THE DIRECT AND INDIRECT COSTS OF FOOD SAFETY REGULATION

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Abstract

The cost of compliance with the Pathogen Reduction Hazard Analysis Critical Control Program (PR/HACCP) rule of 1996 has been controversial since it was first proposed. Surveys have provided some cost information but examined plant size and other indirect effects with limited data and did not make cost estimates of direct cost components, such as mandated tasks. This paper addresses those deficiencies with data from a national survey of meat and poultry plants on PR/HACCP costs. Results indicate that (1) mandated tasks are the most costly component of the PR/HACCP rule, (2) regulation favors large plants over small ones, and (3) private actions are nearly as costly as direct regulation.

Keywords: food safety, regulation, HACCP, costs of regulation

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The Food Safety and Inspection Service (FSIS) promulgated the Pathogen Reduction Hazard Analysis Critical Control Program (PR/HACCP) rule in 1996 as its primary vehicle for regulating meat and poultry processing plants. The regulatory costs imposed on large and small plants were critical to enactment and are as important and controversial today as they were then. At issue is the incremental cost of additional sanitation and monitoring tasks, more planning and reporting requirements, testing mandates, and cost advantages accruing to large plants due to economies of scale in regulatory effort.

Cost estimates of the proposed PR/HACCP rule prior to its promulgation sparked considerable controversy. FSIS's Federal Register announcement in 1996 projected costs of 0.12 cents per pound, but Knutsen et al. had much higher estimates. Later, econometric analyses (Antle; Nganje and Mazzocco; Ollinger and Mueller) estimated costs of 1.3, 0.04 to 43.5, and 0.9 cents per pound. The first direct cost estimates, based on post-PR/HACCP data came from a national survey (Ollinger, Moore, and Chandran) and regional surveys of plants in the Midwest (Boland, Peterson-Hoffman, and Fox.) and small and very small plants in Texas (Hooker, Nayga, and Siebert) and indicated costs of 0.7, 0.9, and 2 to 20 cents per pound, respectively.

The cited econometric estimates were based on conditions existing prior to promulgation of the PR/HACCP rule and projected changes under the regulation. The survey data give estimates of the actual average costs but do not indicate how different components of PR/HACCP drive economic costs nor do they suggest how marginal changes affect costs. This paper differs from those reports in that it uses plant-level data and an econometric model to examine how direct and indirect regulatory effects of the PR/HACCP rule, some private actions (food safety actions that are not required by regulators), and other factors have affected the costs of providing food safety process control since 1996.

Direct regulatory costs include the costs of planning and implementing Standard Sanitation Operating Procedures (SSOPs) and HACCP and adhering to the performance standards mandated by the regulation. Indirect costs arise from the comparative advantage some plants enjoy in performing regulatory requirements. For example, larger plants might be able to reduce its cost per unit of output by spreading costs over a larger volume of output. Private actions include contractual agreements in which a plant's customer may stipulate certain processing practices and other actions that plants must implement and food safety quality standards to which plants must adhere. In exchange, plants may be granted long-run contracts, high volume orders, and/or higher prices (Ollinger and Mueller; Golan et al.; Codron, Giradud-Heraub, and Soler).

An important feature of this study is the use of three unique datasets. One data set has the costs of complying with the PR/HACCP rule and the various food safety practices and technologies those plants use as reported in a survey conducted by the Economic Research Service of USDA. Data sets from the Food Safety Inspection Service (FSIS) provide information on food safety monitoring practices and plant characteristics. Finally, Census data has detailed plant-level production data.

Background

*The PR/HACCP rule and meat and poultry food safety regulation***.**

FSIS promulgated the final PR/HACCP rule on July 25, 1996 and completely phased it in by January 31, 2000. The rule stated that (1) all meat and poultry slaughter and processing plants had to develop, implement, and take responsibility for SSOPs and a HACCP process control program, (2) all slaughter plants had to conduct generic *E. coli* microbial tests to verify control

over fecal contamination, and (3) all slaughter and ground meat plants had to comply with *Salmonella* standards established by FSIS in a testing program conducted by FSIS.

The SSOPs mandated under PR/HACCP were in addition to the SSOPs promulgated by FSIS under the former regulatory regime, which plants still had to meet. Plants also had to comply with the facility control tasks mandated under the former regime. SSOPs are cleaning and sanitizing tasks that enhance pathogen control; facility control tasks require plants to monitor and control rodent infestations, dripping condensation, and other sources of harmful contaminants. See Ollinger and Mueller for a complete description of the regulatory regime prior to the PR/HACCP rule.

HACCP controls differ markedly from SSOPs and facility control tasks in that plants design and implement their own HACCP plans under the guidance of FSIS. More importantly, HACCP systems serve as monitoring activities that call for action if a critical control point deviates from an acceptable level. These monitoring tasks involve recording information about the status of critical control points at particular points in time. Plant managers use the recorded data to assess plant food safety process controls and make adjustments if necessary.

SSOPs and facility control tasks are specifically mandated by FSIS and are considered completed after a FSIS inspector verifies that they have been correctly performed. FSIS inspectors also monitor HACCP tasks to verify plant compliance with their plans and verify that follow-up activities are pursued if critical control points are out of tolerance.

