Chapter 5

Sanitation and Process Control Deficiencies and Plant Exits

Several studies (Boland et al., 2001, and Antle, 2000) show that meat and poultry process control practices comprise a sizeable share of nonmeat input costs for meat and poultry slaughter and processing plants. These findings are not surprising. Food scientists assert that process control practices serve as a foundation for reducing the threat of pathogens in meat and poultry products and are essential for normal business operations. If food safety process control is important to food quality, then plants that reduce food safety process control actions may face adverse repercussions in the marketplace. The purpose of this chapter is to examine the effect of food safety process controls on longrun profits. We use plant survival as a measure of profitability.

Consumers base their purchasing decisions on a wide variety of attributes, such as food safety quality, tastiness, cost, and appearance. Some consumers may be particularly concerned about food safety and might repeatedly purchase higher priced, branded products offered by manufacturers that emphasize product quality in their advertising. Attributes that consumers cannot measure directly, such as food safety, require a brand or another form of certification to denote product quality and consistency. Other consumers, however, may value food safety and consistency less highly and will choose a nonbranded product with a lower price. Thus, firms selling similar products at different quality levels and prices will coexist in the marketplace if they deliver an acceptable level of quality at a reasonable price. Plants selling similar quality products must have identical prices. If a plant sells a high-price product relative to product quality or a lower quality product relative to price, then it must eventually exit the industry. In this chapter, we examine the profit-quality relationship in terms of plant exits and food safety quality. We use performance of SPCPs as a measure of food safety quality.

Food safety is a particularly difficult product attribute to convey to consumers because it cannot be directly observed. Consumers learn about this quality by either eating the food themselves or by observing the consequences of others. Even then, consumers may not know food safety quality. There may be a lag of days or even weeks before a foodborne illness exhibits symptoms, and those symptoms are often “flu-like,” making it difficult for consumers or health care practitioners to identify the source of their illness. So, consumers often do not go to the doctor for confirmation of a foodborne illness and mistakenly attribute a foodborne illness to another food, the environment, or, in the case of unbranded products, to some unknown producer. This imperfect linkage between the source of foodborne illness and the product enables some producers to invest less in process control than they would if this attribute were perfectly revealed. This incentive may be particularly relevant for producers of generic products whose products are commingled by the buyer with other purchased products, making it difficult for a consumer or buyer to identify the seller.

Lawrence et al. (2001) assert that large slaughter plants are more likely to be one of only a few or even the only supplier to a buyer, and meat and poultry processors sell unique or branded products. Moreover, since their production volume is much higher than that of smaller plants, the chance of any single consumer becoming sick is much greater. Thus, we hypothesize that small animal slaughter plants can gain economic benefits by reducing effort devoted to SPCPs because they sell in smaller volumes and may be more likely than larger plants to sell generic products mixed with products from other plants. We further hypothesize that large slaughter plants and further-processors must more diligently practice SPCPs because their products can more readily be identified. We use SPCP performance ratings as recorded by the Food Safety and Inspection Service (FSIS) as a measure of effort devoted to process control.

We consider slaughter and processing as distinct industries. According to the Bureau of the Census data, the main products for slaughter plants are carcasses, bulk meat and poultry parts, ground meat and poultry, and other, mainly generic, raw meat and poultry products.[1] Processing industries produce more distinct products, such as sausages and smoked hams, which are often branded.

Economic Framework

Antle (2000) demonstrates that food safety quality is costly. However, if buyers can easily detect food safety, then meat and poultry firms may find it necessary to closely monitor product contamination.

Oscar Mayer, Sarah Lee, and other further-processors make large financial investments in product quality and brand awareness promotions. Nelson (1970, 1974, and 1978) has argued and Milgrom and Roberts (1986) have shown that firms make these long-term investments in order to earn a reputation for producing quality products. In the meat and poultry industries, Ollinger (2000) and Buzby et al. (2001) provide evidence of reputation effects associated with product wholesomeness.

Losing a reputation for producing safe products can be very costly. Customers do not expect to contract a foodborne illness from products they consume and may severely punish a plant that fails to provide wholesome food. For example, Hudson Meats had to sell its hamburger operations after one of its plants was found to have produced hamburgers contaminated with *E. coli* 0157: H7. Additionally, Sara Lee lost hundreds of millions of dollars when it was identified as the source of products contaminated with *Listeria monocytogenes* that killed several people (Perl, 2000).

