Economic Impacts of the Zero Tolerance Directive on the Cost Structure of Beef Packing Companies

By

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Abstract

Data from a major beef packing company (including regulatory compliance costs) are used to estimate a translog cost function and a system of input demand equations. Regulatory compliance costs associated with the zero tolerance directive have increased the cost share of cattle while reducing the demand for all inputs.

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Introduction and Brief History of FSIS Regulations

Increased scrutiny of the safety of the U.S. food supply has followed in the wake of recent foodborne illness outbreaks (e.g., the 1993 *E. coli* 0157:H7 outbreak in the Pacific Northwest). This increased scrutiny combined with the need to adopt a more science-based approach to meat inspection has prompted the Food Safety and Inspection Service (FSIS) to initiate major changes in recent years. Although considerable economic research pertaining to the cost of foodborne illness to consumers and society (e.g., Marks and Roberts; Roberts, 1991; and Roberts, 1989) and consumers' willingness-to-pay for safer food (e.g., Hayes et al.; Buzby and Skees; Eom; Huang; Choi and Jensen; and Zellner and Degner) has been published, little research addressing the economic impact of food safety regulations on food processors exists. Given proposed changes in federal meat inspection regulations, a better understanding of the economic impact of such regulations on agribusinesses is needed. This study uses data from a major beef packing firm to determine the impact of a specific FSIS regulation (i.e., the zero tolerance directive) on the firm's cost structure.

The current U.S. meat inspection system has changed very little since its inception in the early 1900's. Prior to 1996, the method of inspection used by FSIS was based strictly on an organoleptic (i.e., sight, smell, and feel) approach for detecting unsafe meat. On March 2, 1993, in direct response to the outbreak of *E. coli* 0157:H7 in the Pacific Northwest earlier that year, FSIS began enforcement of the zero tolerance directive which requires plants to trim all identifiable feces, ingesta, and milk found on the surface of carcasses before those carcasses are washed. In December of that year, Inspectors-In-Charge were instructed to slow slaughter lines if the "inspection procedure cannot be adequately performed" (Reed, p.1). This policy has caused firms to incur losses not only due to the physical loss of meat trimmings, but also due to slower line speeds. On October, 17, 1994, FSIS implemented a program to test for *E. coli* 0157:H7 in ground beef. More recently (July 6, 1996), FSIS released the final ruling on the Pathogen Reduction, Hazard Analysis, Critical Control Point (HACCP) Systems regulation which promises to be the most significant change in the meat inspection system since its inception.

Model Development

The impacts of the zero tolerance directive are considered by estimating a cost function using data from a major beef packing company. The translog functional form, which is commonly used in production analyses and studies of the meat products industry (e.g., Melton and Huffman; Ball and Chambers), is used in this study because it is a flexible functional form which places no restrictions on substitution possibilities among factors of production. The translog cost function is represented as:

$$(1) \qquad \ln C = \alpha_o + \Sigma_i\alpha_i \ln P_i + \alpha_q \ln Q + 1/2\Sigma_i\Sigma_j ß_{ij} \ln P_i \ln P_j + 1/2ß_q(\ln Q)^2 + 1/2ß_r(\ln R)^2 + \Sigma_i ß_{iq} \ln P_i \ln Q + \Sigma_i ß_{ir} \ln P_i \ln R + ß_{qr} \ln Q \ln R \qquad i,j = k,l,c,e,o$$

where "ln" represents natural logarithms, C is total cost, P_i is the price of input i, Q is total output, R is a measure of regulatory compliance costs, with k, l, c, e, and o indexing capital, labor, cattle, energy, and all other inputs, respectively. For the translog cost function to be consistent with neoclassical production theory, the following symmetry, homogeneity, and adding-up restrictions must be imposed:

(2) $ß_{ij}=ß_{ji}$; $\Sigma_j ß_{ij}=0$ for all i ; $\Sigma_i \alpha_i=1$; $\Sigma_i ß_{ij}=0$ for all j ; $\Sigma_i ß_{iq}=\Sigma_i ß_{ir}=0$.

Using Shephard's lemma, differentiation of equation (1) yields the following set of input demand functions:

(3) $S_i = \alpha_i + \Sigma_j ß_{ij} lnP_j + ß_{iq} lnQ + ß_{ir} lnR$ $\quad$ i,j = k,l,c,e,o

where $S_i = (P_i * X_i/C)$ is the cost share of input i, and X_i is the quantity of the i^{th} input. Given the translog function, price elasticities for conditional factor demands are calculated using input cost shares and the estimated coefficients of the cost function:

(4) $E_{ij} = (ß_{ij} + S_i S_j - \delta_{ij} S_i) / S_i$ $\quad$ i,j = k,l,c,e,o

where δ_{ij} is the Kronecker delta.

