

Factors Affecting Plant Exit from the U.S. Meat Slaughter, Poultry Slaughter, and Processing Industries: Comparisons Across Industries

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 Presented at the American Agricultural Economics Association meetings, Long Beach, CA, July 27-31, 2002
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1. Introduction

Meat and poultry plants have historically had high rates of plant exit and entry with the total number of plants declining over time. Recent food safety regulations (PR/HACCP, for Pathogen Reduction and Hazard Analysis and Critical Control Points) that have increased the costs of producing meat and poultry products may have affected the rate of plant exit during the 1996 to early 2000 time period over which the regulations were implemented. The PR/HACCP regulations were phased in over a 3-year period (see Table 1) to allow smaller plants more time to make the necessary changes and capital investments and thus avoid closure. While controlling for other factors that affect plant exit, we estimated probit models to determine whether different size plants were more or less likely to exit. We estimated three separate models for federally inspected plants: meat slaughter plants, poultry slaughter plants, and meat and poultry processing only plants. We present the results of these three models and compare the factors affecting plant exit across industries.

Table 1. PR/HACCP Implementation Schedule for Meat and Poultry Plants

Implementation Date	Affected Plant Sizes	Implementation Requirements
January 1997	All plants	• Sanitation standard operating procedures (SSOPs) • Generic <i>E. coli</i> carcass testing
January 1998	Plants with more than 500 employees (large)	• HACCP • <i>Salmonella</i> testing on selected raw products
January 1999	Plants with 10-500 employees (small)	• HACCP • <i>Salmonella</i> testing on selected raw products
January 2000	Plants with fewer than 10 employees or less than \$2.5 million in annual sales (very small)	• HACCP • <i>Salmonella</i> testing on selected raw products

2. Plant Entry & Exit Patterns

- The total numbers of meat and poultry plants have been relatively constant over the 1993 to 2000 time period (Figure 1)
- Exit rates increased for very small plants but decreased for small and large plants during PR/HACCP implementation (Figure 2).
- Entry rates increased for very small and small plants but decreased for large plants during PR/HACCP implementation (Figure 3).
- During PR/HACCP implementation, exit rates were highest for meat slaughter plants, followed by processing-only plants, and then poultry slaughter plants (Table 2).

Table 2. Rates of Entry and Exit of U.S. Federally Inspected Meat and Poultry Plants, 1993 to 1996 and 1996 to Early 2000

Plant Type and HACCP Size ^a	Entry Rates		Exit Rates	
	1993-1996	1996-2000 ^b	1993-1996	1996-2000 ^b
Meat Slaughter Plants				
Very small plants	7.8%	13.0%	12.5%	19.9%
Small plants	6.6%	6.5%	16.4%	17.0%
Large plants	11.9%	0.0%	3.4%	1.6%
Total meat slaughter plants	7.7%	10.3%	3.1%	17.8%
Poultry Slaughter Plants				
Very small plants	37.0%	85.7%	33.3%	32.1%
Small plants	3.5%	26.4%	11.3%	13.2%
Large plants	4.3%	3.4%	0.7%	3.4%
Total poultry slaughter plants	7.1%	20.4%	8.1%	10.0%
Processing Plants				
Very small plants	13.6%	27.8%	15.2%	20.8%
Small plants	9.6%	13.1%	15.8%	12.0%
Large plants	7.5%	6.3%	17.0%	18.8%
Total processing plants	11.6%	20.9%	15.5%	16.9%

^aSlaughter plants include only those slaughtering at least 50 animals per year. Processing plants include only those that do not slaughter.
^bVery small plants have fewer than 10 employees or less than \$2.5 million in annual sales. Small plants have between 10 and 500 employees. Large plants have more than 500 employees.
^cPR/HACCP implementation period.