A plant could continuously clean its facilities and test each animal for excessive bacteria and pathogens in order to verify pathogen control. However, the costs of maintaining such rigorous standards are extremely high and may be unnecessary. Holmstrom (1979 and 1982) reminds us that moral hazard is an asymmetry of information among individuals that results from an inability to observe individual actions, suggesting that manufacturers know more about their products than consumers. Moreover, Barzel (1982) argues that buyers do not learn all of a product's quality attributes because measurement is costly. And Klein and Leffler (1981) argue that firms adhere to higher quality standards only if the expected present value exceeds the expected shortrun gains from product deception. Thus, plants will invest only enough resources in product quality to avoid being detected as a seller of off-quality products.

Lawrence et al. (2001) observed that meat and poultry processing plants often produce branded, specialty, and single-source products that can be linked to the supplier through its label or relationship to the retailer. Thus, these producers must be very diligent about maintaining product quality. Plants that slaughter hoofed animals and produce carcasses, on the other hand, usually sell nonbranded, generic products, making plant identification much more difficult. As with further-processed products, consumers must first identify food as a source of an illness and then recognize the food that caused the illness. If the product was either branded or unique, then the source is identified. If not, the consumer must remember the store where the food was purchased, then the store has to identify the plant that produced the product. If the store purchases identical products from different suppliers, then the source of foodborne illness cannot be determined, but if there is only one provider, then the supplier is known.

It may be easier to identify a large rather than a small slaughter plant. Suppose there are 1,000 consumers of products from plant A and only one consumer of product from plant B. Only 0.1 percent of the consumers of plant A production need to become sick from a foodborne illness and then correctly identify food and type of food as the source of the sickness for the plant to lose its reputation for producing pathogen-free food. However, 100 percent of the consumers of plant B production need to make the same connection for it to lose its reputation.

Tracing the source of a foodborne illness to the plant may also be more successful for large rather than for small slaughter plants. Some stores, restaurants, and wholesalers sell thousands of pounds of meat or poultry per year. These buyers often prefer to lower their transaction costs by purchasing meat or poultry from only one slaughter plant because only large plants have the capacity to meet demand for their products (Ollinger, 1996). However, if large buyers do purchase meat or poultry from small plants, then they must co-

[1] Throughout this chapter we define a slaughter plant as a plant that slaughters an animal and then sells the carcass or cuts the carcass into large components for shipment as boxed beef, trimmings, ground beef, large cuts of meat, and consumer-ready products. The essential feature of the slaughter plant is that an animal is slaughtered at the facility.

mingle products with products from other suppliers, making it difficult to identify the source of an unwholesome product. Summarizing, small slaughter plants should be less likely than large plants to be identified as the source of unwholesome products. All further-processors, on the other hand, can be identified as a source of unwholesome products if a particular type of meat or poultry is identified as the source of a foodborne illness. Thus, longrun profits should be higher for small slaughter plants with a greater percentage of deficient SPCPs and further-processors and large slaughter plants with a lower percentage of deficient SPCPs.

An Empirical Model of Plant Exits

Economic theory suggests that a plant will exit its industry when profits in year t, π_t, are less than the discounted value of the plant at the end of the period, $e^{-rt}V_{t+1}$, minus the current value of the plant, V_t. Thus, a plant will exit an industry when $\pi_t < V_t - e^{-rt}V_{t+1}$.

We follow Anderson (1998) and Muth (2001) who modeled profits and a reduced form of the profit function in the following way:

$$\pi_{it} = P(PD_t, MS_{ijt})*Q_t - C(T_{i,k,t}, D_{i,t}, M_{i,m,t}, F_{i,l,t}), \quad (5.1)$$

and

$$\pi_{it}^{*} = \pi(PD_t, MS_{ijt}, T_{i,k,t}, D_{i,t}, M_{i,m,t}, F_{i,l,t}), \quad (5.2)$$

where PD is product demand, MS is market structure, T is plant technology, D is percent SPCP deficiencies, M is plant product market, and F is company effects.