To obtain a meaningful measure of pairwise input substitution, Blackorby and Russell recommend using Morishima elasticities of substitution (MES). For the translog cost function, Morishima elasticities of substitution are calculated as:

(5) $M_{ij} = [(ß_{ji} + S_j S_i)/S_j] - [(ß_{ii} + S_i^2 - S_i)/S_i]$ $\quad$ i,j = k,l,c,e,o.

Economies of scale (EOS) represent the relative increase in output resulting from a proportional increase in all inputs, and can be written as:

(6) $EOS = (\alpha_q + ß_q lnQ + \Sigma_i ß_{iq} lnP_i + ß_{qr} lnR)^{-1}$ $\quad$ i = k,l,c,e,o.

The firm's short-run, inverse supply curve is given by its marginal cost function as:

(7) $P = MC = (\alpha_q + ß_q lnQ + \Sigma_i ß_{iq} lnP_i + ß_{qr} lnR)*(C/Q)$ $\quad$ i = k,l,c,e,o.

The own-price elasticity of supply (E_s) is approximately equal to the inverse of the own-price flexibility (F_s):

(8) $E_s \approx (F_s)^{-1} = \{C/(PQ) * [ß_q - (\delta lnC/\delta lnQ) * (1 - [\delta lnC/\delta lnQ])]\}^{-1}$.

To capture the impacts of regulatory compliance costs on the demand for inputs, input demand elasticities with respect to regulatory compliance costs are calculated as:

(9) $E_{ir} = (ß_{ir}/S_i) - \alpha_r$ $\quad$ i = k,l,c,e,o.

Data Discussion

Semi-annual data from November 1988 through May 1995 were obtained from the financial statements of five plants (selected for geographical representation) of a major U.S. beef packing firm resulting in a panel data set with 70 observations. Output is measured by the total dressed weight (pounds, carcass weight) of slaughtered animals. Expenditures on capital, labor, cattle, energy, and other inputs are divided by total costs to derive the five input shares used in equation (3). Total expenditures on capital are measured by summing expenditures on depreciation, rent, and total repairs and maintenance. Expenditures on "all other inputs" are calculated as total cost of production less expenditures on capital, labor, cattle, and energy.

Price data are obtained from government sources and from the firm. Following Goodwin and Brester, the implicit user cost of capital is used as a proxy for the price of capital and consists of two components: the real rate of interest and capital depreciation. The real rate of interest is calculated by subtracting the (semi-annual) rate of inflation (measured by semi-annual movements in the consumer price index) from semi-annualized bond rates. Consumer price indices are taken from *CPI Detailed Report* (U.S. Dept. of Labor). Bond rates are simple six month averages (December through May, and June through November) of monthly Baa bond rates reported in the *Survey of Current Business* (U.S. Dept. of Commerce) and *Moody's Bond Survey*. The depreciation component of the user cost of capital is calculated by dividing plant depreciation by net property values (fixed assets less plant depreciation).

Average hourly earnings for production workers in meat packing plants (SIC 2011), obtained from *Employment and Earnings* (U.S. Dept. of Labor), is used as a proxy for the price of labor. The firm's average price paid for cattle (on a dressed weight basis) is calculated by dividing their total cost of live cattle by total dressed slaughter weight. The producer price index for fuels, related products, and power, taken from *Producer Price Indexes* (U.S. Dept. of Labor), is used for the price of energy. The price index for "other goods" is backed out of the index of food marketing costs obtained from *Monthly Food Marketing Cost Index Data* (U.S. Dept. of Agriculture) using a Tornquist index suggested by Moschini.

The firm has recorded the amount of downtime caused by complying with the zero tolerance directive since its enforcement in March 1993. To capture an objective measure of the cost of this regulation, average number of minutes of weekly downtime is multiplied by the number of weeks in each semi-annual period. The regulatory compliance cost variable equals zero for all periods prior to 1993. Thus, this variable represents only those costs incurred as a direct result of slower line speeds due to the zero tolerance directive and does not reflect loss of product value due to trimming.