Figure 1. Number of Active Federally Inspected Meat and Poultry Plants

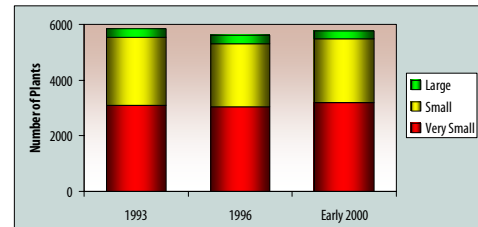


Figure 2. Exit Rates for Federally Inspected Meat and Poultry Plants

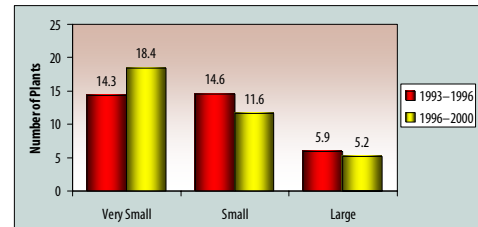
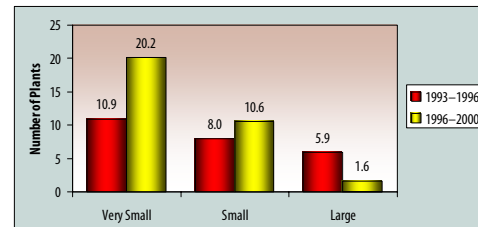


Figure 3. Entry Rates for Federally Inspected Meat and Poultry Plants



3. A Model of the Plant Exit Decision

- A plant will exit the industry when:

$$\pi_i < V_{1i} - e^{-\alpha} V_{2i}$$
 where π_i is profits, V_{1i} is the value of the firm from exiting, and $e^{-\alpha} V_{2i}$ is the discounted value of the firm from remaining in the market at the end of the period.
- Let X_i be the vector of variables influencing the present value of profit for plant i . Then, the payoff function can be written as follows:

$$\Pi_i = \beta' X_i + \epsilon_i$$
- The X_i vector includes plant-, company-, and regional-level characteristics and regional supply conditions for each plant.
- The exit/stay decision is viewed in a probabilistic sense as follows:

$$\text{prob}(\Pi_i < 0) = \text{prob}(Y_i = 1 | X_i) = F(\beta' X_i)$$
 where $F(\cdot)$ is the cumulative normal distribution function, $Y_i = 1$ if plant i slaughtered in 1996 (exit) but not in early 2000, and $Y_i = 0$ if plant i slaughtered in both 1996 and early 2000 (stay).
- Because changes in input prices (included in regional supply conditions) reflect the combined effects of changes in plant costs and the indirect effect of induced changes in output price, the signs on these coefficients are unknown *a priori*.

4. Description of Data

- Plant-level data were obtained from USDA's Food Safety Inspection Service and augmented with company-level data from a private vendor, *infoUSA*, and with regional-level data from the Bureau of Labor Statistics and National Agricultural Statistics Service.
- The variables included in the models, their sources and definitions, and their mean values are listed in Table 3 for each of the models.

