Food Safety Investments in the Meat and Poultry Industries
Survey Results

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An empirical investigation into the level and type of food safety investments made by meat and poultry slaughter and processing plants reveals much about the diffusion of food safety innovation in the meat and poultry slaughter and processing industries.[1] The survey shows that larger plant size and stronger appropriation mechanisms, particularly those associated with buyer safety specifications, result in a higher number of safety investments. In this section, we examine the findings from this survey and their implications for the dissemination of food safety innovations.

ERS Survey Reveals Variation in Food Safety Investment

USDA's Economic Research Service (ERS) recently completed a survey on food safety technologies and practices in the 1,725 largest meat and poultry slaughter and processing plants inspected by USDA's Food Safety and Inspection Service (Ollinger and Moore, forthcoming). The overall survey response rate was about 57 percent or 987 plants.[2] Slaughter-plant respondents accounted for 44 percent of all slaughtered cattle, 77 percent of all slaughtered hogs, 48 percent of all slaughtered chickens, and 55 percent of all slaughtered turkeys. Respondents among processors with no slaughter operations accounted for 55 percent of all processed meat and poultry products.

Data from the survey include information on plant size, products, markets, type of food safety investments, and Pathogen Reduction Hazard Analysis and Critical Control Point (PR/HACCP) rule compliance costs (see box "Pathogen Reduction and Hazard Analysis and Critical Control Point Program (PR/HACCP"). The survey contains approximately 40 questions dealing with food safety technologies and practices covering five broad safety activities: equipment, testing, careful dehiding (for cattle slaughter plants), sanitation, and plant operations (see box "Sample questions from the ERS survey ...", p. 15).

To compare food safety investments across firms, Ollinger and Moore (forthcoming) created an index for each of the five types of food safety activities identified in the food safety questionnaire. In creating the index, they adhered to a number of principles. First, they maintained that the rating system should be monotonic because more intensive operations should yield greater food safety protection than less intensive ones. By monotonic, they meant that plants with more intensive cleaning or with a certain piece of food safety equipment have higher scores than plants with less intensive cleaning or without such equipment. Second, they compared plant food safety systems on the basis of similar technology types since some types of technology, such as plant operations, may have different purposes and long- and short-term effects than other technologies, such as equipment. Thus, they assert that the relevant comparisons are the equipment rating of one plant versus that of another and sanitation of one plant versus that of another, etc. Altogether, they considered five technology types: equipment, testing, dehiding, sanitation, and plant operations. Third, since food safety requires a systematic approach, it is necessary to consider a variety of technology components within each technology type. For example, they considered steam vacuum units, Frigoscandia carcass pasteurizers, and other food safety equipment as equipment technologies. Additionally, they categorized hand and knife cleaning and other cleaning practices as sanitation technologies. See Ollinger, Moore, and Chandran (forthcoming) for additional details on technology components in each technology type.

For the safety index, Ollinger and Moore assigned a value of 1 to safety activities that generated the most food safety process control, and a value of 0 to those that generated the least. They assigned values between

[1] It is worth noting that the Food Safety and Inspection Service examines all meat and poultry plants engaged in interstate commerce for the adequacy of plant food safety controls. Plants deemed to be using unsanitary production practices are prohibited from selling products. Thus, all plants must achieve a high level of food safety quality.

[2] This response rate is substantially higher than that achieved in recent surveys by Hooker et al. (1999) who had a less than 50 percent response rate (41 out of 98 questionnaires) and Boland et al. (2001) who reported a 36-percent response rate (18 of 50 questionnaires).

Pathogen Reduction and Hazard Analysis and Critical Control Point Program (PR/HACCP)

The Pathogen Reduction and Hazard Analysis and Critical Control Point (PR/HACCP) program is administered by the Food Safety and Inspection Service (FSIS) of the U.S. Department of Agriculture, which is responsible for ensuring the safety of raw meat and poultry products. The program covers all Federal- and State-inspected meat and poultry slaughter and processing plants in the United States, as well as foreign plants that export meat or poultry products to the United States. The PR/HACCP final rule was posted in July 1996 (USDA, FSIS, 1996).