Empirical Results

The total cost equation (equation 1) was estimated jointly with the share equations (equation 3) for capital, labor, cattle, and energy using iterated seemingly unrelated regressions. The fifth input demand equation (all other goods) was not estimated to avoid over-identification. However, the parameters were recovered using the parametric restrictions from equation (2). Over 80% of the estimated coefficients (as reported in Table 1) are significantly different

Table 1. Cost Function Parameter Estimates[a]

Parameters	Estimates	Parameters	Estimates	Parameters	Estimates
α_0	0.5446	β_{ko}	-0.0031^{*}	β_r	$0.4E-4^{***}$
	(0.3449)[b]		(0.0017)		(0.8E-5)
α_k	0.0542^{***}	β_{ll}	-0.0278^{***}	β_{kq}	-0.0023^{***}
	(0.0150)		(0.0093)		(0.0008)
α_l	0.0562	β_{lc}	-0.0354^{***}	β_{lq}	-0.0008
	(0.0349)		(0.0007)		(0.0018)
α_c	0.7792^{***}	β_{le}	0.0054^{**}	β_{cq}	0.0070^{***}
	(0.0406)		(0.0022)		(0.0021)
α_e	-0.0233^{**}	β_{lo}	0.0500^{***}	β_{eq}	0.0014^{***}
	(0.0086)		(0.0072)		(0.0004)
α_o	0.1339^{***}	β_{cc}	0.0777^{***}	β_{oq}	-0.0051^{***}
	(0.0269)		(0.0008)		(0.0014)
α_q	0.9775^{***}	β_{ce}	-0.0040^{***}	β_{kr}	-0.2E-4
	(0.0332)		(0.0003)		(0.3E-4)
α_r	-0.0032^{***}	β_{co}	-0.0307^{***}	β_{lr}	-0.0008^{***}
	(0.0008)		(0.0006)		(0.0001)
β_{kk}	0.0030^{***}	β_{ee}	0.0021^{*}	β_{cr}	0.0009^{***}
	(0.0009)		(0.0013)		(0.0001)
β_{kl}	0.0077^{***}	β_{eo}	-0.0035^{*}	β_{er}	-0.0001^{**}
	(0.0023)		(0.0021)		(0.3E-4)
β_{kc}	-0.0075^{***}	β_{oo}	-0.0127^{**}	β_{or}	-0.0004^{***}
	(0.0002)		(0.0062)		(0.0001)
β_{ke}	-0.0001	β_q	0.0008	β_{qr}	0.0001^{***}
	(0.0006)		(0.0016)		(0.4E-4)

[a] Number of Observations=70; Degrees of Freedom: Cost Function=74, Share Equations=102; R-Squared's: System= 0.9999, Cost Function=0.9976, Capital=0.9701, Labor=0.9915, Cattle=1.0000, Energy=0.9710.

[b] Numbers in parenthesis are standard errors. Significance levels indicated by: "*"=0.10, "**"=0.05, "***"=0.01.

from zero at the 10% level.

The generalized R-square measure suggested by Baxter and Cragg was calculated for the complete system (0.9999). A raw moment R-square statistic ($1 - \mathbf{e}'\mathbf{e}/\mathbf{Y}'\mathbf{Y}$) is reported for each equation, where $\mathbf{e}'\mathbf{e}$ is the sum of the squared errors and $\mathbf{Y}'\mathbf{Y}$ is the sum of the squared dependent variables. Price elasticities of demand are reported in Table 2. All inputs have negative own-price elasticities of demand, with the exception of the cattle elasticity which is not statistically different from zero. The own-price elasticity of capital is relatively inelastic, while the other three significant own-price elasticities are elastic. The statistically insignificant elasticity on cattle probably reflects the importance of cattle as an input in the beef packing industry. Ward notes that major beef packing plants strive to operate near capacity. Thus, packers are likely to be relatively unresponsive to cattle price changes if they are trying to maintain a certain level of output. The signs on the estimated cross-price elasticities indicate that labor is a net substitute with all other inputs. Thus, labor is a relatively flexible input in the beef packing industry.

The Morishima elasticities of substitution (reported in Table 3) are calculated at the means of the data and indicate that cattle have the least potential for input substitutability. The highest substitution possibilities exist for labor, again signifying that labor is the most flexible input in the beef packing industry. The MES were also calculated at every data point (estimates available from the authors). The MES of most input ratios have either trended downward or remained relatively constant over the study period. The exceptions are the MES associated with cattle, which have all trended upward since the enforcement of the zero tolerance directive. These trends reflect the nature of the zero tolerance directive in that, conditional on output, the firm has had to increase cattle usage to offset the loss of carcass material caused by trimming.