The PR/HACCP rule did not explicitly require any new equipment or investment. However, plants did have to bring their food safety process control technologies up to FSIS standards and may have had to make additional investments in labor and capital equipment to comply with the generic *E coli* and *Salmonella* standards. For example, plants may have

invested in steam vacuum equipment to remove fecal matter in order to comply with the generic *E coli* standard. This equipment requires an operator to vacuum away-condensed steam and fecal matter from a carcass (usually hogs or cattle).

Private actions and their influence on food safety costs.

The PR/HACCP rule established a minimum standard that plants had to meet in order for FSIS to grant them a license to produce meat or poultry. Some plants either chose or were forced by their customers to go beyond those standards. Ollinger and Mueller describe some events that spurred industry actions. For example, Waldroup et al. report that chicken slaughter plants developed and installed counter-current scalders, bird washes, chlorine rinses and other pathogen-reducing technologies after the television show 60 *Minutes* highlighted the risks of *Salmonella* contamination. Moreover, major buyers, such as McDonalds and Jack-in-the-Box, required suppliers to adhere to standards that exceeded those of FSIS, mandated extensive testing, and encouraged meat and poultry plants to install up-to-date pathogen-control equipment (Ollinger and Mueller, Golan et al.). These trends were not confined to the U.S. Codron, Giraud-Heraub, and Soler provide evidence of widespread adoption of relatively stricter beef quality standards in France during the 1990s. Okello and Swinton, Henson and Northern, Balsevich et al., and Jaffee and Masakure identify other cases in the United Kingdom, Latin America, and Continental Europe, and Henson and Reardon provide a more general overview of private standards in Europe. Starbird notes that contracts reveal product food safety since sellers must adhere to quality standards.

The higher levels of investment in food safety process control required by contractual

agreements and plants' own private standards increased production costs but yielded many benefits, including a lower risk of a product recall, higher prices for better products, larger volume orders, and the maintenance of long-term relationships (Ollinger and Mueller; Golan et al.; Codron, Giraud-Heraub, and Soler).

Private standards (contractual agreements and a plant's own standards) affect food safety process control costs attributed to the PR/HACCP rule in two ways. First, if plants target food safety as a competitive advantage and the aggregate level of food safety process control rises, then plant managers will have to increase investments to retain a competitive advantage (Ollinger, Moore, and Chandran; Codron et al.). Plant managers will also raise investment if they have contractual agreements with buyers who want greater assurances of food safety than that provided by the regulation.

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Economic Framework

*Average Cost of the PR/HACCP rule***.**

Table 1 (from Ollinger, Moore, and Chandran) summarizes the costs of compliance with the PR/HACCP rule of 1996. It gives average cost per pound for cattle, hog, and chicken slaughter and cooked and raw processed meat plants. If there were no economies of scale in food safety process control, then average cost per pound for plants in the top quintile would equal those costs in the lowest quintile. Using this metric, it appears that there are considerable scale economies. Note, these mean costs are not weighted, so they are the sum of all plants in the quintile's cost per pound of meat or poultry divided by the number of plants in the quintile.

The table also shows the fixed costs of compliance with the PR/HACCP rule in terms of total investment since the rule's inception in 1996. The costs are not all in current dollars and it is likely that the fixed costs of larger plants are relatively higher than those costs reported here since larger plants were the first plants required to comply with the PR/HACCP rule, suggesting that their investments would have been made before those of smaller plants and so are higher due to the time value of money.

The apparent economies-of-scale in variable and fixed costs seems to offer strong evidence that the PR/HACCP rule favors large plants over smaller ones. However, the cost estimates do not control for how a plant's product line and the requirements of the regulation conspire to affect regulatory costs. For example, small plants typically produce niche products for specialized markets while large plants tend to produce more commodities, such as boxed beef. Under PR/HACCP rule, a small multi-product plant may actually have higher absolute regulatory costs than a single-product large plant because the PR/HACCP rule requires plants to have separate plans for separate products and to follow prescribed HACCP tasks and SSOPs. To account for these differences in regulatory requirements and other differences, such as the impact of private standards, we propose an informal model of regulatory costs in the next section and then empirically examine its components with data from a recent survey in subsequent sections.

An informal model of regulatory costs.

We follow a regulatory cost model pioneered by Bartel and Thomas who argued that regulatory costs have direct and indirect effects. Recall that direct effects come from the regulation itself and indirect effects arise from different regulatory responses.

We do not specify a particular functional form but do use independent variables that reflect the cost conditions faced by the plant. In equation (1) we express food safety costs attributed to the PR/HACCP rule (SHAR_HACCP) as a function of the cost of labor (W), indirect private market actions -- the value of human and physical capital (**K**), direct private market actions (**M**), and direct (**D**) and indirect (**ID**) regulatory effects. The analysis focuses on costs to domestic incumbents since imports are relatively small and we use cross-sectional data in which all plants have existed at least one year.

$$\text{SHAR\_HACCP} = f(W, \mathbf{K, M, ID, D}) \qquad (1).$$

Some plant managers may invest in human capital and innovative food safety technologies and practices in order to realize higher prices, avoid costly recalls or other food safety catastrophes, enhance their reputation with buyers, etc. We call these investments indirect private actions since managers have no explicit written agreement with a customer to make food safety investments but do recognize that their customers want a higher level of food safety. Other profit-maximizing managers may serve markets that make no such demands, so they will not make food safety investments. Differences in these plant managers' visions of food safety-related threats to their plants and the level of prevention needed to avoid such an event is manifested in human and physical capital investments (**K**).