The four major components of the HACCP program are:

(1) Implementation of a written HACCP plan by every slaughter and processing plant;

(2) Adoption of Sanitation Standard Operating Procedures (SSOPs) by every slaughter and processing plant;

(3) *Salmonella* performance standards for slaughter and ground product plants; and

(4) Generic *E. coli* performance standards for slaughter plants.

The HACCP plan component of the HACCP program requires each slaughter and processing plant to analyze its own production processes and identify Critical Control Points (CCPs) where potential hazards affect food safety. Plants must then develop a written HACCP plan and maintain records to ensure that the production process remains within predetermined critical limits at each control point, based on parameters such as temperature or chlorine level. The largest plants, 500 or more employees, had to implement HACCP plans by January 1998. Smaller plants had until 1999 or 2000 to implement plans, depending on plant size.

The SSOP component of the HACCP program requires all slaughter and processing plants to prepare a written plan describing the daily procedures used to ensure sanitation during production. Plants must also detect, document, and correct any sanitation deficiencies. All plants were required to have SSOPs in place by January 1997.

The *Salmonella* and generic *E. coli* performance standards included in the HACCP program allow FSIS to monitor whether plants are adequately preventing pathogen contamination of raw meat and poultry products. *Salmonella* was selected for monitoring because it is one of the most common foodborne pathogens and is present in a wide variety of raw food products. Generic *E. coli* was selected because it is naturally found in animal feces and serves as an indicator of fecal contamination during production. FSIS sets maximum acceptable limits for both pathogens, based on baseline surveys of each class of animal and food product. All slaughter plants were required to begin testing for generic *E. coli* in January 1997.

0 and 1 to activities that indicated an intermediate level of food safety process control. For example, for the equipment usage question listed above, Ollinger and Moore assigned a value of 1 to plants that responded yes, that they used a steam carcass pasteurizer. For the sanitation question, plants earned 0 points for this activity if they sanitized their drains once per week, 0.33 point if they sanitized more than once per week but less than once per day, 0.66 point if they sanitized more than once per day but less than once per shift, and 1 point if they sanitized more than once per shift. Ollinger and Moore then summed the points within each activity category and divided by the maximum points possible in that category, i.e., the number of questions in that category. This number is the firm's rating for the specific activity category. Each firm was given a rating for each of the five activity categories.

Ollinger and Moore also created an overall safety rating by summing the total number of points from all questions and then dividing that number by the total number of questions. For example, if the entire survey consisted of only the five questions listed above, then a plant would receive a total of 3.66 points if it responded that it 1) has a Frigoscandia pasteurizer, 2) tests for *E. coli* 0157:H7, 3) sanitizes drains once per day, 4) does not offer incentives, and 5) does have a vacuum at the dehiding area. Since there are five questions in this hypothetical survey, the plant's overall safety rating would therefore be 0.732 (3.66/5).

Other rating schemes are possible. For example, there is no reason why each technology component should have an identical maximum score of one. Ollinger and Moore used an equal rating of one as the maximum value because, for most technology components, they had no

Sample questions from the ERS survey of food safety in meat and poultry slaughter and processing plants

The ERS survey of meat and poultry slaughter and processing plants contained approximately 40 questions dealing with food safety technologies and practices covering five broad safety activities: equipment, testing, careful dehiding (for cattle slaughter plants), sanitation, and plant operations. Complete questionnaires and response rates are on the ERS website *http://www.ers.usda.gov/Data/HACCPSurvey/*. A sample question for each safety activity follows.

Equipment usage:
Does this plant use a steam carcass pasteurizer, such as a Frigoscandia, to pasteurize carcasses?

Testing:
Over and above that which is required under PR/ HACCP Rule, does this plant test raw or cooked product with tests for *E. coli* 0157:H7 or *Listeria*?

Sanitation:
Which one statement best describes how often drains are sanitized?

1. Drains sanitized once per week.
2. Drains sanitized one or more times per week, but less than once per day.
3. Drains sanitized one or more times per day, but less than once per shift.
4. Drains sanitized more than once per shift.
5. Don't know.