Using mean values of the price and output variables, economies of scale is calculated as 1.008 with a standard error of 0.002. Given that this estimate is significantly different from 1,

Table 2. Own- and Cross-Price Elasticities of Demand.

Percent	With Respect to a One Percent Change in the Price of:

Change in the Quantity of:	Capital	Labor	Cattle	Energy	Other
Capital	-0.6773*** (0.1094)[a]	0.6344** (0.2798)	0.0075 (0.0266)	-0.1281* (0.0716)	0.1634 (0.2069)
Labor	0.1297** (0.0572)	-1.3635*** (0.2345)	-0.0079 (0.0170)	0.2245*** (0.0575)	1.0171*** (0.1826)
Cattle	0.0001 (0.0002)	-0.0003 (0.0007)	0.0001 (0.0009)	-0.0003 (0.0003)	0.0005 (0.0007)
Energy	-0.2896* (0.1620)	2.4831*** (0.6360)	-0.0715 (0.0747)	-1.3596*** (0.3540)	-0.7624 (0.5740)
Other	0.0396 (0.0502)	1.2060*** (0.2165)	0.0130 (0.0179)	-0.0817 (0.0617)	-1.1769*** (0.1876)

[a] Numbers in parenthesis are standard errors. Significance levels: "*"=0.10, "**"=0.05, "***"=0.01

Table 3. Morishima Elasticities of Substitution.

Quantities	Prices: Capital	Labor	Cattle	Energy	Other
Capital		0.8071*** (0.1582)[a]	0.6774*** (0.1094)	0.3877** (0.1884)	0.7170*** (0.0950)
Labor	1.9979*** (0.4920)		1.3632*** (0.2346)	3.8466*** (0.7247)	2.5695*** (0.4450)
Cattle	0.0074 (0.0269)	-0.0080 (0.0175)		-0.0716 (0.0749)	0.0129 (0.0183)
Energy	1.2315*** (0.3729)	1.5841*** (0.3634)	1.3593*** (0.3540)		1.2778*** (0.3857)
Other	1.3404*** (0.1413)	2.1940*** (0.3649)	1.1774*** (0.1876)	0.4145 (0.6619)	

[a] Numbers in parenthesis are standard errors. Significance levels: "**"=0.05, "***"=0.01

Table 4. Regulatory Compliance Cost Elasticities.

With Respect to a One Percent Change in:	Percentage Change in the Quantity of: Capital	Labor	Cattle	Energy	Other
Compliance Costs	-0.0124*** (0.0038)[a]	-0.0236*** (0.0025)	-0.0043*** (0.0008)	-0.0354*** (0.0074)	-0.0263*** (0.0022)

[a] Numbers in parenthesis are standard errors. Significance levels: "***"=0.01.

the firm is experiencing slight increasing returns to scale.

The firm has a *very* elastic, decreasing marginal cost curve, with an elasticity of supply equal to -158.20. Large beef packing firms are highly capital intensive and try to operate near full capacity (Ward). Thus, these types of firms are likely to be relatively unresponsive to changes in output price.

Table 1 shows that, except for $ß_{kr}$, the estimated coefficients on the regulatory compliance cost variables are statistically significant. The coefficient on the regulatory compliance cost variable in the marginal cost equation ($ß_{qr}$) is positive, indicating that as the cost of compliance with regulations increase, marginal costs increase. Cost shares for capital, labor, energy, and all other goods decrease in response to increases in regulatory compliance costs. However, the statistically significant positive coefficient on the compliance cost variable in the cattle demand equation indicates that the expenditure share of cattle increases in response to increases in regulatory compliance costs. This reflects the nature of the zero tolerance directive, which results in a loss of physical product caused by trimming.

Estimated regulatory compliance cost elasticities, reported in Table 4, are all negative and statistically significant at the 5% level. Thus, although the expenditure *share* of cattle increased because of an increase in regulatory compliance costs, the *quantity* of all inputs (including cattle) decreased because of the regulatory directive.

Costs to Society

The direct cost of the zero tolerance directive is found by comparing annual firm-level costs per head for the 1993-95 period to those for the 1988-92 period. Total firm-level costs per head for the period that the regulation was in place (1993-95) were calculated using average values of all variables for the period and the estimated coefficients from equation (1). Total firm-level costs for the 1988-92 period (i.e., prior to the enforcement of the zero tolerance directive) were calculated using average values of all variables for those years. The difference between costs in these two regimes averaged $68.04 per head, or 7.33% of total slaughtering costs. Multiplying the per head costs of regulatory compliance by the average number of cattle slaughtered annually for 1993-95 (USDA, *Livestock and Poultry Situation and Outlook*) results in an estimate of annual societal costs from productivity losses of the zero tolerance directive of $2,369 million.