Table 3. Variable Definitions, Sources, and Means for the Plant Exit Models

Variables	Source ^c	Definitions	Meat Slaughter Plants (n=920)	Poultry Slaughter Plants (n=280)	Processing-Only Plants (n=4,299) ^d
Plant Characteristics					
Slaughter volume	ADRS	Plant's slaughter volume (million head), 1996	0.148	27.76	—
Slaughter volume ²	ADRS	Plant's slaughter volume squared, 1996	0.305	1,365	—
Age	CORE	Plant's age in 1996 based on year of grant of inspection or grant status date, whichever is earliest	16.95	18.87	14.97
Age ²	CORE	Plant's age squared	370.1	473.8	320.2
Very small size	FAIM/infoUSA	Plant is very small (binary)	0.662	0.100	0.540
Small size	FAIM/infoUSA	Plant is small (binary)	0.268	0.379	0.438
Large size	FAIM/infoUSA	Plant is large (binary)	0.070	0.521	0.022
Slaughters cattle	ADRS	Plant slaughters cattle (binary)	0.839	—	—
Slaughters hogs	ADRS	Plant slaughters hogs (binary)	0.768	—	—
Slaughters chicken	ADRS	Plant slaughters chickens (binary)	—	0.832	—
Slaughters turkey	ADRS	Plant slaughters turkeys (binary)	—	0.254	—
Processing at plant	PBIS	Plant also conducts processing activities (binary)	0.695	0.604	—
Company Characteristics					
Number of plants	M&P (derived)	Number of meat and poultry plants owned by the company	2.934	15.08	2.78
Meat slaughter volume	ADRS (derived)	Total company meat slaughter volume (million head)	1.117	1.085	0.287
Poultry slaughter volume	ADRS (derived)	Total company poultry slaughter volume (million head)	6.984	326.0	16.4
Processing	PBIS (derived)	Company conducts processing activities in at least one plant (binary)	0.717	0.879	—
Regional Characteristics^e					
Entry rate	PBIS (derived)	Rate of plant entry from 1993 to 1996 for similar type plants	0.105	0.072	0.161
Slaughter volume share	ADRS (derived)	Plant's share of the region's slaughter volume	0.052	0.239	—
Herfindahl index (HHI)	ADRS (derived)	HHI based on slaughter volumes for the region in which the plant is located ($0 \leq \text{HHI} \leq 1$)	0.293	0.329	—
Competitive fringe index	ADRS (derived)	HHI divided by the slaughter volume share	1.275	26.38	—
Number of meat slaughter plants	PBIS (derived)	Number of meat slaughter plants in the region	—	—	121.82
Number of poultry slaughter plants	PBIS (derived)	Number of poultry slaughter plants in the region	—	—	31.58
Number of processing plants	PBIS (derived)	Number of processing plants in the region	—	—	602.59
Supply Conditions					
Wage rates	BLS	Hourly wages for SIC 20 Food and Kindred Products in 1996 for the plant's state or area (\$/hour)	11.54	10.45	11.69
Energy index	BLS	Energy price index in 1996 for the plant's area (1982-1984 = 100)	109.00	110.2	110.4
Live cattle price	NASS	Live cattle price for the plant's state or area, average of 1995, 1996, and 1997 (\$/pound)	53.11	—	—
Live hog price	NASS	Live hog price for the plant's state or area, average of 1995, 1996, and 1997 (\$/pound)	46.95	—	—

^aThe abbreviations for data sources are as follows:
 ADRS = USDA's Animal Disposition Reporting System
 BLS = Bureau of Labor Statistics "State and Area Employment, Hours, and Earnings" and "Consumer Price Index: Energy"
 CORE = USDA's Common On-Line Reference for Establishments
 FAIM = USDA's Field Automation and Information Management
 infoUSA is a private data vendor
 M&P = Meat and Poultry magazine
 NASS = USDA's National Agricultural Statistics Service "Meat Animals, Production, Disposition, and Income."
 PBIS = USDA's Performance-Based Inspection System

^bA region was defined as the area within a 150-mile radius of the plant for meat slaughter plants, within a 75-mile radius for poultry slaughter plants, and within a 300-mile radius for processing-only plants.
^cData on the volume of products produced were not available for processing-only plants, so the set of variables included in the processing-only model differs from the meat slaughter and poultry slaughter models.

5. Results of Probit Estimation

- Plant-level characteristics were jointly significant in explaining plant exit in all three models.
- Regional-level characteristics were also jointly significant in explaining plant exit for meat slaughter plants, and supply conditions were also jointly significant in explaining plant exit for poultry slaughter and for processing-only plants.
- The signs of the coefficients on a few of the variables such as regional entry rates and state-level wages suggest that plants in regions with better economic conditions are less likely to exit.
- Many of the differences in results across plant types are likely because of differences in industry organization for meat slaughter, poultry slaughter, and processing.
- The statistically significant factors explaining the probability of plant exit are presented in Table 4. A few of the more notable results are the following:
 - Plant size, as defined by the PR/HACCP regulations, affected plant exit for meat slaughter and processing-only plants but not for poultry slaughter plants.
 - Slaughter volume affected plant exit for poultry slaughter plants but not for meat slaughter plants.
 - Plant age affected plant exit for meat slaughter and processing-only plants but not for poultry slaughter-only plants.