Plant operations:
Does this plant offer worker incentives, such as gifts or compensation, for detecting and reporting possible sources of contamination or unsanitary conditions?

Careful Dehiding:
Does this plant use an air exhaust system vacuum or other system that creates a negative air pressure around the carcass in the dehiding area?

information suggesting that one technology was superior to another for all the equipment and practices they considered. Additionally, instead of a proportional ranking scheme, they could have used a logarithmic or square root scale and still achieved monotonicity. Future research will refine the rating scale.

Plant Size Influences Amount and Type of Food Safety Activity

The ERS survey indicates that plant size influences both the amount and type of food safety investment, as reflected in the plant's food safety ratings. Table B-1 shows how food safety activity varied by cattle slaughter plant size. The table focuses on cattle slaughter plants, and not the other types of plants in the survey, because there is a larger variation in plant size and food safety activity in this industry. This variation provides a basis for comparing safety activity across plant size. Results are similar for other industries unless noted.

The largest cattle slaughter plants had the highest overall food safety rating of the size groups as well as consistently higher ratings across the five food safety activities than smaller plants. Differences were particularly dramatic in the more capital-intensive food safety technologies—equipment, testing, and careful dehiding—in which large-plant food safety technology index values were nearly twice as high as small plant levels. By contrast, ratings for large plants in the more labor-intensive technologies—sanitation and operations—were only about 20 percent higher.

Much of the difference in food safety rating between large and small plants is likely due to economies of scale, particularly with respect to capital-intensive activities. Large plants have much greater volume of production than small plants, lowering their average capital cost per unit of production. Some equipment that raises carcass temperature to 160 degrees or higher can cost more than $1 million, often requires technical skills that are available only in large plants with a variety of automated processes, and can be housed only in very large plants. Ignoring technical skills and plant size and assuming a 5-year life of the equipment, such equipment would cost a large plant (processing 100 animals per hour and running two 8-hour shifts per day, 240 days per year) about

Table B-1—Large cattle-slaughter plants have higher food safety ratings than small plants, mainly because of more capital-intensive activities

	Plant size category[1]			All plants
	Small	Medium	Large	
	Safety rating[2]			
Overall rating	0.43	0.49	0.62	0.50
Equipment	0.32	0.37	0.55	0.39
Testing	0.34	0.48	0.75	0.51
Careful dehiding	0.26	0.36	0.45	0.36
Sanitation	0.51	0.56	0.59	0.56
Operations	0.59	0.60	0.70	0.62
Number of plants	48	158	49	255

[1] Plants in the small category are in the 0-19 percentile of plant sizes; plants in medium category are in the 20-79 percentile; and plants in large category are in the 80-99 percentile.
[2] Higher numbers are better. See text for explanation.

$0.52 per head of cattle in equipment costs alone. By contrast, it would cost a smaller plant, processing only two animals per hour, but otherwise operating under the same conditions, about $26 per head. Note, this estimate varies with the assumed life of the equipment and considers only capital costs. We have ignored maintenance costs, housing costs, and the possibility of smaller scale equipment. Maintenance costs would rise over time and be more costly for smaller plants because they have fewer available skills to maintain complex equipment than do large plants. Housing costs would also be higher for smaller plants because their much smaller processing operations often run in batches rather than the continuous mode for which such equipment is designed. Of course, lower cost and lower volume equipment could also be designed, but there apparently has been little demand for it since, to our knowledge, no such units are for sale, much less installed.

Labor-intensive activities do not require such large fixed costs, and hence the smaller spread between large and small plants for more labor-dependent safety activities. Suppose workers in both the small and large plant are required to clean their knives after they finish cutting a carcass and that 10 cuts are made in each carcass. Additionally, assume workers are paid $12 per hour and that each cut takes 1 minute. For both the small and large plants, the cost per head of cattle for cleaning the knives is $2.40, so the practice favors neither large nor small plants.