In addition to productivity losses, reductions in output caused by extra trimming must also be considered. Feuz et al. estimated that an average of 7.53 pounds of trim loss per head (or a product loss of $19.73 per head) was caused by the zero tolerance directive in 1994 and 1995. Multiplying $19.73 by the U.S. average total number of head slaughtered annually during these years results in a product loss of $687 million. However, these trimmings are not discarded, but are used for non-human consumption. For example, as pet food inputs, trimmings received an average price of $7.88/cwt for the period (USDA, Ag Marketing Service). Multiplying 7.53 pounds per head by the U.S. average total number of head slaughtered (1994-95) results in 262 million pounds of extra trimmings with a total "salvage value" of $20 million annually. Thus, summing productivity losses ($2,369 million) with annual boxed beef product losses ($687 million) and subtracting the salvage value of trimmings ($20 million) results in a net cost to society of regulatory compliance with the zero tolerance directive of $3,036 million annually.

The cost of the zero tolerance policy can be compared to the costs of foodborne illnesses (i.e., the benefits of eradicating illness) caused by pathogenic microorganisms to obtain a measure of the relative costs and benefits of the zero tolerance directive. Roberts and Unnevehr reported the annual cost of foodborne illnesses due to *E. coli* 0157:H7 and *Salmonella* as $216-580 million and $1,118-1,588 million, respectively. These include direct costs (medical expenses) and indirect costs (losses in human productivity). Estimates of the incidence of these two pathogens in beef versus pork and poultry were calculated using prevalence estimates reported by the Council for Agriculture Science and Technology. For each pathogen, the prevalence numbers for each species (e.g., percent of beef samples that contain the pathogen) were multiplied by the average (1993-95) total annual production of the respective species (USDA, *Livestock and Poultry Situation and Outlook*) to obtain an estimate of total incidence by species. The incidence of each pathogen in beef was then divided by the total incidence for all three species to get an estimate of the incidence (on a percentage basis) of each pathogen attributable to beef. Using this procedure, beef is estimated to be responsible for approximately 52% of all *E. coli* 0157:H7 related illnesses and 5.3% of all *Salmonella* related illnesses. Although other estimates of the prevalence of *E. coli* 0157:H7 are not available for comparison, the prevalence estimate for *Salmonella* is similar to that reported by Hensen (table 11, p.16). Costs to society of foodborne illnesses related to these two pathogens and beef consumption are $112.32-301.6 million and $59.25-84.16 million, respectively -- or a total of $171.57-385.76 million.

It is unreasonable to assume that the zero tolerance directive eliminated all foodborne illnesses caused by *E. coli* 0157:H7 and *Salmonella* in beef. However, because it is difficult to quantify the efficacy of the zero tolerance directive, we proceed assuming that the regulation was 100% effective, and recognize that our results overstate this component of the benefits of the zero tolerance program. Nonetheless, annual regulatory compliance costs associated with the zero tolerance directive ($3,036 million) exceed the maximum potential benefits from elimination of foodborne illness caused by *E. coli 0157:H7* and *Salmonella* in beef ($385.76 million). Finally, it must be noted that these estimates ignore other possible benefits of the enforcement of the zero tolerance program such as boosts in consumer confidence which may have ameliorated negative effects on beef demand caused by the 1993 *E. coli 0157:H7* outbreak.

Conclusions and Implications

Data from a major meat packing firm were used to estimate a translog cost function and the impacts of FSIS's zero tolerance directive on the firm's cost structure. The estimated own-price elasticity of demand for cattle and Morishima elasticities of substitution indicate that cattle is the least flexible of five inputs. Cross-price elasticities of demand and elasticities of substitution indicate that labor is the most flexible input in the beef processing industry. An increase in regulatory compliance costs increases the cost share of cattle, while decreasing the use of all inputs, including cattle.

These results do not suggest that federal food safety regulations should be eliminated because our analysis ignores the efficacy of such regulations and potential benefits which may result from increased consumer confidence with respect to food safety. However, our analysis does show that such regulations do have a cost to society. Thus, the costs and benefits of regulations should be thoroughly examined before implementation.

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