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Dimensions of Food Safety Risk Mitigation Strategies Adopted by Meat Processors: The Case of HACCP

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Abstract

Detailed information on the firm level costs of food safety risk mitigation strategies is reported. Survey data for small and very small Texas meat processors is modeled to determine what affects compliance costs. Economies of scale in implementing Hazard Analysis Critical Control Point (HACCP)-based systems are evident particularly when some level of facility modification accompanies the strategy. Alternative impacts, the probability, and number, of products discontinued due to HACCP, is also explored. This form of “partial exit” is positively (though weakly) related to the current range of items produced and again the need to modify the facility to be in compliance. These important aspects of food safety risk mitigation strategies are compared to potential benefits of HACCP in reducing other dimensions of plant level risk.

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Introduction

The Hazard Analysis Critical Control Point (HACCP) system has been the subject of intense political, technical, and economic analysis in recent years. This paper continues this analysis, presenting data on two impacts of the United States Department of Agriculture (USDA) rule that have previously received limited attention. The cost of implementing the requirements in small and very small processed meat plants and the potential reduction in the product range (termed “partial exit”) offered by these plants are modeled. The importance of plant size, sales, process complexity, related infrastructure and labor costs are demonstrated to play important roles in determining the overall impact of the rule.

The number of meat processing plants in Texas declined by about 43 percent from 1982 to 1996. Thus there is great concern in the industry about how to enhance the profitability of these plants to prevent further exit. Processed meat products are high-valued goods that can offer smaller meat processors an opportunity to make excellent returns. These firms face multi-dimensional risks. Food safety risk mitigation strategies in particular are becoming increasingly important to such plants and, therefore, are the focus of this paper.

HACCP plans can allow firms to manage cost, price, production and financial risks as well as food safety risks all within a single system. However, there remain concerns that the USDA HACCP rule may disproportionately impact smaller meat processors and lead to a reduced number of products being offered. This paper attempts to determine this using data collected through a survey of meat processors in Texas conducted in 1999 prior to full implementation of

the rule (small plants were required to have a HACCP system in place by January 25, 1999 and very small plants by January 25, 2000).¹ The data set has a range of small and very small plants.

Background

Reactions to public health risk have brought about sweeping changes in the U.S. meat processing sector. USDA's *Pathogen Reduction; Hazard Analysis and Critical Control Point (HACCP) Systems; Final Rule* (USDA 1996) represents possibly the largest single regulatory change to impact the meat industry. It requires almost all meat and poultry processors of almost any size to implement sophisticated HACCP-based systems *for each product or process*.² Unnevehr (2000) presents an excellent range of economic evaluations of the USDA rule and other applications of the HACCP system around the world. Among the remaining issues of concern the potential influence of the rule on market structure has been hotly debated.

The meat slaughter and processing sectors are characterized as having a “dual” market structure, whilst heavily concentrated for large plants there remains a large number of small and very small federally and state inspected plants. It is these very small plants that may potentially be most influenced by the HACCP rule. The regulatory impact assessment of the final rule argues that any cost disadvantage is mostly negated by the extended timeframe allowed for compliance (USDA 1996, p. 38986). The expected final implementation costs of the regulation were estimated to be between \$0.0011 to \$0.0013 per pound, with annual recurring costs of between \$0.0015 and \$0.0018 per pound. Clearly our total cost measures (an addition of

¹ Small plants are defined as having 10 or more but fewer than 500 employees with very small establishments, defined as having fewer than 10 employees or annual sales of less than \$2.5 million.

² An opportunity is provided for plants to become “custom exempt/retail” and withdraw inspection. This is allowed only for a business that slaughters animals or processes meat for the owners of the animals or products, labeling such “Not for Sale.” This privilege may be removed if USDA believes the plant is operating under insanitary conditions that could pose a health risk.

recurring and non-recurring costs) for the small and very small firms surveyed are dramatically higher (averaging just under \$0.05 per pound – see table 1 and discussion below).

