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# The Food Safety Performance of Ground Beef Suppliers to the National School Lunch Program

Michael Ollinger, Joanne Guthrie, and John Bovay

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## Abstract

This report examines the food safety performance of suppliers of ground beef to the USDA National School Lunch Program (NSLP). Model results show that establishments that bid on contracts to supply NSLP displayed better food safety performance—in terms of fewer numbers of meat samples testing positive for *Salmonella spp*—than other establishments supplying ground beef to the commercial market. Results also show that the difference in food safety performance between the types of establishments may have narrowed after 2009. The report provides evidence that some establishments use information about their past food safety performance to decide whether to bid on contracts to supply NSLP.

**Keywords:** food safety, ground beef, *Salmonella spp*, National School Lunch Program, regulation, probit analyses

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## What Is the Issue?

The Agricultural Marketing Service (AMS) of the United States Department of Agriculture (USDA) bought $150 million worth of raw and cooked ground beef products in 2011 for the National School Lunch Program (NSLP). Schools purchased about one-third of this ground beef as raw product and two-thirds as precooked hamburger patties, Salisbury steaks, cooked ground beef, and other products.

The food safety of meals served in the Nation's schools concerns many Americans, especially those with children in school. Because ground beef is a staple of school menus and has suffered a number of product recalls in recent years, AMS gives the food safety of ground beef particular attention. AMS requires ground beef suppliers to adhere to strict tolerances for *Salmonella spp* and other potentially harmful pathogens. At the same time, AMS is obligated to select low-cost bidders that agree to meet its standards. Ground beef suppliers achieve food safety by investing in sanitation and cleaning. However, these food safety investments are costly and must be recouped through a higher bid price. AMS ground beef suppliers must, therefore, carefully evaluate their bid price relative to their food safety investments.

An article in *USA Today* in December 2009 and other later media reports stated that AMS's food safety standards for ground beef suppliers to NSLP were less stringent than those of major restaurant chains. AMS then strengthened its standards, but experts at the National Academy of Sciences asserted that the revised standards lacked sufficient scientific basis and had other shortcomings. Despite these concerns about ground beef safety and the system's incentive to bidders to underinvest in food safety, no economic analyses of the effectiveness of AMS standards have been published.

This report fills that void by examining economic incentives for suppliers of ground beef to NSLP to improve the food safety of their products. Ground beef suppliers' performance on tests for *Salmonella spp* is used as a measure of food safety. The results have implications for the food safety programs of AMS and USDA's Food Safety and Inspection Service (FSIS), which regulates ground beef sold in general commerce. The results are also relevant to fast food restaurants, grocery stores, and other buyers for the commercial market that require their suppliers to surpass FSIS standards.

ERS is a primary source of economic research and analysis from the U.S. Department of Agriculture, providing timely information on economic and policy issues related to agriculture, food, the environment, and rural America.

## What Did the Study Find?

Ground beef suppliers to NSLP must be low-cost bidders and also meet AMS's strict food safety standards. Producers of ground beef respond to these requirements by (1) seeking AMS approval to supply NSLP and bidding on contracts (active suppliers), (2) seeking AMS approval and *not* bidding on contracts (inactive suppliers), or (3) choosing not to gain approval and selling only in the commercial market. ERS researchers examined the food safety performance for all three categories. Gaining AMS approval to bid to supply NSLP is relatively low cost, but actually supplying ground beef to schools may be costly because AMS suppliers must meet strict food safety tolerances.

ERS researchers found that:

- The food safety performance of active AMS ground beef suppliers to NSLP exceeded the performance of inactive AMS and commercial market suppliers, suggesting that AMS standards encourage superior food safety performance. The data show that *Salmonella spp* contamination in ground beef tested by AMS was nearly absent.

- The food safety performance of inactive AMS ground beef suppliers was worse than that of all other ground beef suppliers on tests that were one-half to one-tenth the FSIS tolerance for *Salmonella Spp.* These relatively weak results imply that AMS's priority on low costs may encourage suppliers that invest less in food safety to seek AMS approval to supply NSLP. Nonetheless, inactive suppliers performed very well, on average, greatly exceeding the FSIS tolerance for *Salmonella spp.*

- The food safety performance of active AMS ground beef suppliers on products sold in the commercial market matched that of commercial suppliers and surpassed that of inactive AMS ground beef suppliers on standards that were one-half, one-fourth, and one-tenth the FSIS tolerance for *Salmonella spp.*

- Some evidence suggests that AMS suppliers consider their food safety performance prior to bidding on contracts to supply the NSLP and place bids only if they are confident their performance meets AMS food safety standards. AMS suppliers that do not bid on NSLP contracts sell their ground beef in the commercial market to other buyers.

## How Was the Study Conducted?

ERS researchers used probit regressions to estimate the effect of being a particular type of supplier (active and approved, inactive and approved, commercial supplier only) on the probability that the ground beef produced by the establishment exceeded the tolerance for *Salmonella spp* established by FSIS.

Data came from FSIS and AMS. The FSIS data included *Salmonella spp* test results, USDA administrative data, and Dun & Bradstreet information on firm characteristics. AMS data included *Salmonella spp* test results and contract bidding data.

# The Food Safety Performance of Ground Beef Suppliers to the National School Lunch Program

## Introduction

In 2009, public concern arose following widespread news reports questioning the food safety of ground beef supplied to the National School Lunch Program (NSLP) after initial investigative reports by Morrison, Eisler, and DeBarros in *USA Today.* Subsequently, U.S. Department of Agriculture's (USDA) Agricultural Marketing Service (AMS), which purchases ground beef for NSLP, strengthened its food safety standards (table 1). Both the new and existing standards were stricter than those required of all meat establishments by USDA's Food Safety and Inspection Service (FSIS), which regulates the safety of meat, poultry, and egg products sold to the general public. In addition to complying with Federal standards, some suppliers must meet food safety standards imposed by private purchasers, such as fast-food chains and grocery stores.