Some plants made considerable investments in human capital prior to promulgation of the PR/HACCP rule. These plants should have lower adjustment costs to the requirements of the regulation. For example, Golan et al. report that Texas American Beef focused on food safety process control had a comprehensive food safety process control system in the early 1990s as a way to differentiate its products from its competitors.

Physical capital investments include mechanical technologies that control pathogens through temperature or chemical applications, cleaning and operating technologies designed to limit the spread of pathogens, and other technologies. Roberts gives several examples of these technologies. Golan et al. discuss experiences of EXCEL and IBP, which purchased steam pasteurizers for all of their cattle processing plants, and Texas American Beef, which instituted a sophisticated pathogen-detection and control system. The use of these sophisticated practices and equipment did not necessarily lower production costs and may have raised them since new equipment and production procedures may have required more labor.

Direct private market actions (**M**) are explicit agreements between plants and large buyers, such as fast food restaurant chains, in which plant managers agree to undertake food safety process control tasks and make specific investments in return for guaranteed markets, higher volume orders, higher prices or some other benefit (Ollinger and Mueller; Golan et al.; Codron, Giraud-Heraub, and Soler; Codron).

Another direct private action occurs when contractual arrangements with suppliers or upstream buyers are so burdensome and production processes compatible enough that plant managers choose to vertically integrate (Williamson; Reimer). Vertical integration offers greater control over product quality since negotiations over contractual terms are eliminated, as one management controls the entire process.

Previous research points to three variables that should be included in the vector **ID**. Antle, Boland, Peterson-Hoffman, and Fox. Hooker, Nayga, and Siebert, and Pashigian provide ample evidence that regulation favors larger plants. Large firms may also have lower costs (Pashigian; Bartel and Thomas), and Pashigian found that regulation favors more capital intensive industries.

There are other indirect regulatory effects also. Pashigian, provides evidence that regulation favors union workers because unionization tends to raise the costs of providing worker benefits. Bartel and Thomas found that regulation also favors importers because domestic producers have to comply with regulatory costs. Finally, Moore's analysis indicates that regulation favors incumbents because regulation raises industry entry costs. We do not consider these factors because (1) unionization in the meat and poultry industry existed in a much weaker condition by 2000 than it did prior to 1985, (2) we are considering only domestic plants, and (3) all plants in our data set have existed at least one year.

The direct costs **(D)** of the PR/HACCP rule include additional labor inputs for three important features of the PR/HACCP rule. First, each plant must develop HACCP plans for each of its FSIS-designated product categories. These HACCP plans have to be updated when products change or regulations change. Additionally, plant personnel have to perform SSOP tasks and monitor HACCP systems. Finally, plants must comply with performance standards by monitoring and maintaining existing processes if they meet the performance standards and by investing in food safety process controls if they do not. Food safety process control investments require plants to hire more production workers to perform tasks and operate equipment.

The empirical model and econometric methods.

We use Ordinary Least Squares and equation 2 to empirically examine the direct and indirect costs of the PR/HACCP rule. Food safety costs ($SHAR\_HACCP_i$) is regressed on proxies for wages, indirect private actions -- human and physical capital, direct private market actions, and direct and indirect regulatory effects.

$$SHAR\_HACCP_i = \beta_0 + \beta_1 State\_Wage_i + \beta_2 Experience\_QC_i + \beta_3 FS\_Tech_i +$$
$$B_4 Buyer_i + \beta_5 Process_i + B_6 Employees_i + B_7 Multi_i +$$
$$B_8 Cap\_Lab_i + \beta_9 Plans\_Sale_i + B_{10} Tasks\_Emp_i +$$
$$B_{11} Shar\_HACCP\_Task_i + \beta_{12} PW\_QC_i + \varepsilon_i \qquad (2)$$

where food safety costs attributed to the PR/HACCP rule is defined as the costs of complying with the PR/HACCP rule as a share of plant sales. The cost of complying with the PR/HACCP equals non-labor variable costs plus the labor costs associated with planning, and the labor costs of performing mandated SSOP and HACCP tasks and maintaining and staffing new food safety technologies.

Data comes from the ERS survey. Question 14 of the ERS survey gives non-labor variable costs. Planning costs are the number of days required to make HACCP plans for plant product lines (question 15 on the ERS survey) times the average annual wage from Census files divided by 270 days (the number of workdays in a year). Labor costs for performing mandated tasks and staffing new technologies equal the number of production and quality control workers hired to meet requirements of the PR/HACCP rule (question 7 on the ERS survey) times the average annual wage of meat and poultry slaughter and processing workers for 2000 (obtained from Census files) divided by 270. Sales equal the total value of shipments from Census data.