Table 4. Statistically Significant Factors Explaining the Probability of Plant Exit

Variable ^a	Effect on Exit ^b
Meat Slaughter Plants	
Plant age	Each additional year of age decreases the probability of exit by 0.4 percent until 46 years of age, and then each additional year increases the probability of exit.
Very small size ^c	A very small plant is 35 percent more likely to exit than a large plant.
Small size ^c	A small plant is 55 percent more likely to exit than a large plant.
Regional entry rate	An increase in the regional plant entry rate by 1 percent decreases the probability of exit by 13.2 percent.
Regional competitive fringe index (CFI)	An increase in the CFI by one standard deviation (3,839) increases the probability of exit by 4.3 percent.
Wage rates	An increase in the state-level food processing wage of \$1 per hour decreases the probability of exit by 2.2 percent.
Poultry Slaughter Plants	
Slaughter volume (million head)	Each additional million birds slaughtered decreases the probability of exit by 0.04 percent up to 65 million birds, and then each additional million birds increases the probability of exit.
Very small size	A very small plant is 6 percent more likely to exit than a large plant.
Slaughter share in region	An increase in a plant's regional slaughter volume share of 1 percent increases the probability of exit by 2 percent.
Level of market concentration	An increase in the HHI by 1 unit decreases the probability of exit by 3.1 percent.
Wage rates	An increase in the state-level food processing wage of \$1 per hour decreases the probability of exit by 0.3 percent.
Processing-Only Plants	
Plant age	Each additional year of age decreases the probability of exit by 0.4 percent until 32 years of age, and then each additional year increases the probability of exit.
Number of plants owned by the company	Each additional plant owned by the same company increases the probability of exit by 0.4 percent.
Regional entry rate	An increase in the regional entry rate of 1 percent decreases the probability of exit by 2.8 percent.
Number of other processing plants in the region	Each additional processing plant in the region decreases the probability of exit by 0.01 percent.
Energy price index	An increase in the energy price index by 1 unit increases the probability of exit by 0.7 percent.

^aOnly variables that were found to have a significant effect on the probability of exit are listed.
^bWe evaluated the marginal effects of the variables at the sample means for continuous variables and for a discrete change from 0 to 1 for the binary variables.
^cWe also tested the null hypothesis that the very small and small dummy variable coefficients are actually equal, but we could not reject it ($p=0.25$).

6. Conclusion

The results of our analysis indicate that the factors affecting plant exit did indeed differ among types of plants. While controlling for other plant characteristics that affect plant exit, very small and small meat slaughter plants and very small poultry slaughter plants were more likely to exit than large plants during implementation of the PR/HACCP regulations. However, the plant size category did not appear to affect the probability of processing-only plant exit. The results also show that meat slaughter and processing-only plants in regions with higher rates of entry were actually less likely to exit, perhaps because high rates of entry correspond to favorable economic conditions for the region, as do higher wage rates in some cases.

In addition, because of the different institutional structures for the meat slaughter and poultry slaughter industries, the measures of market share and competition had different effects in these industries. The findings that the competitive fringe index is an important determinant of exit for meat slaughter plants and that the regional market shares and Herfindahl indexes are important determinants of exit for poultry slaughter plants underscore the importance of accounting for measures of concentration in regional input markets. The results of this analysis may be of interest to policy-makers seeking to help mitigate or alleviate the economic effects of the PR/HACCP regulation.

For More Information

For more details on the analysis and results, see the following:
 Muth, M.K., S.A. Karns, M.K. Wohlgenant, and D.W. Anderson. July 2002. "Plant Entry and Exit from the Meat Slaughter Industry During Pathogen Reduction and HACCP Implementation." *Journal of Agricultural and Resource Economics* 27(1):187-203.
 Muth, M.K., M.K. Wohlgenant, S.A. Karns, and D.W. Anderson. May 2002. "Factors Affecting Plant Exit from the U.S. Meat Slaughter, Poultry Slaughter, and Processing Industries: Comparisons Across Industries." Working paper.

This study is one of several studies funded by the U.S. Department of Agriculture, Food Safety and Inspection Service. Contract number 53-3A94-00-006, "Evaluation Studies of Pathogen Reduction and Hazard Analysis and Critical Control Points." All views expressed here are those of the authors and not necessarily of the Food Safety and Inspection Service.