We cannot observe longrun profitability, but we do know that plants must exit an industry when the discounted value of profits, Π_t, are less than zero. Consequently, we define $Y_i = 1$ if the plant "i " existed in 1992 but did not exist in 1996, and define $Y_i = 0$ if it existed in both 1992 and 1996. Then, we use a Probit regression to examine the determinants (X_i) that may be correlated with the likelihood of a plant exiting. Since plants with negative profits must exit the industry, we write:

$$E(Y|X) = Prob(Y_i = 1) = Prob(\Pi_i < 0) \text{ and} \quad (5.3)$$

$$\Pi_i = \beta' X_i + \varepsilon_i, \quad (5.4)$$

where X_i is a vector of factors affecting profits and ε_i is the error term:

$$\begin{aligned} Prob(Y_I = 1) &= Prob(\beta' X_i + \varepsilon_i < 0) \\ &= Prob(\varepsilon_i < -\beta' X_i) \\ &= Prob(\varepsilon_i > \beta' X_i) \quad (5.5) \\ &= 1 - F(B' X_i), \quad (5.6) \end{aligned}$$

where E is the expectation operator, β is a vector of parameters to be estimated, and $F(B'X_i)$ is the cumulative distribution. Marginal effects are estimated separately as:

$$= \frac{\partial E[Y|X]}{\partial X} = \{\frac{dF(\beta' X)}{d(\beta X)}\}\beta = f(\beta' X)\beta, \quad (5.7)$$

where f (.) is the standard normal density function that corresponds to the standard cumulative distribution, F(.). (For technical details, see Greene, page 643.)

Model Specification

Profits vary with demand conditions. If consumer demand for meat or poultry products declines, then industry profits likewise should decline. However, all plants would be affected equally by a drop in demand if the market is national. Koontz et al. (1993) argue that boxed beef prices are determined on a national rather than a local level. Empirically, Anderson et al. (1998) provide no evidence that demand conditions affect plants differently. Hence, we assume competitive markets exist and that price differences for identical products do not exist.

Azzam and Schroeter (1995) argue that cattle markets are subject to imperfect competition, permitting larger purchasers to earn higher profits. Ward and Bliss (1989) assert that forward contracting for cattle by larger packers in concentrated markets can reduce animal availability for smaller purchasers and drive up the prices for other purchasers. However, unpublished census data show that large meatpackers pay higher prices for animals, suggesting that forward contracting is simply a way to guarantee an ample supply of inputs and that large meatpackers select higher quality animals. Empirically, Morrison-Paul (2000) found no evidence of market power in either the input or output markets in her study of the cattle slaughter industry, and Anderson et al. (1998) found that very small regional market share and market structure and forward contracting effects in their model of cattle slaughter plant exits. Due to these results, we consider market structure effects for slaughter plants but expect only a modest effect, if any, on plant survival. Meat processors purchase generic packed meat products and compete in a national product market, so they should not be affected by market structure effects.

MacDonald et al. (2000), Duewer and Nelson (1991), and Ward (1993) in cattle slaughter, Ollinger et al. (2000) in poultry slaughter, MacDonald and Ollinger (2000) in hog slaughter, and our results for meat processing (chapter 4) show that economies of scale is a key determinant of plant cost structure. Thus, large plants should be less likely to exit the industry since they, on average, have lower costs than smaller ones.

Plant capital embodies past and recent technological change. Since existing knowledge cannot be destroyed and new knowledge accrues, new technology must, on average, represent an advancement over older plant technology. For plant survival, this means that newer plants should be less likely to exit an industry than older plants because they should be able to accommodate the most recent technological advancements. However, Dunn et al. (1988) found that new plants often fail because they underestimate technological demands of the market. Thus, there may be a nonlinear relationship between plant age and plant survival.

MacDonald et al. (2000) found that about half of all bacon, ham, sausages, and other pork products were produced in slaughter plants in 1982, whereas only about 30 percent of these products were produced in slaughter plants in 1992. This change indicates a shift toward plant specialization that likely contributed to the lower costs of production reported by MacDonald et al. (2000) over the 1963-92 period. Since greater specialization implies fewer products and processes, we expect plant exits to rise as the number of plant processes rises and, in the slaughter industry, as the share of slaughter production declines.