This average compliance cost of \$0.05 per pound may be compared to the estimates of Antle (2000) who modeled HACCP costs determining a range of \$0.03 to \$0.17 per pound (p. 93). Further, reporting on survey results conducted prior to any implementation of the rule, Nganje and Mazzocco (2000) found a range of compliance costs between \$0.0004 and \$0.4351 per pound). Clearly there is considerable variability and uncertainty in each of these measures (our own survey respondents reported per pound costs between \$0.02 and \$0.20). However, there appears to be a clear indication that there are economies of scale in implementing HACCP.

The concern that these economies of scale may be sufficient to promote exit leads to the need to closely model and monitor previous and current exit and entry rates for the segment of most concern – namely the very small plants. However, effective market structure may alter without complete exit if the HACCP rule has diseconomies of scope as well as economies of scale.

Although less research has focused on this aspect of the food safety risk mitigation strategy, the potential is explored in the regulatory impact assessment of the final rule. USDA estimated that, on average, very small plants would require 2.29 HACCP plans. It is upon this estimate that their calculations of economies, or diseconomies, of scope are based. Our two estimates of process complexity (RANGE and MIX) average is greater than 3. This, in part, may be due to the more complex nature of the plants in our data set, with many producing multiple processed meat products involving meat from several different species. Whilst imperfect proxies of the actual number of distinct HACCP plans, these variables do suggest that the USDA approximation may be biasing down implementation (and probably annual) costs. We suggest

that “partial exit” is a factor that requires additional analysis and is, therefore, explored further below.

HACCP plans can allow firms to manage cost, price, production and financial risks as well as food safety risks all within a single system (Mazzocco 1996). HACCP plans usually include as a critical control point the receiving of raw materials. Thus input costs are likely to be better monitored as items may be rejected if they are expected to increase the food safety risk of the plant. The creation of specific critical limits upon receiving will, therefore, lead to a tighter control of such costs. Further, as the links between animal production and slaughter methods and the safety of the resulting cuts of meat become better understood, it is expected that closer scrutiny of production and processing methods will be placed at this stage (see, Hooker et al. 1999; Billups et al. 1999). The close review of labor practices and more generally the resulting process modification that normally accompanies the preparation (and updating) of a HACCP plan may also identify other cost savings for plants implementing the risk mitigation strategy.

If HACCP is successful in reducing quality variability (the issue of “joint products” or food safety gains coinciding with other non-safety quality enhancements such as shelf life) then the food safety risk mitigation strategy will lead to reduced price risk. Although the potential for price premiums is removed given the mandatory basis of the strategy (i.e., firms cannot compete based on if they have adopted or not) it is becoming clear that HACCP plans are not created equal. As food safety illness outbreaks and USDA administrative actions³ are linked to meat processing plants that have HACCP plans *in situ* the general debate over the effectiveness of the system has reappeared (see e.g., USDA 2000 Tables 5 and 6). This issue becomes relevant in price risk management in the sense that “good” plants may use their annual HACCP plan review,

³ Such actions include the withholding of marks of inspection, suspension of inspection, notification to establishment of intended enforcement actions, and withdrawal of inspection.

and perhaps HACCP records to demonstrate process control and therefore the ability to deliver a consistent quality to their key customers.

Generally, HACCP may jointly reduce production risk and price risk (less re-work, fewer final product rejections) - see Caswell et al. (1998) for a general discussion on how such effectiveness measures may be constructed. However, to be socially desirable these reduced costs must not merely be *transferred* (as additional costs) to input suppliers, rather total supply chain risk reduction costs must be lowered (Hooker 2000, p. 70).

Finally, financial risk management may be enhanced through the presence of HACCP. Although still preliminary, evidence of insurance cost savings and reduced legal liability costs due to the presence of certain food safety and/or quality risk mitigation strategies is starting to be presented (see, for example, Buzby and Frenzen 1999).

USDA recently announced the impacts of the HACCP rule in their *Quarterly Regulatory and Enforcement Report, October 1, 1999 to December 31, 1999* (USDA 2000). This report discusses the impact of HACCP on 300 large and approximately 2,300 small firms (the findings for the remaining approximately 3,400 very small plants are reported only under the previous traditional inspection format – i.e., not HACCP). The next update of this USDA report might be read in conjunction with this presented paper to compare USDA's hypothesized impact on very small firms with the empirical findings presented herein.