A committee of experts organized by the National Academy of Sciences (2010) to evaluate AMS food safety standards criticized the standards for lack of scientific basis, overuse of expert opinions, and other reasons. However, no economic analyses of the effectiveness of AMS standards have been publicly reported. This report aims to fill that void by examining economic incentives for suppliers of ground beef to NSLP to improve the food safety of their products. Specifically, we evaluate the effect of AMS standards on food safety performance as measured by the numbers of ground beef samples testing positive for *Salmonella spp* in an FSIS testing program.

The results have implications for both AMS and FSIS food safety programs. For example, if establishments that comply with the stricter AMS standards performed better than other establishments, it could be suggested that stronger FSIS standards could improve the food safety of ground beef supplied to the commercial market that is subject only to FSIS regulation. Better food safety performance by the establishments eligible to supply NSLP (AMS suppliers) than by non-suppliers that are not subject to any standards (besides those of FSIS) would suggest that more stringent standards can be effective at ensuring food safety. Such a finding would have implications beyond AMS because private industry groups, too, have developed and promoted their own standards—at least as restrictive as those of AMS—to help suppliers meet industry objectives.

ERS researchers examined a model in which food safety performance was determined by inputs of labor, processing technology, and AMS standards. It was expected that the food safety performance of AMS suppliers would surpass the food safety performance of suppliers that sold only in the commercial market (FSIS-only suppliers).

This report first discusses the uses of ground beef in schools and AMS's purchasing program for NSLP. Then, the report gives a sketch of FSIS regulations and presents an empirical model that is tested with AMS and FSIS administrative data. The results and conclusion follow.

Table 1

**Key differences in food safety product testing and process controls between FSIS regulations and AMS standards**

| Process control | AMS tolerance | AMS testing frequency | FSIS tolerance | FSIS testing frequency |
|---|---|---|---|---|
| **Microbial testing** | | | | |
| *E coli* O157:H7 | 0.0 | 2,000 pounds | 0.0 | Random: Less than once per year |
| *Salmonella spp* | 0.0 | 10,000 pounds | 0.113 | Random: Usually, less than once per year |
| Standard plate count | 100,000/gram | 10,000 pounds | No requirement | No requirement |
| *Staphylococcus aureus*[1] | 500/gram | 10,000 pounds | No requirement | No requirement |
| Generic *E. coli* | 500/gram | 10,000 pounds | Done at establishment | Schedule in Ollinger and Mueller (2003) |
| Total coliforms | 1,000/gram | 10,000 pounds | No requirement | No requirement |
| **Slaughter operation** | **AMS Standard** | | **FSIS Standard** | |
| Removal of major lymph glands, thymus gland, and cartilage | Required | | No requirement | |
| Removal of white fibrous materials, e.g., shoulder and elbow tendons | Required | | No requirement | |
| Removal of yellow elastin | Required | | No requirement | |
| Removal of spinal cord material | Required | | Required | |
| Use of meat from non-ambulatory animals | Not allowed | | Permitted with veterinarian consent | |
| Processing interventions to control pathogens | At least two. One must be a critical control point | | No requirement | |
| Routine testing of *E. coli* types including *E. coli* O157:H7 | Several E. coli types | | Generic *E. coli* only | |

[1]Samples were submitted to a laboratory for testing. If the upper specification limit was exceeded, the production lot was not allowed to be delivered to U.S. Department of Agriculture (USDA).

Source: USDA, Food Safety and Inspection Service (FSIS) pathogen test results were based on sampling and testing conducted at FSIS. USDA, Agricultural Marketing Service (AMS) pathogen test results were based on samples taken by the establishment operator and sent by the operator to an independent testing company that tested the sample.

## Ground Beef Purchases and Suppliers

AMS purchases raw ground beef for school districts as part of the USDA commodity foods program. All AMS ground beef purchases come from establishments that satisfy AMS requirements, have not incurred FSIS enforcement action, and have an active Federal Grant of Inspection. Establishments meeting these criteria can petition AMS for approval to be a ground beef supplier to NSLP. Once approved, these AMS suppliers can bid on any contract to supply ground beef for a school district anywhere in the country through a competitive process in which AMS solicits bids from all AMS-approved suppliers. Establishments respond with offer prices that include shipping costs. If prices are too high, AMS is not obligated to buy any meat. Otherwise, AMS purchases enough meat to satisfy demand by selecting the lowest cost bids.

School districts also purchase ground beef products from wholesalers. Overall, school districts and AMS spent around $300 million on raw and cooked ground beef products in 2011 according to the USDA's School Purchase Study-III (USDA, FNS, 2012). AMS purchased about half of this meat, and school districts purchased about half.

About one-third of all ground beef came as raw product, and the other two-thirds came as a finished product or was processed into a finished product by a contractor working for the school district. Ground beef products include precooked hamburger patties, Salisbury steaks, cooked ground beef, and other products.

Suppliers of ground beef to NSLP must maintain a meat processing system that meets AMS standards and satisfies AMS audits. The current standards and auditing requirements are described in AMS's *Technical Requirements Schedule – GB – 2013 for USDA Purchases of Ground Beef Items, Frozen* (USDA, AMS, 2013). The first *TRS* for ground beef was promulgated in 2003 (USDA, AMS, 2003). More stringent standards impose additional costs, which suppliers' bid prices must cover. These higher costs may be offset by better capacity and resource utilization or by better use of existing marketing resources.

Regardless of whether a price premium or an offsetting cost reduction is available, AMS suppliers must be compensated for the greater risks associated with meeting more stringent standards. If neither price premiums nor lower production or marketing costs were available, suppliers would sell their ground beef to other buyers and to wholesalers and would not undergo the additional process controls imposed on AMS suppliers.