Percent-deficient SPCPs reflect adherence to good manufacturing practices and should indicate the process control effort practiced by the plant. However, since conforming to such standards is costly (Klein and Leffler, 1981), firms adhere to higher standards only if the expected present value exceeds the expected shortrun gains from selling a low-quality product. Thus, firms making large investments to build brand awareness must also have a lower percentage of deficient SPCPs, suggesting that a higher percentage of deficient SPCPs encourages plant exits.

Consumers cannot readily identify the food manufacturer of nonbranded products. Raw beef, pork, and, to a lesser extent, poultry are usually sold under store brands and come from multiple suppliers, obscuring supplier identity. Thus, if consumers are displeased with a product, they must stop buying all products of that type, e.g., ground beef from all producers. In terms of the performance of sanitation and process control tasks, this means that slaughter plants have a weaker incentive to comply with SPCPs than do processors, and slaughter plants that are better able to avoid detection have less incentive than others. Since small plants are more likely to be one of many suppliers to a buyer and process controls are costly, an increase in the percentage of deficient SPCPs should reduce small plant exits. However, a high percentage of deficient SPCPs may induce large slaughter plants to close because large plants are more likely to be a single supplier to a buyer and, given their greater production volume, more likely to cause a foodborne illness if they fail to produce pathogen-free food.

Different product markets may have different survival prospects because of unique factors, such as processing technologies and final product demand conditions. Thus, we control for processing operations.[2] We also control for possible company-wide effects since plants owned by firms may achieve synergies with companion plants. However, firms may be more likely to close these plants if demand drops and the firm can reduce its cost of production by shifting all production to other facilities. Thus, the effects of being a multiplant firm cannot be determined *a priori*.

Data

Data include the 1992 percent-deficient SPCP data and the 1992 and 1996 Enhanced Facilities Database (EFD) for all meat and poultry slaughter and processing plants (primarily SIC 2011, 2013, and 2015). Both of these datasets were discussed in chapter 4. Since slaughter plants and further-processors have substantially different operations, we split this sample into

[2] In 1992, FSIS identified a number of different processing operations conducted in plants. These data are reported in the Enhanced Research Database and can be interpreted as a fundamental manufacturing process underlying particular types of products and their associated product markets.

separate data sets for slaughter plants (any plant that slaughtered animals) and further-processors (plants in SIC 2011, 2013, or 2015 with no slaughter operations). Slaughter plants that do no processing of animal carcasses were dropped from the sample because FSIS does not report SPCPs for them. FSIS has a different inspection program for these plants.

The data from the EFD that are useful for this chapter include the number and type of slaughtered animals, SIC codes, pounds of meat or poultry produced, plant age, and categorical data on plant manufacturing processes. The EFD defines pounds of production as further-processed products, such as hot dogs, plus semi-processed raw meat products, such as boxed beef but not bulk slaughter products, such as carcasses.

Since some plants produce only carcasses or sell some output as carcasses, we defined output as equal to pounds of carcasses plus pounds of further-processed and semi-processed products. We converted number of animals slaughtered to pounds of meat and poultry carcasses by multiplying the number of slaughtered animals times the average animal liveweight meat production for that species as reported in the 1992 Longitudinal Research Database (LRD) by a 60-percent conversion rate from liveweight to raw meat for cattle, hogs, sheep, and goats and a 100-percent conversion rate for chicken and turkeys. For each plant, total meat from slaughtered animals equaled the total amount of meat coming from all animal species slaughtered by the plant. The liveweight pounds per animal species as reported in the LRD in 1992 are 1,128 pounds for cattle, 249 pounds for hogs, 154 pounds for sheep and goats, 4.4 pounds for chickens, and 21.6 pounds for turkey.

Variable Specifications

The dependent variable (Y_i) was set at one if the plant existed in the EFD in 1992 but not in 1996 and set at zero if it existed in both the 1992 and 1996 EFD datasets.[3] OUTPUT is the total amount of semi-processed and processed meat and poultry and the estimated pounds of meat from slaughtered animals.