Though economies of scale probably explain a large part of the safety variation between large and small plants, they do not explain it all—particularly for less capital—intensive activities. Another possible contributing factor is linked to the observation that large plants tend to supply large, homogeneous markets with relatively elastic demand, while smaller plants tend to serve smaller markets with less elastic demand. In homogeneous markets, in which a number of firms produce and market similar or identical products, any slip in safety could result in a sharp drop in demand for the offending plant. Buyers could replace sub-standard products with product from competing plants. The product from smaller plants may be less fungible. Small plants tend to compete with the larger firms by providing differentiated products for niche markets, such as fresher or more specialized cuts. Their products are less easily replaced, and their buyers may be more willing to overlook food safety slips or to work with a plant to overcome safety problems. To protect their markets, large plants may therefore have more incentive than small plants to adopt food safety innovations.

In fact, slaughter plants that can consistently supply high levels of product safety, as required by a number of major food retailers, gain access to almost guaranteed markets for large volumes of product. Plants that can produce the desired level of safety at the lowest cost will reap the largest benefits, and those that can supply the desired amount of safety only at higher prices will face greatly reduced demand. Plants in markets with relatively elastic demand have incentive to adopt the most efficient approaches for achieving product safety. Large slaughter plants operating in elastic markets may therefore have more incentive to adopt the safety activities included in the ERS survey than plants operating in less elastic markets.

An additional incentive for large firms to innovate is tied to the observation that large and small firms tend to face different size markets. As discussed in the theory section, even if innovative activity is scale neutral, the benefits of innovation are proportional to the size of the market. Holding constant the cost of innovation, more innovative activity would be expected in the larger market or in the market expected to grow more rapidly. This fact may have spurred large plants, which tend to operate in large markets, to innovate more than small plants, which tend to operate in smaller markets.

Another reason large firms may invest more in food safety than small firms is that food safety lapses have the potential to be very costly for large firms because they may involve large amounts of product. Large amounts of contaminated product increase both the probability of detection and the cost of recall. Larger plants have more potential for larger amounts of contamination than smaller plants because mistakes that expose product to contamination spread more quickly the faster the line speed and the greater the volume of production.

For example, suppose both large and small plants clean their dehiding areas once per hour. Assume also that workers in each plant rupture the intestines of an animal at the beginning of the hour. A plant running 100 head of cattle per hour will contaminate the carcasses of those 100 animals before cleaning the contaminants while a plant running two head of cattle per hour will contaminate the carcasses of only those two animals. The problems do not stop there, however. If each one of the contaminated cattle has trim that goes into separate bins, then those 100 cattle contaminate 100 bins. Further, if each one of those 100 bins is then mixed with 20 other bins to achieve a desired ground meat quality (a common practice), then the 100 head of cattle would have contaminated 2,000 bins of meat while the small plant would have contaminated only 40 bins. The greater volume of contaminated product produced by the larger plant increases the likelihood of a detectable foodborne illness outbreak and the likelihood that the plant will be identified and held liable. As a result, larger plants may have greater incentive to invest in food safety activities.

Appropriability Influences Food Safety Investment

The survey data also reveal that meat and poultry processors that had mechanisms for appropriating the benefits of food safety innovation used more types of safety investment and had better safety ratings. Among the processors in the survey, the appropriability mechanism most strongly linked with more safety investment was *buyer specification*. When buyers specify higher safety or quality requirements from their suppliers—and pay a premium or guarantee sales—they provide processors with a way to benefit from safety investments. Processors who invest to supply safer products appropriate the benefits of their investments through the price premiums or guaranteed sales.

In the meat industry, a growing number of large buyers, such as Burger King, Jack in the Box, McDonald's, and Wendy's, require their suppliers to meet safety and quality standards. These buyers spend millions of dollars advertising their brand names and building reputations for safety and quality. To protect their brand-name investments, these buyers set input safety and quality standards and require their suppliers to meet them. These standards cover a wide variety of safety activities ranging from pathogen tolerance levels to accounting procedures. Buyers enforce the standards through testing and process audits.