We have data on 887 establishments that FSIS tested for *Salmonella spp* over the study period (2006–2012). AMS approved only 54 of these establishments to supply NSLP. The 833 ground beef suppliers not selling to NSLP (commercial suppliers) may have more lucrative contracts with large restaurants and other large commercial customers, or they may sell to a wholesaler on the spot market. Establishments approved to supply NSLP may also sell ground beef in commercial markets.

Suppliers selling to large commercial customers must adhere to those companies' requirements, which may exceed FSIS standards. Establishments selling ground beef to wholesalers must adhere to FSIS standards but no other food safety requirements. The sellers to wholesalers may have lower processing costs because they do not have to perform additional food safety tasks, but wholesalers do not offer the price premium or the sales that can be guaranteed by large buyers under purchasing agreements.

## Ground Beef Suppliers and Food Safety

Ground beef processing involves several steps. First, ground beef processors purchase boneless beef from slaughter plants or obtain boneless beef trim from their own slaughter operations. Next, they blend trim meat from many cattle to get an optimal mix of lean meat, fat, and texture. Then, the ground beef processors grind the mixture of boneless beef into ground beef with a specified texture and fat content that is packaged and shipped to buyers. Processors can help ensure food safety by buying meat from a reliable source and by cleaning and sanitizing contact surfaces and following operating procedures that control pathogens.

FSIS food safety regulations apply to all cattle slaughter and processing establishments selling products in interstate commerce. AMS establishes more stringent standards that all suppliers of ground beef to NSLP must satisfy. These standards include a requirement to purchase boneless beef from an establishment that adheres to AMS standards. AMS standards are not regulations. Rather, they are similar to the purchasing requirements demanded by private purchasers such as fast food restaurants and grocery stores. Processors can choose to comply with commercial buyers' or AMS standards, or they can choose not to comply with any additional standards and sell to wholesalers. However, all processors must comply with FSIS regulations.

# FSIS Food Safety Regulation and AMS Standards

All ground beef producers face three types of FSIS food safety oversight: product recalls, process controls, and performance standards. They are also subject to testing for *E. coli* O157:H7 and other pathogens.

A product recall is an ex post safety measure under which establishments that supplied products that pose a threat to public health recall their products. A recall may result from an FSIS investigation, or it may be initiated independently by the supplier, without Government intervention. The direct costs of product recalls are the costs of (1) communicating with vendors, (2) reimbursing vendors for lost sales and replacement goods, (3) cooking or otherwise reconditioning some recalled products for use as rendered product or other lower value items, (4) transporting all materials either for reconditioning or disposal, and (5) disposing of some recalled products as waste. Although these direct costs of a product recall can be high, the indirect costs of a poor reputation for food safety can be greater.

If an establishment is associated with a product recall, the results can be lost sales, lower prices as a means of attracting wary consumers, and, in some cases, bankruptcy. Thomsen et al. (2006) find that sales of branded frankfurter products declined more than 20 percent after product recalls. Some studies (Piggott and Marsh, 2004; Marsh et al., 2004) have determined that adverse meat and poultry food safety events led to temporary declines in meat and poultry consumption. Finally, Thomsen and McKenzie (2001) and Salin and Hooker (2001) found that firms suffered significant declines in stock prices after recalls of meat or poultry.

Starbird and Amanor-Boadu (2006) argued that traceability and inspection generate a strong incentive to provide food safety. Traceability is the ability to identify the supply chain of a product. It enhances food safety because, if a food is linked to a public health threat such as a foodborne illness or outbreak, then the source is known and the producer can be managed by regulators and may be targeted by liability lawsuits. Traceability also helps pinpoint the location of products so they can be removed from the marketplace.

Ground beef sold to NSLP can be easily traced. AMS suppliers ship ground beef to State agencies that store commodities in warehouses from which they are later shipped to school districts. There is a direct link between the AMS supplier and the State but not necessarily between the supplier and the school district. Traceability between the school and the AMS supplier depends on the number of ground beef suppliers to the State and whether the State ships ground beef from more than one supplier to the school district. If all ground beef comes from one supplier, then traceability is nearly certain. However, if the State ships ground beef from many suppliers, then traceability may not be possible in the absence of accurate inventory recordkeeping and labeling. In practice, relatively few suppliers ship to any given State because AMS contract bid prices include shipping costs, giving local producers a cost advantage. Combining the likelihood of traceability with regulatory oversight by FSIS and AMS's additional requirements gives AMS suppliers a strong incentive to supply ground beef to NSLP that meets a high food safety performance standard.

## FSIS Process Controls and Performance Standards

FSIS and its antecedent USDA agencies have regulated meat food safety since Congress mandated in 1906 that meat processors follow hygienic practices. Congress greatly expanded USDA's authority for meat safety under the Wholesome Meat Act (WMA) and the subsequent regulations that

established many process controls. These process controls include Sanitation Standard Operating Procedures (SSOPs), which require establishments to perform (1) knife cleaning and other food safety tasks during operations (operating tasks), (2) equipment disassembly and cleaning and other tasks at the beginning or end of a shift (pre-operating tasks), and (3) a number of additional tasks related to facilities maintenance; cooking times and temperatures; and preparation of fermented, smoked, and other processed products (see Ollinger and Mueller (2003) for further discussion).

FSIS added a new dimension to its regulatory authority when it issued the Pathogen Reduction/ Hazard Analysis and Critical Control Point (PR/HACCP) rule on July 25, 1996. This regulation required meat and poultry slaughter and processing establishments to develop and implement HACCP process control programs for each product. FSIS verifies the adequacy of all HACCP plans.

FSIS inspectors monitor the performance of all SSOPs and tasks specified in the HACCP plan. If FSIS detects that establishments fail to perform these tasks, FSIS officials consult with establishment managers to improve performance and assess penalties if the performance failure persists.