$State\_Wage_i$ is the average state wage for meat and poultry production workers in the state in which the plant was located. Indirect private actions include human and physical capital. The human capital variable, $Experience\_QC_i$, equals one for plants that had a formal food safety process control system prior to implementation of the PR/HACCP rule in 1996 and zero otherwise. We considered a pre-HACCP food safety process control system to be formal if the

plant (1) used schematics or flow diagrams to identify critical pathogen control points and (2) systematically reviewed plant operations prior to promulgation of the PR/HACCP rule. These data come from questions 16 and 17 of the ERS survey.

FS_Tech_i is the physical capital variable and is defined as a plant-level index of food safety technology, as given in Ollinger, Moore, and Chandran. The index is a continuous variable between zero and one and is monotonic in that plants with higher index values use more sophisticated equipment, do more frequent cleaning, have superior worker training systems, and/or have other practices and technologies that are superior in controlling pathogens than plants with lower index values. Data comes from 35 to 40 questions on five types of technologies given in the ERS survey. The five technologies are: sanitation, operations, food safety processing equipment, plant capital investments, and hide removal technologies.

Direct private market actions include contractual agreements with buyers and vertical integration. To account for contractual agreements, we include the dummy variable ($Buyer_i$). This variable is defined as one for plants that have customers that specify requirements that are more stringent than those demanded by FSIS and zero otherwise (question 44 of the ERS meat survey).

Vertical integration occurs in slaughter plants that also process meat into raw or cooked products. The cooked and raw meat processors in our data are not vertically integrated because, by definition, those plants are strictly processors without slaughter operations. We account for vertical integration in slaughter plants with $Process_i$, which equals one for slaughter plants that produce ground meat, fabricated cuts, or other raw or processed meat and zero otherwise. We also include $Process_i$ in the regressions for the processing industries in order to control for the cost differences of a raw meat processor also producing cooked products and vice versa. For

these plants, $Process_i$ equals one for cooked meat processors that also produce raw products and vice versa for raw meat processors.

The indirect regulatory variables have straight-forward definitions. $Employees_i$ is the number of plant employees. $Multi_i$ equals one for plants owned by firms that own more than one establishment and zero otherwise. Cap_Lab_i is the capital to labor ratio and equals the ratio of the plant's value of buildings and equipment at the end of the period divided by the plant's total employment.

There are four direct regulation variables. $Plans\_Sales_i$ equals a plant's cost of developing HACCP and SSOP plans as a share of plant sales. These costs equal the number of days required to devise HACCP and SSOP tasks (question 15b of the ERS survey) times average wages from Census data divided by 270 days per year. Sales have already been discussed. $Tasks\_Emp_i$ equals the number of SSOPs and HACCP tasks performed in 2001 in order to comply with the PR/HACCP rule divided by the total number of employees. SSOP and HACCP tasks come from FSIS files. We also distinguish between the costs of SSOP and HACCP tasks by including a variable ($Shar\_HACCP\_Task_i$) defined as HACCP tasks divided by the combined total of SSOP and HACCP tasks required to comply with SSOP and HACCP plans. If HACCP tasks are more costly than SSOPs then $Shar\_HACCP\_Task_i$ is positive.

The PR/HACCP rule requires plants to meet tolerances for *Salmonella*, generic *E coli*, and fecal matter. Plant managers that cannot meet these performance standards with their existing food safety process controls or fear that they might not meet them in the future must hire production workers to operate food safety equipment, such as steam vacuum units, staff new operating practices, or do more intensive cleaning. Plants that are able to meet performance standards did not have to hire any production workers. All plants had to hire quality control

personnel to perform SSOP and HACCP tasks. Thus, the ratio of production workers hired to comply with the PR/HACCP rule divided by all production and quality workers hired in response to the PR/HACCP rule (PW_QC_i) should correspond to the regulatory effort required to comply with the *Salmonella* and generic *E coli* performance standards and should be positively related to the costs of the PR/HACCP rule.

Three unique datasets provide the data.

Data are a matched dataset coming from a national survey conducted by the Economic Research Service in 2001 on the costs of the PR/HACCP rule and food safety technology, the Enhanced Facilities Database (EFD) of FSIS for 2000, and the Longitudinal Research Database (LRD) from the Bureau of the Census.

The survey garnered responses from about 1,000 of the 1,720 plants considered to be manufacturers in the administrative data files maintained by FSIS. FSIS regulates more than 6,000 retail stores, restaurants, and manufacturing facilities that process meat or poultry. Plants may or may not ship product across state lines. We defined an establishment as a manufacturer if it slaughtered animals or was assigned to SIC 2011, 2013, or 2015 in the EFD and had either sales exceeding $7.0 million per year or production greater than 1.0 million pounds per year.

The ERS data include only plants from the EFD that responded to the survey, so they are not nationally representative and it may not be valid to generalize results. However, several reasons lead us to believe that the bias is small. First, the final dataset has a large number of plants, including 161 federally inspected cattle and hog slaughter plants, 64 federally inspected poultry slaughter plants, and 298 federally inspected cooked and raw meat processors with no slaughter

operations. Second, the share of total output closely tracks the share of plants responding to the survey. Third, a regression analysis by the authors suggests that no correlation exists between plant size and survey response.

To account for remaining biases in the data, we treated it with a post-stratification adjustment (Gelman and Carlin). Under this approach, the regression is adjusted with a response weight equal to the reciprocal of the share of plants responding to the survey.