Other variables are defined as follows. PLANTAGE equals 93 (representing 1993) minus the year in which FSIS issued a meat grant or a poultry grant to the plant. All plants are at least 1 year old. A meat or poultry grant from FSIS gives meat or poultry plants the right to be inspected by FSIS and to produce, sell, and ship meat or poultry in both intrastate and interstate commerce. MULTSPECIE was set to one for plants slaughtering more than one animal species and set to zero otherwise.

The variables PROCESSES and SHSLAUTER reflect plant specialization. PROCESSES was coded as one if a slaughter plant used one or more or if a further-processing plant used two or more of the following processes: sausagemaking, production of ready-to-eat product, production of cured products, production of cooked but uncured products, or production of dry-cured products. If PROCESSES was not one, it was coded as zero. SHSLAUTER was pounds of slaughtered animal meat divided by the sum of processed and semi-processed meat and meat from slaughtered animals.

Table 5.1 shows a jump in the exit rates for the larger slaughter and all processing plants that fall in the 90th percentile of percent-deficient SPCPs. Below the 90th percentile, there is little apparent change in exit rates as the percentage of deficient SPCPs rises. Thus, we suspect that exit rates are a discontinuous function of percent-deficient SPCPs and set DEF90 at one for plants that fall in the 90th percentile of percent-deficient SPCPs and at zero otherwise.

The market variables for the slaughter plant model include a dummy variable equal to one for chicken plants and zero otherwise (CHIK) and other similarly defined dummy variables for turkey plants (TURK) and cattle slaughter plants (BEEF). For processors, the variables SAUSAGE, READY-TO-EAT, CURED, COOKED-UNCURED, CURED-UNCOOKED, and DRYCURED were set equal to one if the plant produced sausage, ready-to-eat, cured, cooked but uncured, cured but uncooked, or dry-cured products, respectively, and set at zero otherwise.

Three variables are used in the slaughter model to capture market structure effects: SHREGION, HERFREGION, and HERFREGION/SHREGION (see Anderson et al., 1998, for a similar formulation). SHREGION is the market share of the plant in the FSIS regional circuit, HERFREGION is the Herfindahl Index in the FSIS regional circuit, and HERFREGION/SHREGION provides a measure of a plant's relative dominance in the FSIS regional circuit, i.e.,

[3] Sometimes plants switch from Federal to State inspection programs. We have no way of identifying these plants and count them as exiting.

whether or not it is located on the industry fringe. Note, the Herfindahl Index is a measure of market power and equals the sum of the squares of firm market shares.

Results for Slaughter Plants

Table 5.1 illustrates how plant exits vary by the percentage of deficient SPCPs and plant size for slaughter plants. Reading down the table, exit rates are higher for the smallest slaughter plants with lower percentage of deficient SPCPs and the larger plants with a higher percentage of deficient SPCPs. These data are consistent with the hypotheses that: (1) small plants with a high percentage of deficient SPCPs benefit from the lower production costs associated with lower quality control effort, and (2) large slaughter plants with a high percentage of deficient SPCPs are penalized for selling poor-quality products.

Table 5.2 contains the results of the Probit regressions for slaughter plants. The log likelihood of the model is significant at the 99-percent level and the pseudo R^2 is 0.07.[4] Variables include technology, market, company, and market structure effects and interactions of output with other independent variables. A Wald test (table 5.2) shows that plant technology variables are jointly significant at the 99-percent level and market effect have a 95-percent level of significance. Neither company nor the market structure effects are jointly significant.

All the technology, market, and company effect variables are significant except those for plant age and the beef market. None of the market structure variables are significant.

Marginal effects are particularly important because they indicate how a marginal change in a variable affects the outcome. DEF90 is of particular interest and is consistent with expectations. It and its interaction with output are significant. These results suggest that very small plants in the 90th percentile of percent-deficient SPCPs are less likely to exit than their larger competitors. However, as plant size increases, the advantage enjoyed by plants in the 90th percentile dissipates until they reach about the mean plant size. After the mean plant size, high deficiency levels make it more likely to exit the industry. These results make sense. Production from small slaughter plants often cannot be directly linked to the supplier because products are co-mingled with identical products from other suppliers, obscuring the source of off-quality products. As pointed out by Libecap (1992), these slaughter plants have a strong incentive to minimize effort devoted to tasks like SPCPs because these tasks are costly and the consequences of failing to perform them are borne by the industry. However, this is not the case for large slaughter plants. As pointed out earlier, these plants are more likely to be a single supplier to a large restaurant chain or grocery store because those buyers prefer to minimize their transaction costs by dealing with a single seller (Ollinger, 1996). This single-supplier relationship makes it much easier to trace products to a supplier, forcing producers to perform quality control more diligently. Additionally, small plants produce much less product per hour than large plants, so an unsanitary condition that persists for an hour affects a much smaller volume of output and is consumed by fewer customers, reducing the likelihood of causing sickness.