FSIS mandated performance standards for the first time when it promulgated the PR/HACCP rule. One performance standard requires slaughter establishments to test animal carcasses for generic *E. coli,* an indicator organism that reveals the adequacy of process controls. FSIS also requires slaughter establishments and ground meat and ground poultry establishments to comply with *Salmonella spp* and *E. coli* standards. Under this FSIS *Salmonella spp* standard, FSIS randomly selects establishments for testing from a pool of establishments that are not undergoing testing and evaluates their performance on *Salmonella spp* tests. Ground beef establishments must have no more than 5 of 53 samples test positive for *Salmonella spp* over a test period that depends on the frequency of production runs.

If an establishment meets one-half the tolerance (that is, has no more than 2 of 53 samples test positive), then it is considered to have sustained good control and is placed in category 1. Establishments in category 1 are tested no more than once per year but at least once every 2 years. Establishments with a performance level of one-half the tolerance to just meeting the tolerance are placed in category 2, and establishments that exceed the tolerance are placed in category 3. Establishments in categories 2 and 3 are tested more often than establishments in category 1. Establishments in category 3 are generally tested more often than those in category 2, but establishments in both categories are considered on a case-by-case basis.

Aside from the PR/HACCP rule, FSIS prohibits detectable levels of *E. coli* STECs (shiga toxigenic *E. coli,* including O157:H7 and non-O157 STEC serotypes) in ground beef and *Listeria monocytogenes* and *Salmonella spp* in ready-to-eat products, such as lunch meat.

## Agricultural Marketing Service Standards

AMS requires its suppliers to adhere to product quality standards, such as fat and lean meat content, and food safety standards.[1] Young (2005) argues that stricter food safety standards for food consumed by children are necessary because children are more vulnerable to foodborne illnesses than healthy adults are.

[1]Current AMS food safety standards are given in *Technical Requirements Schedule – GB – 2013 for USDA Purchases of Ground Beef Items, Frozen* (USDA, AMS, 2013) and include process controls and pathogen tests that are in addition to those required by FSIS.

Establishments gain AMS approval to supply ground beef to NSLP by submitting a technical proposal documenting their production processes and how they handle each performance requirement listed within AMS's TRS. They must also pass an audit proving that all AMS manufacturing, packaging, sampling, and testing requirements have been met.

All products shipped by establishments that contract with AMS to supply ground beef to NSLP must meet all AMS standards. If products fail to meet AMS processing standards or tolerances for harmful pathogens, then AMS rejects the product and prohibits the supplier to sell it to other USDA food programs. Persistent failures may prompt AMS to disqualify the establishment as an AMS supplier.

AMS requirements became more demanding than those mandated by FSIS when, in 2003, AMS established a zero-tolerance standard for *Salmonella spp.* AMS also issued process controls that require suppliers to document their food safety procedures and, like FSIS, established a zero-tolerance standard for *E. coli* O157:H7.

The first major revision of AMS standards occurred in 2007 when AMS required its suppliers to use boneless beef inputs only from AMS-approved slaughter establishments; perform additional process controls; and comply with tolerance standards for generic *E. coli*, standard plate counts, and total coliforms. Like generic *E. coli*, coliforms are indicator organisms. AMS further updated its standards with the 2010 *Technical Requirements Schedule* for USDA purchases of ground beef items and the 2010 *Statement of Work (*USDA, AMS, 2010*)*. The new standards included a tolerance for *Staphylococcus aureus* and the adoption of testing protocols similar to those used by fast food restaurants and other large meat buyers (NAS, 2010).

Table 1 summarizes the key differences between AMS standards and FSIS regulations. Note that while AMS suppliers must comply with all FSIS regulations and stricter AMS standards for pathogen controls, they must also comply with stricter AMS standards for animal handling and other animal welfare practices than those FSIS requires.

It is also important to note the distinction in the underlying motivations for *Salmonella spp* testing by AMS and FSIS. AMS uses *Salmonella spp* test results as a tool to enforce its zero-tolerance standard for *Salmonella spp* and conducts testing for each 10,000-pound lot. If a lot does not meet AMS standards, it cannot be sold to other USDA food programs. In contrast to AMS, FSIS uses *Salmonella spp* testing to gauge whether establishments have adopted proper food safety process controls, making it necessary only periodically to test an establishment's ground beef. Additionally, FSIS permits establishments to continue production even if they fail to meet the performance standard, if they are regaining food safety process control. Both FSIS and AMS prohibit the sale of ground beef with detectable levels of STECs (shiga toxigenic *E. coli,* including O157:H7 and non-O157 STEC serotypes).

## AMS Contracting and Food Safety

AMS is required by law to take the lowest price bid to supply ground beef to NSLP. This low-price mandate gives establishments an incentive to bid as low a price as possible while still earning a profit and fulfilling the contract requirements regarding food safety and other conditions.

Food safety is costly to provide because it requires strict diligence. It is also not easily measured, partly because the tests are specific while types of contaminants and food safety risks are many. Often, food safety quality is not known until consumption, and even then it is uncertain. This difficulty in measuring food safety—combined with AMS's policy on accepting the lowest bid price on its contracts—gives AMS suppliers an incentive to lower their costs by reducing their food safety effort.

Akerlof (1970) demonstrated how lower quality suppliers can drive out higher quality suppliers in markets, such as the used car market, in which quality is only truly revealed through use and sellers have better information than buyers about quality. This market phenomenon, called *adverse selection*, has also been discussed in other markets, such as bank credit (Stiglitz and Weiss, 1981) and insurance (Rothschild and Stiglitz, 1976).

However, there are economic forces in the market for ground beef sold to NSLP that reduce the possibility of adverse selection. First, AMS enforces strict pathogen limits on ground beef supplied to NSLP, with penalties for product failures. Costs of failure to meet AMS standards include the costs of preparing ground beef according to AMS instructions, testing, and disposing of the rejected products. For small establishments, these costs may be particularly high if sales to NSLP constitute a large share of their total sales. Second, as discussed earlier, traceability provides greater assurance of food safety than inspection alone if the cost of being discovered is high (Starbird and Amanor-Boadu, 2006).