The firms examined in this study manufacture smoked meats and are located throughout Texas. They perform processing steps such as seasoning, blending, grinding, smoking, cooking and packaging, with only a few firms performing the slaughter step. In addition to their primary activity of meat processing, a few of these firms operate meat markets, restaurants, and/or small food distribution businesses. These firms are small and cater to local tastes. They are

differentiated from one another based upon the unique varieties of sausages and other products, the family history of their business, and the cultural activities of their area. The products of different firms are distinguished from one another on the basis of region, brand name, size, shape, meat content, seasoning, grind (texture), color, natural casing and packaging.

Procedures and Data

In order to examine the impact of HACCP upon small and very small meat processors, a draft questionnaire was developed with the help of Dr. Joe Harris, CEO of the Southwest Meat Association, and Dr. Davey Griffin, Extension Meat Scientist at Texas A&M University. This questionnaire was pre-tested by means of site visits to ten meat processing firms. Following revisions from the pre-testing, a final questionnaire was sent to 137 firms via fax. The administration protocol consisted of first calling a firm to see if they were interested in participating. If they did not object, a survey was immediately faxed to their location. Mail was used for those firms not having fax capability. Following distribution, telephone calls were made to those firms failing to respond within two weeks. Such calls continued until either a completed questionnaire or a refusal was received. In total 84 firms completed the questionnaire. However, some questionnaires contained omissions. Thus the effective response rate was 70 firms, or 51%.

The survey sought to determine the impact of HACCP regarding both cost as well as number of products produced. Table 1 presents the key variables examined. HCOST reports the firm's predicted impact of HACCP in cents per pound. The mean level of cost was just under \$0.05/lb. PCUT is the number of products which firms predicted would be discontinued due to

HACCP. The mean level of PCUT was 1.17. This is about a third of the average number of items currently offered by the firms.

The survey also examined a number of zero/one dummy variables regarding the plant: the intention to add an entirely new facility (BUILD), to expand (ADDFAC), or modify (MODFAC) the current facility, and if the current facility is over ten years old (AGE10). Data for the need to hire new staff (NEWEMP), the mandatory HACCP compliance date of January 2000 (H2000), the intention to drop inspection requirements and go custom-exempt (CUSTX), and the demand of customers that the facility be inspected by a Federal or State agency (CUSTIN) are also reported. Other relevant variables include the number of employees formally trained in HACCP (HAEMP)⁴, the total number of employees working for the firm (EMP), and the annual production of meat (PNDS).

Among responding firms, 76% met the “very small” classification and therefore faced a HACCP compliance deadline of January 2000, almost 9% planned to switch to custom-exempt status in lieu of compliance, while the remaining 15% were small firms already in full compliance. One dramatic impact of HACCP is evident from the fact that 37% of respondents indicated they would at least modify their facilities to comply with the rule. The average firm had almost nineteen employees with two of these being formally trained in HACCP. The average per plant cost of this HACCP training is calculated to be \$2,025. The small size of these firms is highlighted by the fact that average meat production was only 798,930 pounds per year.

Models and Hypotheses to be Tested

⁴ USDA (1996) suggested that very small plants would, on average, have to train at least two workers in HACCP techniques. Our measure (HAEMP) averaged just under 2, but the average per plant training costs are significantly lower than those presumed by USDA (\$5,028).

The data are evaluated with three sets of econometric models, as discussed below. In each set a pair of models is constructed using alternative measures of product range (RANGE and MIX).

Models 1 and 2 - ⁵

The objective of this first pair of models is to test the following hypothesis:

H_0 = costs of implementing HACCP depend on plant size, facility modifications, process complexity, and other factors

H_A = costs of implementing HACCP are invariant of plant size, facility modifications, process complexity, and other factors

The model is based on the general linear form which relates the cost of compliance to a set of variables (hypothesized signs are included in parenthesis).