The ERS data include approximately 10 questions dealing strictly with costs and benefits of HACCP regulation, 35 on food safety technologies and practices, and 15 miscellaneous questions about plant and other characteristics. The questions about the costs of the PR/HACCP rule dealt with the number and types of workers hired, planning costs, non-labor variable costs, and capital investments. The HACCP questions also asked subjective questions, such as the aspect of the PR/HACCP that was most costly. The questions are provided and the responses are tabulated and summarized at http://www.ers.usda.gov/data/haccpsurvey/.

The EFD covers about 9,000 manufacturing and other establishments monitored by FSIS and state food safety agencies. These establishments include all meat and poultry manufacturing plants and other establishments that process meat or poultry as a minor business, e.g. some grocery stores. The EFD provides very little production data for plants monitored by state agencies but data for plants inspected by FSIS include counts of the number of slaughtered animals, estimated sales and employment, types of processing operations (e.g. animal carcasses or ready-to-eat products), and some other data on establishment characteristics.

The LRD includes information on all meat and poultry manufacturers from its survey of Manufacturers taken at five year intervals. The most recent survey was taken in 2002. The LRD also has data on a subset of larger plants and a sampling of smaller plants for the inter-Census

years. Data in the LRD include value of shipments, number of workers, production hours, wages, end of period value of buildings, end of period value of machinery, etc.

Results

Results are given in table 2. The R^2 statistics vary from 0.16 to 0.50. Estimated costs (all dummy variables set equal to one) were \$0.0255, \$0.0152, -\$0.004, \$0.029, and \$0.0273 per dollar of sales for cattle, hog, and chicken slaughter and cooked and raw meat processing, respectively. These are similar to the computed average costs given in table 1: \$0.022, \$0.014, \$0.01, \$0.016, and \$0.013 per pound for the same industries. Note, slaughter plants may also process meat but the processed meat plants do not slaughter animals.

Now consider table 2 and the individual reported results. Results show that state wages are negatively associated with PR/HACCP costs in four of five cases. A positive sign means that the productivity of workers in high wage states equals productivity in low wage states, resulting in relatively higher costs for plants in high wage states. A negative sign means that the higher wages offered in high-wage states paid for more productive workers that enabled plants in those high wage states to hire fewer workers and incur lower costs than plants in low wage states.

Indirect private actions include previous experience (human capital) and the technology index (physical capital). Previous experience with a food safety process control system prior to enactment of the PR/HACCP rule should confer an advantage on those plants. Results show that, in three of the five industries, plants with some experience with food safety process control systems prior to the PR/HACCP rule had modestly lower costs. The other two cases were positive and insignificant. Results also show that plants with high levels of capital investment (food safety technology index ratings) had consistently higher food safety costs. Recall that a

high technology index results from more intensive cleaning, the use of advanced food safety equipment, such as steam vacuum units, and other food safety practices. These activities enhance food safety process control, but they also raise costs.

By making marginal changes to the independent variables, we can examine their impact on food safety costs. As reported in table 4, a ten percent increase in the food safety technology index raises food safety costs by 8.50 to 17.7 percents in the five industries. These percent changes were obtained by multiplying the coefficient on FS_Tech (e.g. 0.042 for cattle slaughter —table 2) times a 10 percent change in the mean value of FS_Tech (e.g. 0.50 for cattle-table 3) divided by mean of PR/HACCP costs as a share of sales (e.g. 0.0123 for cattle-table 3).

Direct private actions include buyer contracts and vertical integration. Results indicate that buyer contracts had a substantial impact on food safety process control costs. Coefficients were significant and positive in four of five cases, and plants making contractual commitments with buyers had food safety costs that were 40.2 to 105.0 percent higher than plants without buyer contracts in the cattle, hog, and chicken slaughter and raw meat processing industries. From an industry perspective, a ten percent increase in the mean number of plants with buyer contracts led to an increase in food safety costs of 2.3 to 9.1 percent in cattle, hog, and chicken slaughter and raw meat processing, respectively (table 4). Finally, notice that vertical integration had only a small effect on food safety costs in the slaughter industries.

Previous research has indicated that that regulation can have large indirect effects. In meat and poultry, large, more capital intensive plants and firms should have lower costs relative to smaller, more labor-intensive plants and firms. Empirically, we should obtain negative values for measures of plant and firm size (Employees and Multi) and capital intensity (capital-labor ratio). Results show that the number of employees is negative in all cases and significant in two

of them; Multi is negative in only two cases and modestly significant in only one of those. The capital-to-labor ratio is negative in three cases and modestly significant in only one. These results suggest that, of the indirect effects, only plant size affects food safety costs.

A ten percent change in plant size shows only a small cost advantage (economies of scale) for larger plants. However, there are huge differences in plant sizes in all of the meat and poultry industries. For example, some plants in some industries are more than ten times larger than the mean. In cattle slaughter, just a 100 percent increase in plant size (i.e. twice the mean) leads to a 4.2 percent reduction in food safety costs. One hundred percent increases in hog and chicken slaughter and cooked and raw meat processing plant sizes lead to changes in costs ranging from reductions of 3.2 percent in raw meat processing to 60.5 percent in chicken slaughter.