As mentioned earlier, an NSLP supplier linked to a recalled product faces severe costs. First, it must incur the costs of recalling and reconditioning the product and the possibility of liability payments to affected students and their families. Second, the supplier could be deemed ineligible to bid on future NSLP contracts and may face repercussions in the commercial market. In some cases, a recall of product sold to one buyer may trigger cancelled sales to other buyers. For example, the *Chicago Tribune* (1997) reported that Burger King cancelled a contract with Hudson Beef after Hudson Beef recalled millions of pounds of ground beef. Hudson Beef eventually sold its operations in 1997 and exited the industry. More recently, the *Los Angeles Times* (Pierson, 2014) reported that FSIS temporarily forced the closure of Central Valley Meats because of animal abuse and other conditions, causing AMS to cancel NSLP purchases from that establishment.

# Economic Framework

Economists have examined the cost of food safety regulation (Antle, 2000; Ollinger and Mueller, 2003; Ollinger and Moore, 2009); the effectiveness of food safety regulations in controlling *Salmonella spp* (Ollinger and Moore, 2008); and the effectiveness of food safety technologies in controlling *Salmonella spp* (Muth et al., 2007; Ollinger and Moore, 2008). Muth et al. (2012) considered the impact of financial performance on *Salmonella spp* tests. This report most closely follows the models of Muth et al. (2007) and Ollinger and Moore (2008).

Food safety was modeled in a production framework in which food safety (*FS*) was affected by inputs of labor devoted to food safety (*L*), the food safety of meat inputs (*M*), capital (*K*), technologies (*t*), establishment characteristics (*Z*), and NSLP food safety precautions (*S*). NSLP food safety precautions included the effect of AMS processing standards and food safety testing.

(1) FS = S(**L,** M, K, **t, Z**, P, S)

AMS required all establishments that sold boneless beef as inputs to AMS suppliers to be in compliance with FSIS food safety regulations and be approved by AMS as a boneless beef producer for AMS suppliers. Thus, *M* could be dropped because the food safety of raw meat inputs had to meet a uniformly high standard that did not vary across establishments. The empirical model could be written as:

$$(2)\quad FS = \alpha_0 + \sum_i \beta_i L_i + \delta K + \sum_j \rho_j t_j + \sum_k \lambda_k Z_k + \delta P + \omega S + \xi$$

We used results from the FSIS *Salmonella spp* testing program as a measure of food safety performance. Under the FSIS *Salmonella spp* testing program, an establishment had to meet a tolerance of no more than 5 of 53 samples testing positive for *Salmonella spp.*[2] This criterion has already been briefly described.

An establishment undergoing FSIS *Salmonella spp* testing either passes the test or remains under constant FSIS review. Because all establishments must meet the FSIS standard, AMS suppliers may or may not have performed better than other suppliers on a measure of food safety equal to the FSIS tolerance. However, because AMS suppliers had to meet stricter standards than those required of other suppliers, they should have had superior performance on more stringent *Salmonella spp* tests. Thus, we evaluated performance at a tolerance equal to one-half the tolerance established by FSIS. In this case, FS equaled one if an establishment's performance on *Salmonella spp* testing was less than or equal to one-half the FSIS tolerance and zero otherwise. The choice of one-half the FSIS tolerance as a measure of performance on *Salmonella spp* tests was arbitrary. Thus, we considered two stricter levels of stringency—one-fourth, and one-tenth the FSIS *Salmonella spp* tolerances—to evaluate the robustness of the results. Equation 2 was then rewritten as a binary choice model, given in equation 3:

$$(3)\quad FS_{ey} = \alpha_0 + \sum_i \beta_i L_{iey} + \delta K_{ey} + \sum_j \rho_j t_{jey} + \sum_k \lambda_k Z_{key} + \delta P + \omega S_{ey} + \xi_{ey}$$

[2]Our observations do not necessarily consist of entire sets of 53 samples. For example, FSIS may test only 20 samples from a given establishment in a year, because they started sampling near the end of the year. Or, if at least 6 samples test positive before 53 samples are taken, FSIS will not complete the sample set.

where

$$FS_{ey} = 1 \; if \; FS^{*}_{ey} \leq \text{tolerance}$$

$$FS_{ey} = 0 \; if \; FS^{*}_{ey} > \text{tolerance}$$

Detailed definitions of the variables are provided in table 2. The subscripts *e* and *y* represent observations at the establishment year level. Each of the three levels of stringency is examined separately in independent regressions. Below, the other variables are described.

Labor devoted to food safety (*L*) is reflected in the performance on SSOPs and the tasks needed to implement HACCP process control programs. SSOPs and HACCP tasks are monitored by FSIS inspectors who record whether a task was performed and in compliance with FSIS standards. A high number of noncompliances implies less effort devoted to food safety process control, and a low number of noncompliances implies more effort devoted to food safety process control. FSIS inspectors do have some discretion over their assessment of establishment performance of SSOPs and HACCP tasks, suggesting that our measure included inspector error.

There are two types of SSOPs—pre-operational and operational SSOP tasks. Pre-operational SSOP tasks are those at the end or beginning of the production day; operational tasks are those duties performed during production. HACCP tasks are process-control tasks that are specified in the establishment's HACCP plan. Ollinger and Moore (2008) find that better performance of SSOPs and HACCP tasks improved performance on *Salmonella spp* tests.

Establishment size is used as a proxy for capital (*K*). Muth et al. (2007) and Ollinger and Moore (2008) find that establishment size positively affects food safety performance in the cattle, hog, and chicken slaughter industries.