Marginal effects are particularly important because they indicate how marginal changes affect outcomes. For DEF90, marginal effects suggest that plants in the 90th percentile of percent-deficient SPCPs are 35 percent less likely to exit. However, the effect diminishes with plant size. For a plant equal to about the industry mean plant size, the percent-deficient SPCPs have no effect on plant survival. For plants larger than the industry mean, plants in the 90th percentile of percent-deficient SPCPs are more likely to exit the industry.

We turn now to the other marginal effects. The negative signs on the coefficients for the marginal effects of output are consistent with MacDonald et al. (2000) and Ollinger et al. (2000). They indicate that a 10-percent increase in plant size reduces the likelihood of exiting the industry by about 1 percent. Positive coefficients on the coefficients for the multi-species, processes, and slaughter interacted with output are also consistent with results by MacDonald et al. (2000) and Ollinger et al. (2000). These results suggest that slaughter of more than one animal species, the use of more than one further-processing operation by small slaughter plants, and strict specialization in slaughter by large plants encourage plant exits. The marginal effects on share of slaughter suggest that a 10-percent increase in pounds of meat from slaughtered animals as a share of output reduces the likelihood of exiting by about 2 percent.

[4] Pseudo R^2 = 1 minus the ratio of the log likelihood estimate of the final model to that of the most restrictive model.

Company effects and market structure variables were not jointly significant. The market structure result is consistent with Anderson et al. (2000) and Morrison-Paul (2000). We also tested percent-deficient SPCPs as a continuous variable and found that it was modestly significant. These results are available from the author. Finally, we considered vertical and horizontal integration across plants and the share of meat inputs from a plant's main animal input as a share of meat from all animal inputs, but they were insignificant.

Results for Processing Plants

Table 5.1 shows how plant exits vary by the percentage of deficient SPCPs and plant size in the processing industries. As shown, exit rates increase with percent-deficient SPCPs for all size categories. These results are consistent with the hypothesis. Since further-processors typically produce branded and unique products that can readily be traced back to the producer (Lawrence et al., 2001), buyers can, and do, penalize plants for selling poor-quality products.

Table 5.3 contains the results for the Probit regression of plant exits over the 1992-96 period in further-processing industries. The plant technology variables include output, plant age, number of processes, and the dummy variable for plants falling in the 90th percentile of percent-deficient SPCPs. Plant product markets are represented by dummy variables for specific plant processes used to produce sausage, cured, cooked and uncured, cured and uncooked, and dry-cured products. Company effect variables include whether the plant is part of a firm that owns multiple plants producing meat or poultry products.

The technology variables—output, output squared, plant age, and whether or not the plant had more than two further-processing operations or falls in the 90th percentile of percent-deficient SPCPs—were jointly significant at the 99-percent level. Market effects were jointly significant at the 95-percent level of significance but company effects were not. Output, number of processes, the 90th percentile of deficient SPCPs, and the dummy variables for cured and cooked/uncured products were significant.

Results are consistent with previous research. The negative sign on the marginal effect of output is consistent with cost function results for the processing industries that show economies of scale exist in production. Results suggest that a 100-percent increase in plant size would lead to a 5-percent decrease in the likelihood of exiting the industry.

There is no current evidence for the cost effectiveness of specialization in meat processing, but results suggest that it pays to specialize. The marginal effects of the PROCESS term shows that plants with more than two processes were about 8.1 percent more likely to exit the industry.