$H_{COST} = f \{ \text{RANGE (+) or MIX (+), BUILD (+), ADDFAC (+), MODFAC (+), HAEMP (+), NEWEMP (+), EMP (-) PND5 (-), AGE10 (+), H2000 (+/?), CUSTX (+/?), CUSTIN (?) } \}$

Costs are expected to be positively related to process complexity.⁶ Similarly, facility modification (either adding new buildings, expanding or redesigning current facilities) should increase the cost of compliance. As these costs increase we expect to see an increase in HCOST.

⁵ estimated using White's heteroskedastic-consistent covariance matrix estimation to correct the estimates for an unknown form of heteroskedasticity.

⁶ Martin and Anderson (2000) identified diseconomies of scope (through process complexity) in other agribusiness's adopting HACCP-based systems (see pp. 24-5). The authors also restated an earlier finding that smaller meat and poultry processing companies usually have more complex processes than larger plants (taken from Anderson et al.1997).

The indicators of plant scale (EMP and PNDS) are expected to have negative signs indicating returns to size in implementing this risk mitigation strategy. Older plants are presumed to require additional redesign leading to higher costs. The next two variables are interesting and difficult to sign. *Ex ante* it may be expected that very small plants and those that choose to become custom exempt forecast higher HACCP compliance costs (here the excluded set of firms are small plants that were required to be HACCP compliant in 1999). Therefore the H2000 and CUSTX variables may be expected to take a positive sign. However, as no previous study has tested this hypothesis it is unwise to predict. Finally, it is not immediately clear which sign is expected for the CUSTIN parameter. Prior customer requirements for tight process control (as indicated by the federal/state inspection requirement) may subsequently lead to lower HCOST (i.e., “good” firms are selected/signaled by meeting this qualification and thus require limited changes to attain full compliance). Alternatively, as this question was posed as “what % of customers demand...” entering a “1” if the percentage was positive, we may be overestimating the prior use of such requirements.

Models 3 and 4 ⁷

H_0 = probability of HACCP leading to products being withdrawn depends plant size, facility modifications, process complexity, and other factors

H_A = probability of HACCP leading to products being withdrawn is invariant of plant size, facility modifications, process complexity, and other factors

$\Pr(\text{DISCONT}=1) = f \{ \text{RANGE (+) or MIX (+), BUILD (+), ADDFAC (+), MODFAC (+), HAEMP (-/?), NEWEMP (-/?), EMP (?), PNDS (?), AGE10 (+), H2000 (+/?), CUSTX (+/?), CUSTIN (?)} \}$

Generally the hypothesized relationships discussed above for HCOST are expected to have similar effects on the probability that we see partial exit. However, HAEMP and NEWEMP may differ. If a plant chooses to formally train a larger number of workers in HACCP or hire extra workers it may then be able to support the previous range of products, being better able to manage a larger number of HACCP plans. It is not clear if there should be economies of scale effects on the probability of product withdrawal. Hence, the lack of a clear theoretical sign on EMP and PNDS.

Models 5 and 6⁸

H_0 = number of products withdrawn due to HACCP depends on plant size, facility modifications, process complexity, and other factors

H_A = number of products withdrawn due to HACCP is invariant of plant size, facility modifications, process complexity, and other factors

PCUT = f { RANGE (+) or MIX (+), BUILD (+), ADDFAC (+), MODFAC (+), HAEMP (-/?),
NEWEMP (-/?), EMP (?), PNDS (?), AGE10 (+), H2000 (+/?), CUSTX (+/?), CUSTIN (?) }

A similar pattern of signs to those discussed above is hypothesized for the PCUT equation.

⁷ estimated using probit regression due to 0-1 dummy dependent variable.

⁸ estimated using White's heteroskedastic-consistent covariance matrix estimation to correct the estimates for an unknown form of heteroskedasticity.

Results

The parameter estimates and standard errors of models 1 and 2 are exhibited in Table 2. The R-squared values of these models (0.262 and 0.285) are very respectable considering that the data used in the analysis are cross-sectional in nature. Results are similar regardless of whether the "mix" or "range" variable was used in the model. Based on the statistically significant estimates, results indicate that those firms which will be building a new facility due to HACCP have higher costs of implementation than those firms which do not have plans of building a new facility. Interestingly, firms in which HACCP requirements begin in January 2000 (the very small firms) have higher HACCP implementation costs than those firms which are already under HACCP regulations prior to January 2000. Those who are claiming custom exempt status are also having higher HACCP implementation costs than others, *ceteris paribus*.