Establishment technology (*t*) is reflected in the vintage of the establishment (age), whether it is vertically integrated, and whether the establishment is owned by a firm that owns other establishments. Muth et al. (2007) find that a higher establishment age is correlated with reduced *Salmonella spp* levels in hog and chicken slaughter and further-processing establishments. Moreover, Terry Lutz of AMS indicated in a 2014 interview that "younger" establishments (i.e., establishments that were more recently established and with a less experienced workforce) often have more difficulty complying with AMS pathogen-testing standards. We accounted for vertical integration (whether an establishment slaughters cattle) because these establishments have greater control over pathogen contamination.

Firms can influence decisions at the establishment level and may benefit from economies of scale in applying the same management practices across establishments, so an important characteristic (*Z*) is whether the establishment is owned by a firm that owns other establishments. The period after 2009 (*P*) is distinguished from the earlier period because AMS introduced more stringent food safety standards at the end of 2009 that took effect in 2010. Finally, AMS suppliers (*S*) are accounted for because more stringent AMS standards should lead to superior food safety performance. The term $\xi_{ey}$ in equation 3 is a stochastic error term.

Table 2

**Mean values of selected economic variables of AMS supplier and commercial supplier**

| Variable | Variable label | Definition | AMS supplier | Commercial supplier |
|---|---|---|---|---|
| FS0 | Just meets *Salmonella spp* standard | One if share of meat samples testing positive for *Salmonella spp* is less than or equal to FSIS standard, zero otherwise | 0.946 | 0.957 |
| FS1 | One-half *Salmonella spp* standard | One if share of samples testing positive for *Salmonella spp* is less than or equal to one-half FSIS standard, zero otherwise | 0.775*** | 0.870 |
| FS2 | One-fourth *Salmonella spp* standard | One if share of samples testing positive for *Salmonella spp* is less than or equal to one-fourth FSIS standard, zero otherwise | 0.586*** | 0.771 |
| FS3 | One-tenth *Salmonella spp* standard | One if share of samples testing positive for *Salmonella spp* is less than or equal to one-tenth FSIS standard, zero otherwise | 0.387*** | 0.590 |
| $L_1$ | HACCP_PASS | One if establishment has no noncompliance reports (deficiencies) for HACCP tasks, zero otherwise | 0.595 | 0.570 |
| $L_2$ | SSOP_P_PASS | One if establishment has no deficiencies for pre-operation SSOPs, zero otherwise | 0.423 | 0.481 |
| $L_3$ | SSOP_O_PASS | One if establishment has no deficiencies for operational SSOPs, zero otherwise | 0.450*** | 0.703 |
| K | Employees | Employees per establishment | 294*** | 118 |
| $t_1$ | Establishment age | Current year minus year meat grant was issued | 19.0*** | 30.0 |
| $t_2$ | Slaughters cattle | One if establishment slaughters cattle, zero otherwise | 0.369*** | 0.122 |
| $t_3$ | Does further processing | One if establishment further processes some meat, zero otherwise | 0.288 | 0.330 |
| Z | Multi-establishment firm | One if establishment is part of a multi-establishment firm, zero otherwise | 0.081 | 0.122 |
| P | Post_2009 | One if year is after 2009, zero otherwise | 0.495*** | 0.310 |
| S | AMS supplier | One if AMS supplier to NSLP and zero otherwise | 1.00 | 0.00 |
| | Observations | | 111 | 1,597 |

Note: *, **, *** indicate that the difference in mean values between the two columns are statistically significant at the 0.10, 0.05, and 0.01 levels, respectively.

U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS) suppliers were approved by AMS to supply the National School Lunch Program (NSLP) with ground beef and also sold ground beef in commercial markets; commercial suppliers (USDA, Food Safety and Inspection Service (FSIS)-only establishments) sold ground beef only to buyers in commercial markets and were not approved to sell ground beef to NSLP. AMS suppliers and commercial suppliers underwent testing for *Salmonella spp* by FSIS for products to be sold in the commercial market. Both groups were held to the same standards as those discussed under FSIS regulation. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedure.

Source: USDA, Economic Research Service estimates based on data provided by FSIS.

# Data

The data include observations on all establishments producing ground beef whose products were tested for *Salmonella spp* by FSIS over 2006–2012. After deleting observations with missing values, there were 1,708 observations, 111 of which corresponded to establishments approved by AMS to supply NSLP and 1,597 of which corresponded to establishments that supplied only commercial markets. There were around 850 establishments, so the average establishment had 2 observations over the study period.

SSOP and HACCP compliance data and establishment characteristics came from FSIS administrative data and were available for all establishments inspected by FSIS in all years. The FSIS administrative data include the types and numbers of animals slaughtered, estimates of ground beef production, name and address information, and the date each establishment began operation. *Salmonella spp* test results came from FSIS and AMS. The FSIS data were available from the pool of randomly selected establishments that FSIS monitored over the course of a year. The frequency of testing depended on establishments' history of performance on *Salmonella spp* tests, as described previously. AMS *Salmonella spp* data were available for all active AMS suppliers that shipped ground beef to school districts participating in NSLP during the year. No AMS *Salmonella spp* data existed for inactive AMS suppliers and establishments that produce ground beef and sell it in the commercial market (FSIS-only establishments).

Dun & Bradstreet data were used to identify the number of employees at the establishment level, business activities at the establishment, and whether the establishment was part of a firm that owned more than one establishment. The data also included sales, a subsidiary indicator, a manufacturing indicator, a small business indicator, a public/private indicator, square footage of the establishment, major industry category, line of business, a primary activity code, and some financial variables.

Data from the AMS Web site were used to identify the establishments approved to supply NSLP and those that bid on contracts to supply NSLP. The AMS Web site also gave information about each bid, such as product type, quantity of meat supplied, and price.

## Estimation Procedures

The data are pooled, meaning they include temporal and cross-sectional components. Pooling makes it necessary to consider possible autocorrelation errors and heteroskedasticity. Beck et al. (1998) obtained accurate standard errors using duration dependence techniques for pooled data with a binary dependent variable that extended over 30 periods and had little or no change in the dependent variable. Our data were also panel data with a binary dependent variable, but the average duration of the temporal component was less than two periods, making a duration dependence model inappropriate.