Of most interest is the DEF90 variable. The magnitude of the coefficient for the percentage of deficient SPCPs suggests that plants with a percentage of deficient SPCPs in the 90th percentile have a 5-percent higher likelihood of exiting the industry than other plants. The positive sign on percent-deficient SPCPs for further-processors (in sharp contrast with the negative sign for small slaughter plants) suggests that plants falling in the 90th percentile of percent-deficient SPCPs are more likely than other plants to exit the industry, regardless of plant size. Why might this be so? As suggested earlier, further-processors can be much more easily linked to production of pathogen-tainted products than slaughter plants because further-processed products are more likely to be either branded or a specialty item (Lawrence et al., 2001). Slaughter products, on the other hand, are often generic and commingled with products from many suppliers by a buyer, obscuring the identity of the producer.

We also tested percent-deficient SPCPs as a continuous variable and considered vertical and horizontal integration dummy variables for a multiple-plant firm. The continuous percent-deficient SPCPs variable for further processing was significant. Neither the vertical nor horizontal integration terms were significant and were dropped.

Summary

This chapter examined the effect of plant technology, market effects, company effects, and market structure effects on plant exits in the meat and poultry slaughter and processing industries. Results suggest that plant technology variables and market effects variables in both industries significantly affect plant survival rates. Of particular interest was the effect of percent-deficient SPCPs on the likelihood of plant exits. Results suggest that large slaughter plants and all processing plants with a high percentage of deficient SPCPs (the 90th percentile of percent-deficient SPCPs) have a higher likelihood of exiting than other plants, despite any cost savings that their competitors may realize from reducing their sanitation and process control effort (and costs). Why might this be so? Large slaughter plants produce very large volumes of meat products; thus, the likelihood of any single consumer's becoming sick is a lot greater, all else equal. Moreover, large plant output constitutes a larger share of the product stocked by a retailer, making detection more likely. Processors, on the other hand, produce unique products that are often branded, so they have an even stronger incentive to produce wholesome products because their identity is much more easily revealed, regardless of size.

The second major finding is that the discontinuous nature of the relationship between exits and percent-deficient SPCPs means that only plants severely lax in their sanitation and process control effort would likely exit the industry due to food safety process control performance. Thus, plants have considerable flexibility in producing products with various degrees of food safety quality without being penalized. This finding has important regulatory implications. If enforcement of SPCPs were strictly practiced and directed mainly at the most serious violators, there would be little regulatory effect on most plants, and regulatory actions would provide a strong incentive for plants to avoid deviating substantially from the median level of SPCP performance. Regulatory policy would, no doubt, still encourage plant exits, but those plants would be the ones with the poorest process control performance and least willing to undertake additional process control effort. In terms of regulation under the Pathogen Reduction/ Hazard Analysis and Critical Control Point rule, this means that any increase in regulatory stringency would increase exit rates, particularly among the most poorly performing plants. However, those plants that do exit would be the ones that would be more likely to exit anyway.

Table 5.1— Percentage of slaughter plant exits by plant size and percentile of percent-deficient SPCPs, 1992-96

Percent-deficient SPCP category	Plant size			All sizes
	Less than one-half mean size	One-half to twice mean size	More than twice mean size	
		Percent exits, 1992-96		
Slaughter plants:				
Less than 10th percentile	8.3	0.0	0.0	8.2
10-90th percentile	9.6	7.4	2.9	8.5
More than 90th percentile	4.0	15.0	7.1	7.1
All percent-deficient levels	8.9	8.6	4.1	8.3
Processing plants:				
Less than 10th percentile	11.8	0.0	0.0	11.4
10-90th percentile	10.0	8.7	4.8	9.2
More than 90th percentile	15.0	14.8	7.3	12.8
All percent-deficient levels	10.7	9.3	5.4	9.9
		Number of plants in 1992		
Slaughter plants:				
Less than 10th percentile	144	1	1	146
10-90th percentile	459	108	69	636
More than 90th percentile	50	20	28	98
All deficiency levels	653	129	98	880
Processing plants:				
Less than 10th percentile	220	6	2	228
10-90th percentile	789	172	124	1,085
More than 90th percentile	80	27	41	148
All deficiency levels	1,089	205	167	1461