These cost differences are quite large and are consistent with findings by Antle, Boland, Peterson-Hoffman, and Fox, Hooker, Nayga, and Siebert, and Ollinger, Moore, and Chandran. However, it is difficult to see how these differences affect survival. Large plants already enjoy substantial economies of scale, yet small plants persist by producing niche products and avoiding direct competition with their large competitors (MacDonald, Ollinger, Handy, and Nelson). Thus, the actual disproportionate impact on survival of the PR/HAACP on the survival of small plants relative to large ones may be quite small.

The direct regulatory effects – planning costs, tasks per employee, and the ratio of new production workers to new production and non-production workers -- are stronger than the indirect effects. We expected positive signs for each of the coefficients, and each one was positive and significant in four of the five industries. The other coefficients were negative and insignificant. Positive signs mean that food safety costs rise with more PR/HACCP requirements

Direct effects are particularly important because they can be controlled by a regulator. Examining chicken slaughter first, table 4 shows that a 10 percent increase in planning costs per unit of sales for chicken results in a 3.4 percent increase in the costs of complying with the PR/HACCP rule per unit of sales. Similarly, 10 percent changes in planning costs lead to cost changes of 1.3 to 3.3 percent in cattle slaughter and cooked and raw processed meat.

Changes in the number of HACCP and SSOP tasks per employee implies changes in the monitoring and cleaning tasks required to comply with the PR/HACCP rule. A 10 percent change in the number of tasks per employee increases costs by 3.2 to 14.8 percent in cattle and hog slaughter and cooked and raw meat processing industries.

Remember that the ratio of newly hired production workers in response to the PR/HACCP rule to the combined total of newly hired production workers and quality control workers reflects changes in the food safety process control system necessary to meet performance standards. Results show that a ten percent change in this production worker ratio raises costs from about 1.0 to 1.5 percent in four of the industries (table 4).

Discussion

Table 5 contains the contributions to costs made by direct and indirect effects of private actions and the PR/HACCP rule. We focus our discussion on physical capital, buyer contracts, number of employees, and all of the direct regulatory costs. We ignore the other variables because they are either exogenous to the plant (state wages) or cannot be changed (whether a plant had experience with quality control programs prior to the PR/HACCP) or were not significant.

Buyer contracts and physical capital investments are elements of a private food safety process control system because plants must adhere to explicit requirements from a customer (buyer contract) or plants are indirectly bound to self-imposed standards by its own strategic objective to have a competitive edge in food safety. Results suggest that direct and indirect private actions elicited expenditures ranging from $0.0175 to $0.038 per dollar of sales in the cattle, hog, and chicken slaughter and cooked and raw meat processing industries (table 5). These costs exceed direct regulatory costs in the slaughter and the raw meat processing industries and are more than 50 percent of direct regulatory costs in the cooked meat processing industry.

A central theme among economists is that indirect regulatory costs, particularly plant size, are important. We found that large plants do have a cost advantage over smaller ones. Plants 10 times larger than the mean size plant had cost advantages ranging from $0.0045 to $0.045 per dollar of output over mean size plants in all of the industries. These estimates were computed by setting the difference in costs equal to the coefficient on the parameter (-0.0036 for cattle) times the difference between ten times the mean number of employees minus the mean number of employees (1.430 – 0.143 for cattle).

Now compare direct and indirect regulatory costs. We evaluate direct regulatory variables at their mean values and indirect regulatory cots due to plant size at the mean and ten times the mean size plant. Mean size plants incur considerably more direct costs than any offsets due to economies of scale in regulatory costs (total direct costs versus mean plant size offsets) in the cattle and hog slaughter and both processing industries. All of the direct regulatory costs are offset by plant size in chicken slaughter. At ten times the mean plant size, direct regulatory costs still are larger than indirect cost offsets in hog and cattle slaughter and cooked meat products. Net costs (direct minus indirect costs) ranged from $0.0179 per dollar of sales in cooked meat

processing to $0.0234 per dollar of sales in cattle slaughter. Cost in the raw meat processing and chicken slaughter industries were completely offset by economies of scale.

Table 5 also shows that tasks per employee (Tasks_EMP + Shar_HACCP_Tasks) accounted for more than 80 percent of all direct regulatory costs in cattle and hog slaughter and raw meat processing and were about 60 percent of direct regulatory costs in cooked meat processing. However, tasks were near zero in chicken slaughter. In that industry, planning costs accounted for nearly all of the direct costs

Notice that the costs of complying with performance standards – the ratio of production workers hired to comply with the PR/HACCP rule to the total of production workers and quality control workers hired in response to PR/HACCP– contributes less than 10 percent of direct regulatory costs and are less than one-sixth to one-tenth of the costs of tasks per employee in all industries except chicken. This means that performance standards could be made six times more stringent (in terms of costs) than currently exists in cooked meat processing and ten times higher in cattle and hog slaughter and raw meat processing and result in the same cost to the plant as tasks per employee.

Now suppose that the generic *E coli* and *Salmonella* performance standards are as effective at controlling pathogens as are SSOP and HACCP tasks. This would mean that the performance standards provide food safety process control at one-sixth or less of the cost of the SSOPs and HACCP tasks, suggesting the most efficient way to increase regulatory oversight would be to increase the stringency of the performance standards.