Instead, a binary probit regression was used. We chose a binary probit over an ordered probit because it is only necessary to show that AMS-approved establishments have better food safety performance relative to other establishments. We evaluate the robustness of our results by considering three tolerances that are more stringent than that mandated by FSIS: one-half, one-fourth, and one-tenth the FSIS tolerance.

Beck et al. (1998) showed that autocorrelation cannot be detected in probit models. In the absence of other tools to detect autocorrelation, we examined our model with a Wooldridge test (Wooldridge, 2002, pp. 282-283) for autocorrelation in linear regression models. This test was not designed for our limited dependent variable data, but the results could still be used to indicate strong autocorrelation. The Wooldridge test rejected autocorrelation at the 99-percent level for all models in which the dependent variable equaled one-fourth or one-tenth the FSIS tolerance for *Salmonella spp* and at the 95-percent level for the model in which the dependent variable equaled one-half the FSIS *Salmonella spp* tolerance.

The results of the Wooldridge test and the short duration of the data suggest that autocorrelation is unlikely. Nevertheless, a Huber sandwich was used to adjust for autocorrelation. A Huber sandwich adjusts for most of the error in the standard error if there is autocorrelation and does not affect results if there is no autocorrelation (Beck and Katz, 1997).

We also tested our model for multiplicative heteroskedasticity in establishment size since establishment size varies substantially across establishments. A log-likelihood test did not reject the null hypothesis that the model was homoskedastic in size; thus, the model was not adjusted for heteroskedasticity.

Marginal effects indicate the percentage change in the dependent variable of a regression due to a change in an independent variable. The coefficients on a variable in a linear regression (e.g., ordinary least squares) gave the marginal effects of changes in that variable (i.e., if the coefficient was 0.5, then a 10-percent change led to a 5-percent change in the outcome).

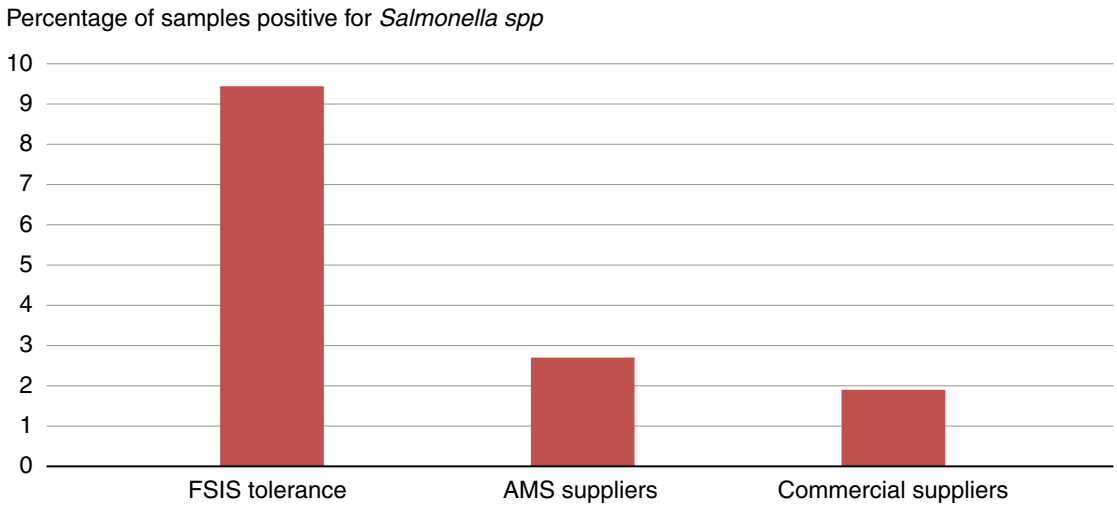
For nonlinear regressions, such as probit regressions, the coefficient on the regression cannot be used for determining marginal effects. Fortunately, there is a transformation that gives a marginal-effects parameter (Greene, 1990, p. 704). All values reported in our tables of regression results are given in terms of marginal effects.

# Results

This section proceeds as follows. First, we empirically examine the model outlined in equation 3 using FSIS *Salmonella spp* testing data. These data represent the food safety of ground beef sold in the commercial market and not necessarily ground beef sold to NSLP. Then, we revise the regression model represented by equation 3 to include separately active and inactive AMS suppliers. Both groups had been approved to bid on AMS contracts. However, active AMS suppliers bid on contracts to sell ground beef to NSLP, whereas inactive AMS suppliers did not bid on contracts to sell ground beef to NSLP. The reference group in all cases was FSIS-only establishments, which were establishments that supplied ground beef only to commercial markets and never to NSLP.

Most active AMS suppliers and all inactive AMS suppliers and FSIS-only establishments sell products in the commercial market. FSIS conducts *Salmonella spp* testing of these products that are sold in the commercial market. Figure 1 shows that all plants easily met the FSIS tolerance for the percentage of samples testing positive for *Salmonella spp*. It also indicates that the ground beef sold by AMS suppliers (aggregating both active and inactive suppliers) to the commercial market was more likely to test positive for *Salmonella spp* than ground beef sold by FSIS-only suppliers. The summary statistics (see table 2) show that, in aggregate, AMS suppliers and FSIS-only suppliers were approximately as likely to meet the FSIS tolerance standard for Salmonella spp. However, AMS suppliers in aggregate were less likely than FSIS-only establishments to have met the FSIS *Salmonella spp* tolerance or a tolerance equal to one-half, one-fourth, or one-tenth the FSIS *Salmonella spp* tolerance. As discussed below, the ground beef supplied to NSLP has significantly less *Salmonella spp* contamination than the ground beef sold on the general commercial market. Table 2 also indicates that AMS suppliers (1) were larger and had more recently obtained a Federal Grant of Inspection than FSIS-only establishments (as indicated by the "estab-