Table B-2 shows a marked difference between cattle slaughter plants facing buyer specifications and others. Again, cattle slaughter plants are an interesting case because of the large variation in safety activity in these plants. Results are similar for the other industries unless noted. The largest differences appear for safety activities requiring the most sophisticated technologies, equipment, testing, and careful dehiding. However, even for the other two activities, sanitation and plant operations,

Table B-2—Food safety ratings for cattle slaughter plants with buyer specifications are considerably higher than for other plants

Process control method	Does customer impose standards[1]	
	No	Yes
Overall rating	0.43	0.63
Equipment	0.30	0.56
Testing	0.35	0.77
Careful dehiding	0.28	0.48
Sanitation	0.51	0.61
Operations	0.58	0.68
Number of plants[2]	128	98

[1] Question in survey asks, "Do some major customers of plant test product for pathogens or harmful bacteria or require sanitation and product handling practices that are more stringent than those demanded by FSIS?"
[2] 29 plants did not indicate whether customers impose standards.

there is a large difference. The pervasiveness of the difference in safety activities between firms with and without buyer specifications suggests that buyers establish standards along a wide spectrum of activities.

Export markets may also entail higher quality specifications. These markets can provide a lucrative outlet for meat suppliers if plants meet the importing country's food safety standards. Table B-3 provides ratings for food safety technology for cattle slaughter plants that serve export markets. The pattern of the ratings, as in table B-2, shows a distinct difference in plant food safety technology between cattle slaughter plants that export and those that do not. The magnitude of the differences and their pervasiveness across all five categories is striking. The greatest differences are for equipment, testing, and careful dehiding technologies. The differences are smaller for sanitation and plant operations, yet a substantial gap remains.

Branding should have the same effect on food safety activity as buyer specifications and export markets. Meat processors, such as Oscar Meyer, that sell branded products through retail outlets are held directly responsible for food safety quality by consumers. These processors, and others who are easily linked to their product, should have stronger incentives to invest in safety than processors that sell unbranded products to large grocery stores and restaurant chains or to a host of smaller buyers that serve as intermediaries between the slaughter plants and the consumer. Having no brand name means that consumers can make no connection between the producer and food safety.

Table B-3—Food safety ratings for cattle slaughter plants that serve export markets are higher than for non-exporters

Process control method	Does plant export products[1]	
	No	Yes
Overall rating	0.43	0.64
Equipment	0.28	0.62
Testing	0.36	0.79
Careful dehiding	0.28	0.51
Sanitation	0.54	0.60
Operations	0.59	0.68
Number of plants[2]	169	84

[1] Question on survey asks, "Does this plant export products outside the United States?"
[2] 2 plants did not indicate whether they export.

Surprisingly, selling branded product appeared to have less impact on safety investment than buyer specification. Table B-4 shows plant food safety technology differences between hog slaughter plants selling products under their own brand and other plants. The survey data show only a modest difference in safety activity between the two types of plants. Dehiding and sanitation are higher for plants not selling products under their own brand and the other categories are higher for plants that do sell products under their own brand.

One explanation for this result could be that surveyed firms may have misunderstood the branding question. This question asked whether the plant produced products under its own name. The intent of the question was to see if the plant sold branded products to consumers. However, the overwhelming majority of all plants responded affirmatively. Yet, most plants, particularly cattle slaughter plants, do not sell directly to consumers. Thus, it appears that respondents understood the question to be whether the product was shipped to a customer with the producer's name on the box, regardless of whether it was going to final consumers or vendors to be repackaged or further processed.

The confusion over the branding question resulted in a watered-down definition of branded for the analysis: "branded" denotes plants that either sell a branded product to consumers or put their name on a box of products that are shipped elsewhere for processing. The very modest differential illustrated in table B-4 shows that selling under a brand, as defined here, failed to generate much of a difference in the use of food safety technologies.

Table B-4—Food safety rating of hog slaughter plants that sell products under their own brand are about the same as other plants

Process control method	Is product sold under plant's own brand?[1]	
	No	Yes
Overall rating	0.44	0.50
Equipment	0.34	0.39
Testing	0.40	0.50
Careful dehiding	0.32	0.30
Sanitation	0.59	0.55
Operations	0.52	0.61
Number of plants[2]	25	180

[1] Question on survey asks, "Does this plant produce products under its own brand?"
[2] 5 plants did not indicate whether they sell products under their own brand.