Conclusion

This paper empirically examines the impacts of indirect and direct regulatory effects and private actions on the reported costs of complying with the PR/HACCP rule. The primary indirect effect is plant size, and direct effects include planning costs, HACCP and SSOP tasks per employee, and production workers hired in response to the PR/HACCP rule as a share of all newly hired production and quality control workers (a measure to capture effort devoted to performance standards). Results suggest that economies of scale in food safety process control give the very largest plants a substantial cost advantage over their smaller competitors. Economies of scale offset almost all direct regulatory costs in two industries and offset some of the direct costs in the other industries. Of the direct regulatory costs, HACCP and SSOP tasks imposed the greatest costs in four industries and planning costs made the largest contribution in the other industry.

Results also show that the costs of complying with the generic *E. coli* and *Salmonella* performance standards were one-sixth to one-tenth of the cost of completing SSOP and HACCP process control tasks in four of the industries. This means that, if the performance standards give one-sixth or more additional process control than SSOP and HACCP tasks and if FSIS regulators wanted to enhance food safety process control, then the least costly option would be to increase the stringency of performance standards rather than to raise the number of process control tasks.

Private actions (buyer contracts and plant food safety capital investments) accounted for nearly half of the costs of complying with the PR/HACCP rule. There are two likely reasons why private actions have such a significant impact on costs. First, plants have one food safety process control system and they may not distinguish between the costs of complying with the PR/HACCP rule and private actions, causing them to report all food safety process control cost as a cost of PR/HACCP. Second, if a plant or buyer makes superior food safety process control a strategic goal, then the plant or a buyer would have to stiffen its stringency requirements

whenever the benchmark quality increases. Thus, a rise in regulatory requirements results in a rise in the stringency (and cost) of private actions.

It is also interesting to note that Ollinger and Moore (forthcoming) attribute more than two-thirds of *Salmonella* reduction to private actions, while private actions accounted for from 41 to 59 percent of all costs in hog and cattle slaughter and the two processing industries and just about all costs in poultry slaughter. Combined, these results suggest that the cost of providing food safety process control per unit of *Salmonella* reduction is lower for private actions.

Limitations and Further Research

The main limitation of this study is that the ERS survey and the final dataset were not nationally representative, meaning that results cannot theoretically be generalized. As discussed earlier, the bias may have been minimal since the share of total output of respondents closely tracks the share of plants that participated in the survey. Additionally, a regression analysis by the authors showed no correlation between plant size and survey response, and the data were treated with a post-stratification adjustment (Gelman and Carlin).

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Table 1—PR/HACCP costs increase with Plant Size[1]

Percentile of Plant Size	----------Slaughter----------			----------Processing-------	
	Cattle	Hogs	Chicken	Cooked Meat	Raw Meat
Variable Costs	----------dollars per pound----------				
0-19	0.023	0.016	0.025	0.018	0.020
80-99	0.008	0.005	0.004	0.005	0.005
Mean	0.022	0.014	0.010	0.016	0.013
Fixed Costs					
0-19	0.055	0.050	0.013	0.079	0.027
80-99	0.009	0.008	0.004	0.019	0.012
Mean	0.022	0.026	0.008	0.036	0.017
Number of plants	135	96	58	198	139

Notes:

• Intermediate percentiles were left out because they follow a trend of higher to lower costs.

•Many plants answered only some of the questions. We used only plants reporting all variable and fixed costs. The average costs are the average costs for that percentile category only.

•Values are the unweighted costs, sum of costs per plants divided by the number of plants.

Source: Ollinger, Moore, and Chandran.

Table 2: Direct regulation, buyer requirements, and food safety technology have the greatest impact on the costs of complying with PR/HACCP. [1]

	----------slaughter----------			------processing--------	
Variables	Cattle	Hog	Chicken	Cooked[2]	Raw
Intercept	-0.002 (-0.13)	-0.033 (-2.03)	0.009 (0.58)	0.002 (0.10)	-0.037^{+} (-1.31)
Wages					
State_Wage	-0.001*** (-2.68)	0.001*** (4.21)	-0.0008 (-1.90)	-0.0010** (-2.38)	-0.0004^{+} (-1.41)
Private Actions					
Indirect					
Human Capital: Experience_QC	-0.009^{+} (-1.48)	-0.007^{+} (-1.33)	0.0008 (0.28)	-0.013^{+} (-1.45)	0.006 (1.21)
Physical Capital FS_Tech	0.042** (2.64)	0.046** (2.51)	0.014 (1.28)	0.038* (1.65)	0.056*** (3.99)
Direct					
Buyer	0.013** (2.28)	0.012** (2.19)	0.009* (1.67)	-0.0004 (-0.05)	0.007^{+} (1.48)
Process	-0.006 (-0.60)	-0.005 (-0.95)	-0.0001 (-0.02)	-0.010 (-1.20)	0.0002 (0.03)
Regulation Effects					
Indirect					
Employees	-0.0036 (-0.97)	-0.0049 (-0.75)	-0.008*** (-2.67)	-0.006 (-0.31)	-0.031*** (-2.50)
Multi	-0.002 (-0.27)	-0.011^{+} (-1.50)	0.0004 (0.06)	0.002 (0.25)	0.003 (0.51)
Cap_Lab	-0.00004 (-0.27)	-0.0002* (-1.90)	0.00002 (0.16)	0.000002 (0.01)	-0.00001 (-0.06)
Direct					
Plans_Sales	0.865^{+} (1.58)	-0.105 (0.13)	9.23*** (2.23)	6.97*** (5.31)	3.23*** (3.99)
Tasks_EMP	0.0002** (1.96)	0.0003*** (4.55)	-0.0003 (-0.77)	0.0002** (2.27)	0.00034*** (2.97)
Shar_HACCP_Tasks	0.018 (0.69)	-0.00008 (0.00)	0.005 (0.27)	0.029 (0.90)	0.015 (0.45)
PW_QC	0.012* (1.90)	0.012** (2.00)	-0.004 (-0.96)	0.017* (1.70)	0.014** (2.35)
R^2	0.36	0.50	0.16	0.28	0.39
Observations	81	82	64	191	109