The parameter estimates and standard errors for models 3 and 4 are presented in Table 3. Similar to models 1 and 2, the McFadden R-squared values of these models are very good at 0.421 and 0.427, respectively. The empirical estimates in both models are similar. The results indicate that firms which are expanding their current facility due to HACCP, are more likely to discontinue some products due to HACCP. Similarly, firms which are hiring new staff due to HACCP are more likely to discontinue some products due to HACCP. However, firms which are required to implement HACCP in January 2000 are less likely to discontinue products due to HACCP.

Models 5 and 6 are exhibited in Table 4. The dependent variables in these models represent the number of products discontinued due to HACCP. While the findings between models 1 and 2 and between models 3 and 4 are similar, the results between model 5 and model 6 are not completely the same. Both models suggest that firms which are building a new facility

or expanding their current facility due to HACCP have more products to be discontinued from production due to HACCP than others. Results from model 5 also indicate that the number of different items within a sales mix is positively related to the number of products to be discontinued due to HACCP. A finding from model 6, on the other hand, suggests that those firms required to implement HACCP in January 2000 have less products that will be discontinued due to HACCP.

This paper is the first to consider the impact of HACCP implementation on very small meat processors and provides a rich data set collected at an important stage in the process. The other unique contribution of the paper is the analysis of product exit. Although previous research has demonstrated that exit rates of plants may have been increased due to regulatory requirements no analysis of the impact on the product mix offered by firms has existed to date.

Concluding Remarks

This paper provides a discussion of two related impacts of the HACCP regulation on small and very small meat processing firms in Texas. Implementation costs are significantly related to addition of a new facility due to the regulations, custom exempt status, and starting date of required implementation. The second measure of impact presented, the probability of products being withdrawn following implementation of HACCP. Probability of product withdrawal is related to addition of facility and staff due to HACCP and required starting date of implementation of regulations. The number of product withdrawal is also related to building or expansion of facility due to HACCP and the number of items within a sales mix.

Generally this paper reinforces earlier research in the area of food safety costs of compliance but stresses the need to consider broader measures of market structure implications –

including the potential exit of smaller firms and/or the product range offered by these firms. Further, the earlier discussion of additional risk mitigation gains from linked cost, price, production, and financial strategies highlights that firm level benefits of HACCP may be positive.

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Table 1. Definitions and Descriptive Statistics for Model Variables, n = 70 firms.

Variable Description	Variable Name	Mean	Standard Deviation	Min.	Max.
<u>Dependent Variables</u>					
The firm's cost of implementing HACCP, cents per pound. ¹	H COST	4.798	3.762	2	20
Will products be discontinued due to HACCP? (yes=1, no=0)	DISCONT	0.271	0.447	0	1
The number of products to be discontinued due to HACCP.	PCUT	1.171	2.660	0	15
<u>Independent Variables</u>					
The number of convenience prepared products.	RANGE	3.371	3.185	0	10
The number of different items within sales mix.	MIX	3.514	1.481	1	7
Will a new facility be built due to HACCP? (yes=1, no=0)	BUILD	0.042	0.204	0	1
Will the current facility be expanded due to HACCP? (yes=1, no=0)	ADDFAC	0.0714	0.259	0	1
Will the current facility be modified due to HACCP? (yes=1, no=0)	MODFAC	0.371	0.486	0	1
The number of formally HACCP trained employees.	HAEMP	1.914	1.271	0	8
Will new staff be hired due to HACCP? (yes = 1, no=0)	NEWEMP	0.442	0.500	0	1
The total number of employees in the firm.	EMP	18.607	20.053	2.5	75
The annual number of pounds of meat produced by the firm.	PNDS	798,930	992,720	0	2,500,000
Is the firm's facility over ten years old? (yes=1, no=0)	AGE10	0.814	0.391	0	1
Do HACCP requirements begin in January 2000? (yes=1, no=0)	H2000	0.757	0.431	0	1
Will the firm claim custom exempt status? (yes=1, no=0)	CUSTX	0.085	0.281	0	1
Do any customers require Federal or State Inspection? (yes=1, no=0)	CUSTIN	0.556	0.436	0	1