The effects of the appropriability mechanisms were similar for cattle, poultry, and pork slaughter plants; however, the effect of one of the appropriability mechanisms was slightly different for processors. Table B-5 summarizes responses for cooked-meat processors without slaughter operations (results were similar for raw-meat processors). The table shows that plants with buyer specifications had distinctly higher equipment and testing activity ratings than plants without, but nearly identical ratings for sanitation and plant activities.

Why did buyer specifications not have the same positive effect on sanitation and plant activities? One possible explanation for the higher testing rating for plants with customer requirements is that the buyer may demand proof that the products it buys are safe. The almost equal scores for plants with or without customer requirements for sanitation and plant operations could be due to the nature of the meat processing industry compared to animal slaughtering. Processing plants tend to sell unique products that can be readily linked to the producer. This linkage forces producers to adhere to as strict a standard as a buyer would require explicitly in a contract since buyers, regardless of whether they have specifications, can readily punish a plant that practices poor food safety quality control. Slaughter plants, on the other hand, produce generic products that cannot be distinguished from products from other plants with which they may be commingled. Thus, without buyer specifications, slaughter plants may feel they can adhere to weaker sanitation and food safety operating activities.

Appropriability Mechanisms Encouraged Early Adoption of HACCP-Like Programs

The influence of appropriability is also evident in rates of adoption of HACCP-like programs prior to implementation of PR/HACCP (see box “Pathogen Reduction and Hazard Analysis and Critical Control Point Program (PR/HACCP”). HACCP programs are designed to enhance safety and quality control management in food processing operations. Producers who are able to reap the benefits of improved quality or safety should have stronger incentives to adopt these programs than producers who cannot.

The ERS survey queried plants about their use before 1996 of the three core elements of HACCP programs: schematics, review of operations, and product or environmental testing. If plants had the three core elements, they were considered to have a HACCP-like program. Table B-6 shows the relationship between plants with HACCP-like programs and the three appropriability mechanisms (branding, buyer specifications, and export markets). The data indicate that plants subject to buyer specifications were much more likely than other plants to have implemented a HACCP-like process control program before 1996.

ERS Survey Indicates that Buyer Specifications Are Key to Spurring Safety Innovation

The ERS survey shows that plant size and appropriability mechanisms seem to encourage the use of more

Table B-5—Food safety ratings for three appropriability mechanisms for cooked-meat processing plants without slaughter operations

Process control method	Market mechanisms					
	Product sold under own brand		Customer food safety requirements		Plant exports	
	No	Yes	No	Yes	No	Yes
Overall rating	0.55	0.57	0.51	0.64	0.53	0.63
Equipment	0.51	0.55	0.46	0.65	0.49	0.65
Testing	0.67	0.61	0.47	0.78	0.51	0.78
Careful dehiding	--	--	--	--	--	--
Sanitation	0.53	0.56	0.55	0.57	0.56	0.56
Operations	0.61	0.63	0.60	0.66	0.61	0.65
Number of plants	12	356	202	166	230	138

Table B-6—Percent of plants with HACCP-like programs prior to promulgation of the PR/HACCP rule by various appropriability mechanisms

Industry category	Appropriability mechanisms					
	Product sold under own brand		Customer food safety requirements		Plant exports	
	No	Yes	No	Yes	No	Yes
	Percent					
Cattle slaughter	16	24	23	49	14	38
Hog slaughter	20	18	15	24	15	22
Poultry slaughter	22	26	12	33	7	29
Processing—cooked-meat	22	25	17	36	18	36
Processing—raw meat	20	24	16	32	17	32
	Total number of plants by market mechanism					
Cattle slaughter	43	210	128	98	169	84
Hog slaughter	25	180	106	66	138	68
Poultry slaughter	11	99	65	28	16	93
Processing—cooked-meat	23	575	354	244	378	220
Processing—raw meat	109	690	439	360	458	341

sophisticated food safety technologies. Investments by large plants could be a response to economies of scale, greater product demand, and demand elasticity, but production technologies that make large plants more likely to be exposed for a food safety failure may also drive these investments. Appropriability mechanisms, such as product branding, buyer specifications, and export markets, enable suppliers to benefit from food safety and encourage the adoption of a spectrum of food safety practices and equipment.