Dependent variable is the cost of complying with PR/HACCP rule divided by plant sales.

1. t-statistics in parentheses. +, *, **, *** 80, 90, 95, and 99 percent levels of significance.

2. Includes other fully processed products that do not require cooking, such as pepperoni.

Table 3: The mean values of selected variables[1]

	----------Slaughter----------			--------Processing------	
Variables	Cattle	Hog	Chicken	Cooked[2]	Raw
Private Actions					
Indirect					
Human Capital: Experience_QC	0.27	0.27	0.33	0.35	0.35
Physical Capital: FS_Tech	0.50	0.48	0.61	0.56	0.55
Direct					
Buyer	0.43	0.41	0.83	0.57	0.58
Process	0.85	0.86	0.96	0.69	0.79
Regulation Effects					
Indirect					
Employees (in 1000s)	0.143	0.215	0.662	0.132	0.111
Direct					
Plans_Sales	0.0018	0.0024	0.0003	0.0012	0.0012
Tasks_EMP	86.89	88.12	11.67	39.57	44.89
Shar_HACCP_Tasks	0.42	0.44	0.51	0.39	0.39
PW_QC	0.147	0.149	0.380	0.179	0.183
Costs					
HACP_COST_SAL	0.0123	0.0179	0.0082	0.0250	0.0174

1. Due to disclosure restrictions, data do not include variables based mainly on Census data.

2. Includes other fully processed products that do not require cooking, such as pepperoni.

Table 4: Percent change in PR/HACCP costs as a share of sales with 10 percent changes in the value of selected regulation and private actions variables.[1]

	----------Slaughter----------			-------Processing------	
Variable	Cattle	Hog	Chicken	Cooked[2]	Raw Meat
Private Actions					
Indirect					
Human:					
Experience_QC	-1.97	-1.06	-	-1.82	-
Physical:					
FS_Tech	17.10	12.30	10.40	17.70	8.50
Direct					
Buyer	4.52	2.75	9.13	-	2.33
Process	-0.02	-0.02	-0.0003	-	-
Regulation					
Indirect					
Employees	-0.42	-0.59	-6.46	-2.00	-0.32
Direct					
Plans_Sales	1.30	-	3.40	3.34	2.23
Tasks_EMP	14.10	14.80	-	3.20	8.80
Shar_HACCP_Tasks	6.10	-0.20	3.10	4.50	3.40
PW_QC	1.40	1.00	-	1.21	1.47

1. Changes in the dummy variables (Buyer and Experience_QC) are based on a 10 percent change in the number of plants entering into contracts with buyers or having had a quality control program prior to PR/HACCP.

2. Includes other fully processed products that do not require cooking, such as pepperoni.

Table 5: Contribution to food safety costs at mean values.[1]

Type of Change	Cattle Slaughter	Hog Slaughter	Chicken Slaughter	Cooked[2]	Raw Meat
Wages					
State_Wage	-0.015	0.015	-0.012	-0.0135	-0.006
Private Actions					
Indirect					
Human Capital					
Experience_QC	-0.009	-0.007	0.0008	-0.013	0.006
Physical Capital					
FS_Tech	0.021	0.022	0.0085	0.021	0.031
Direct					
Buyer	0.013	0.012	0.009	-0.004	0.0070
Process	-0.006	-0.005	-0.0001	-0.010	0.0002
Regulation					
Indirect					
Employees	-0.00052	-0.0010	-0.005	-0.00079	-0.0034
Multi	-0.0002	-0.011	0.0004	0.002	0.003
Cap_Lab	-0.0004	-0.0002	0.0002	0.00002	-0.00001
Direct					
Plans_Sales	0.0016	-0.00025	0.0028	0.0084	0.0039
Tasks_EMP	0.0174	0.0264	-0.0035	0.0079	0.0153
Shar_HACCP_Tasks	0.0076	-0.000035	0.0025	0.0110	0.0059
PW_QC	0.0018	0.0018	-0.0015	0.0030	0.0026
Total Direct	0.0284	0.0279	0.0003	0.0303	0.0267

1. Experience_QC, Multi, Cap_Lab, and Process equal one. Other values equal their means.

2. Includes other fully processed products that do not require cooking, such as pepperoni.