agency responsible for regulating the meat and poultry industry. While USDA inspectors examine meat before it gets to grocery freezers, the FDA must increasingly rely on the companies it regulates to keep their factories clean and their products safe.

An intervention policy to enable production efficiencies to offset regulation expense for the industry might be necessary to compensate for these welfare losses. An example of such a policy intervention is the recently implemented HACCP-based inspection model project (HIMP) for processors of young poultry, market hogs and fed cattle. Under this method, food safety and non-food safety defects are set to pre-determined performance criteria. For young poultry, the HIMP method places a carcass inspector prior to the chiller and critical assessments are made of each carcass. FSIS inspectors still do off-line inspections to ensure safety. In the food safety categories, FSIS inspector verification checks found a 99.9% reduction in defects over traditional slaughter inspection (USDA FSIS). One major advantage of HIMP is that food safety risks are effectively minimized without increased costs of government inspection and with increased throughput and reduction in plant downtime. Dollars saved from the government inspection function could be reallocated for other purposes, such as food handling and food preparation education initiatives. In addition, efficiency gains in the plants would help to offset the additional costs to processors of ‘‘Mega-Reg’’ implementation.

References

Antle, J. (2000). No such thing as a free safe lunch: The cost of food safety regulation in the meat industry. *American Journal of Agricultural Economics*, *82*, 310–322.

Beghin, J., & Chang, R. (1992). Differentiated products and supply controls in the analysis of agricultural policy reform: The case of tobacco. *Agricultural Economics*, *7*, 301–315.

Bernard, J. C., & Willett, L. S. (1996). Asymmetric price relationships in the U.S. broiler industry. *Journal of Agricultural and Applied Economics*, *27*, 279–289.

Brown, A. B. (1995). Cigarette taxes and smoking restrictions: Impacts and policy implications. *American Journal of Agricultural Economics*, *77*, 946–951.

Buzby, J. T., Roberts, C. T., Lin, C.-T. J, & MacDonald, J. M. (1996). *Bacterial foodborne disease: Medical costs and productivity losses*. USDA, Agricultural Economic Report No. 741.

Davis, G. C., & Espinoza, M. C. (1998). A unified approach to sensitivity analysis in equilibrium displacement models. *American Journal of Agricultural Economics*, 868–879.

Eales, J. S., & Unnevehr, L. J. (1993). Simultaneity and structural change in U.S. meat demand. *American Journal of Agricultural Economics*, *75*, 259–268.

Gardner, B. L. (1975). The farm-retail price spread in a competitive food industry. *American Journal of Agricultural Economics*, *57*, 399–409.

Huang, K. S. (1993). *U.S. demand for food: A complete system of price and income effects*. Washington, DC: USDA, ERS Technical Bulletin No. 1821.

Knutson, R. D., Cross, H. R., Acuff, G. R., Russell, L. H., Nichols, J. P., Ringer, L. J., Savell, J. W., Childrers, A. B., & Wang, S. (1995). *Reforming meat and poultry inspection: Impacts of policy options*. Unpublished, Texas A&M University: Institute for Food Science and Engineering (AFSE), Agricultural and Food Policy Center, Center for Food Safety.

Lemiex, C. M., & Wohlgenant, M. K. (1989). Ex ante evaluation of the economic impact of agricultural biotechnology: The case of porcine somatotropin. *American Journal of Agricultural Economics*, *71*, 903–914.

Richards, T. J., & Patterson, P. M. (1998). *The economic value of spin control: Food safety and the strawberry case*. National Food and Agricultural Policy Project, Arizona State University.

Roberts, T., & Smallwood, D. (1991). Data needs to address economic issues in food safety. *American Journal of Agricultural Economics*, *73*, 933–942.

Summer, D. A., & Wohlgenant, M. K. (1985). Effects of an increase in the Federal excise tax on cigarettes. *American Journal of Agricultural Economics*, *67*, 235–242.

Sullivan, J., Wainio J., & Roningen, V. (1990). *A database for trade liberalization studies*. Washington, DC: USDA, ERS, Agricultural Trade and Analysis Division.

United States Department of Agriculture (2001). *Red Meat Yearbook, 1970–2000*. Washington, DC: Economic Research Service.

United States Department of Agriculture's Food Safety Inspection Service (2001). *An overview of the HACCP-based inspection model project: Backgrounder* (http://www.fsis.usda.gov/oa/background/himp_overview.htm).

Unnevehr, L. J., & Jensen, H. H. (1996). HACCP as a regulatory innovation to improve food safety in the meat industry. *American Journal of Agricultural Economics*, 764–769.

Unnevehr, L. J., Gomez, M. I., & Garcia, P. (2001). The incidence of producer welfare losses from food safety regulation in the meat industry. *Review of Agricultural Economics*, *20* (1), 186–201.