1. N=62 (see text for explanation)

Table 2. Regression Results - Costs of Implementation

Variable	<u>Model 1</u> Coefficient (Standard Error)	<u>Model 2</u> Coefficient (Standard Error)
Constant	1.721 (2.220)	0.351 (2.052)
MIX	-0.2632 (0.259)	-
RANGE	-	0.241 (0.158)
BUILD	6.110* (1.569)	5.875* (2.463)
ADDFAC	-1.405 (1.190)	-0.643 (1.174)
MODFAC	0.936 (1.205)	1.072 (1.216)
HAEMP	0.278 (0.428)	0.389 (0.487)
NEWEMP	1.131 (0.985)	0.989 (0.967)
EMP	0.029 (0.021)	0.865E-04 (0.029)
PNDS	-0.552E-06 (0.383E-06)	-0.329E-06 (0.392E-06)
AGE10	-0.116 (1.091)	-0.099 (1.030)
H2000	2.856* (1.034)	2.362* (1.188)
CUSTX	4.215* (1.879)	3.194* (1.881)
CUSTIN	-0.128 (1.122)	0.093 (1.048)
N=62	$R^2 = 0.262$	$R^2 = 0.285$

* denotes statistical significance at the 0.05 level.

Table 3. Regression Results - Probability of Product Withdrawal

Variable	<u>Model 3</u> Coefficient (Asymptotic Standard Error)	<u>Model 4</u> Coefficient (Asymptotic Standard Error)
Constant	-0.509 (1.439)	-0.067 (1.285)
MIX	0.077 (0.170)	-
RANGE	-	0.062 (0.072)
BUILD	6.303 (172.36)	6.414 (169.05)
ADDFAC	1.711* (0.927)	1.821* (0.975)
MODFAC	0.751 (0.511)	0.757 (0.508)
HAEMP	0.337 (0.250)	0.312 (0.246)
NEWEMP	1.385* (0.476)	1.393* (0.472)
EMP	-0.011 (0.018)	-0.019 (0.021)
PNDS	0.303E-06 (0.285E-06)	0.355E-06 (0.298E-06)
AGE10	0.112 (0.641)	0.019 (0.622)
H2000	-1.597* (0.857)	-1.910* (0.933)
CUSTX	-0.276 (1.238)	-0.556 (1.303)
CUSTIN	-0.078 (0.616)	-0.076 (0.610)
N=70	McFadden R ² = 0.421 % right predictions = 85.7	McFadden R ² = 0.427 % right predictions = 85.7

* denotes statistical significance at 0.05 level.

Table 4. Regression Results - Number of Products Withdrawn

Variable	<u>Model 5</u> Coefficient (Standard Error)	<u>Model 6</u> Coefficient (Standard Error)
Constant	-0.010 (1.586)	1.229 (1.295)
MIX	0.344* (0.177)	-
RANGE	-	0.153 (0.132)
BUILD	2.244* (1.025)	2.233* (1.138)
ADDFAC	1.256* (0.556)	1.108* (0.396)
MODFAC	1.017 (0.909)	0.802 (0.894)
HAEMP	-0.398 (0.261)	-0.209 (0.300)
NEWEMP	1.059 (0.763)	1.181 (0.779)
EMP	-0.009 (0.011)	-0.020 (0.017)
PNDS	0.938-07 (0.206E-06)	0.153E-06 (0.206E-06)
AGE10	0.515 (0.394)	0.365 (0.372)
H2000	-1.042 (0.735)	-1.578* (0.680)
CUSTX	0.402 (1.737)	-0.086 (1.561)
CUSTIN	0.228 (0.594)	-0.020 (0.541)
N=70	$R^2 = 0.183$	$R^2 = 0.181$

* denotes statistical significance at 0.05 level.