Table 5.2—Effect of percent-deficient SPCPs on slaughter plant exits, 1992-96

Variable[1]	Likelihood effect		Marginal effect		Mean
	Estimate	Standard error	Estimate	Standard error	
Plant technology:	χ^2 (10)=27.7***				
INTERCEPT	4.718	3.108	0.607	(0.400)	-
Log OUTPUT	-0.784*	0.418	-0.100*	(0.054)	15.30
Log OUTPUT Log OUTPUT	*0.026*	0.014	0.0033*	(0.0018)	241.20
Log PLANTAGE	-0.483	0.540	-0.062	0.070	2.632
Log PLANTAGE* Log PLANTAGE	-0.047	0.100	-0.006	0.013	7.386
Log PLANTAGE* Log OUTPUT	0.032	0.035	0.004	0.005	40.38
MULTSPECIE	0.418*	0.252	0.054*	0.032	0.621
PROCESSES	1.363*	0.831	0.175*	0.106	0.536
PROCESSES* Log OUTPUT	-0.104*	0.057	-0.013*	0.007	8.332
Log (SHSLAUTER)	-1.558*	0.833	-0.200**	0.105	-0.596
Log (SHSLAUTER) *Log OUTPUT	0.114*	0.061	0.015**	0.008	-9.037
DEF90	-2.713*	1.469	-0.350**	0.185	0.112
DEF90* Log OUTPUT	0.174**	0.088	0.022**	0.011	1.874
Markets:	χ^2 (10)=7.0**				
BEEF	-0.267	0.271	-0.034	0.035	0.728
CHICKEN	-0.510*	0.324	-0.066*	0.041	0.10
TURKEY	0.055*	0.313	0.071*	0.040	0.057
Company:	χ^2 (2) = 2.8				
MULTFOOD	5.823*	3.372	0.749*	0.430	0.165
MULTFOOD* Log OUTPUT	-0.319*	0.183	-0.041*	0.023	3.183
Market structure:	χ^2 (3) = 2.2				
SHREGION	-3.305	3.594	-0.426	0.452	0.016
HERFREGION	0.341	1.103	0.044	0.142	0.117
HERFREGION/ SHREGION	$-0.372*10^{-5}$	$0.596*10^{-5}$	$-0.478*10^{-6}$	$0.764*10^{-6}$	1970
Log Likelihood	-234.2**				
Pseudo R^2	0.07				
Observations	879				

Notes: *Significant at the 90% level; ** significant at the 95% level; *** significant at the 99% level.
[1] The symbol * used in some variable definitions represents the multiplication function, so Log Output*Log Output is Log Output times Log Output.

Table 5.3—Effect of percent-deficient SPCPs on processing plant exits, 1992-96[1]

Variable[2]	Likelihood effect		Marginal effect		Mean
	Estimate	Standard error	Estimate	Standard error	
Plant technology:		χ^2 (7)=40.0***			
INTERCEPT	1.631	1.104	0.262	0.178	-
Log OUTPUT	-0.305**	0.155	-0.049**	0.025	14.00
Log OUTPUT* Log OUTPUT	0.006	0.006	0.001	0.001	202.00
Log PLANTAGE	0.009	0.384	0.0014	0.061	2.560
Log PLANTAGE* Log PLANTAGE	-0.114	0.072	-0.018	0.012	7.128
Log PLANTAGE* Log OUTPUT	0.027	0.027	0.004	0.004	36.26
PROCESS	0.501**	0.207	0.081**	0.033	0.247
DEF90	0.321**	0.147	0.051**	0.023	0.101
Markets:		χ^2 (6)=14.4**			
SAUSAGE	-0.193	0.155	-0.031	0.025	0.144
READY-TO-EAT	-0.127	0.131	0.020	0.021	0.389
CURED	-0.220*	0.136	-0.035*	0.022	0.529
COOKED and UNCURED	-0.389***	0.140	-0.062***	0.022	0.215
CURED and UNCOOKED	-0.017	0.140	-0.003	0.022	0.697
DRYCURED	0.036	0.199	0.006	0.032	0.062
Company:		χ^2 (1) =0.6			
MULTMEAT	0.163	0.192	0.026	0.031	0.079
Log Likelihood		-448.5***			
Pseudo R^2		0.05			
Observations		1461			

Notes: *Significant at the 90% level; ** significant at the 95% level; *** significant at the 99% level.
[1] Interactions with output were insignificant and were dropped.
[2] The symbol * used in some variable definitions represents the multiplication function, so Log Output*Log Output is Log Output times Log Output.