Figure 1
**In products sold in commercial markets, AMS suppliers had more samples test positive for *Salmonella spp* than did commercial suppliers**




Note: Under the FSIS Salmonella spp standard, ground beef establishments must have no more than 5 of 53 samples test positive for Salmonella (9.4 percent) over a test period that depends on the frequency of production runs. The difference in *Salmonella spp* levels for U.S. Department of Agriculture (USDA) Agricultural Marketing Service (AMS) suppliers and commercial suppliers is statistically significant at the 0.01 level. "AMS suppliers" includes both active (bidding on contracts) and inactive suppliers. Commercial suppliers supply ground beef only to the commercial market.
Source: USDA, Economic Research Service estimates based on *Salmonella spp* data from USDA, Food Safety and Inspection Service (FSIS).

lishment age" variable), (2) were more likely to be a slaughter establishment and less likely to further process meat than FSIS-only establishments, and (3) had worse compliance with SSOPs but better compliance with HACCP tasks than did FSIS-only establishments.

Table 3 shows the estimated effects of model parameters on performance by establishments on FSIS *Salmonella spp* testing of products sold in the commercial markets. Measures of performance are whether the establishments met one-half, one-fourth, or one-tenth of the FSIS *Salmonella spp* tolerance. Chi-square statistics (in the bottom row of the table) show that all regression models were statistically significant, and multiplicative heteroskedasticity was rejected in all cases. Of particular interest are the results for AMS suppliers to NSLP. Table 3 shows that AMS suppliers performed significantly worse than did FSIS-only establishments on *Salmonella spp* tests with standards that were one-half, one-fourth, and one-tenth the FSIS tolerance. Establishment groups performed equally as well on tests with standards equal to the FSIS tolerance. The interaction term *AMS suppliers Post_2009* was positive in all cases, suggesting a narrowing of differences on *Salmonella spp* test results after 2009.

Other results indicate that (1) larger establishments—as measured by the number of employees—were likely to perform worse on *Salmonella spp* tests, (2) older establishments were likely to perform better on *Salmonella spp* tests, and (3) compliance with HACCP tasks and SSOPs was correlated with good performance on *Salmonella spp* tests. (The coefficients on compliance with HACCP tasks and SSOPs were significant in six of nine cases.) The other variables did not have significant effects on *Salmonella spp* test performance. These results are consistent with previous research showing that HACCP tasks and SSOPs and establishment age positively affect food safety performance. Previous research has shown no impact of establishment size on the food safety performance of ground beef producers.

A number of other establishment characteristics were included in preliminary regressions but were not significant and were dropped from the regressions reported. These characteristics included whether the AMS supplier was approved to supply NSLP in the previous year.[3] Other variables, such as pounds of ground beef produced and the establishment's square footage, were also examined as potential measures of establishment size. We used number of employees as the measure of establishment size because the data for this variable appeared to be of better quality than for other possible measures. All size variables yielded similar results.

The regression results indicate that AMS suppliers performed slightly worse on *Salmonella spp* tests than did other establishments. This poor performance was consistent with adverse selection (Akerlof, 1970; Stiglitz and Weiss, 1981; Rothschild and Stiglitz, 1976). However, it seems implausible that AMS would establish a zero-tolerance standard for *Salmonella spp*, require testing of each lot of ground beef shipped to NSLP, and then purchase ground beef that did not comply with its standards. Therefore, we investigated further.

## Food Safety Test Performance of Active and Inactive AMS Suppliers in General Commerce

AMS permits establishments to bid on NSLP contracts if they pass an audit and meet FSIS standards. However, AMS suppliers must still comply with all AMS food safety standards on ground

[3]Terry Lutz of AMS suggested using this variable because of his experience with recently approved establishments failing to meet AMS standards.

Table 3
**Marginal effects of food safety performance of AMS suppliers on ground beef sold in the commercial market**

| Variable | (1) One-half tolerance for *Salmonella spp* | (2) One-fourth tolerance for *Salmonella spp* | (3) One-tenth tolerance for *Salmonella spp* |
|---|---|---|---|
| HACCP_PASS | 0.047*** (0.017) | 0.034 (0.020) | 0.066** (0.026) |
| SSOP_P_PASS | 0.047*** (0.017) | 0.069*** (0.022) | 0.046* (0.027) |
| SSOP_O_PASS | 0.011 (0.018) | 0.031 (0.026) | 0.063** (0.029) |
| Log (establishment employees) | -0.027*** (0.006) | -0.037*** (0.009) | -0.061*** (0.011) |
| Log (establishment age) | 0.023** (0.009) | 0.027** (0.012) | 0.039*** (0.015) |
| Slaughters cattle | 0.029 (0.029) | 0.017 (0.040) | 0.013 (0.047) |
| Further processing | 0.016 (0.022) | 0.003 (0.029) | -0.000 (0.033) |
| Multi-establishment firm | 0.043** (0.021) | 0.036 (0.033) | 0.039 (0.045) |
| Post_2009 | -0.001 (0.020) | 0.017 (0.025) | 0.007 (0.029) |
| AMS supplier | -0.156** (0.081) | -0.305*** (0.118) | -0.357*** (0.111) |
| AMS supplier × Post_2009 | 0.103*** (0.023) | 0.139** (0.066) | 0.186 (0.137) |
| Model chi-square | 71.5*** | 63.2*** | 79.8*** |
| Observations | 1,708 | 1,708 | 1,708 |
| Chi-square of likelihood of heteroskedasticity | 0.00 | 0.61 | 0.04 |

Note: *, **, *** = 0.10, 0.05, and 0.01 levels of significance, respectively.
U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS) suppliers were approved by AMS to supply the National School Lunch Program (NSLP) with ground beef and also sold ground beef in commercial markets; commercial suppliers (USDA, Food Safety and Inspection Service (FSIS)-only establishments) sold ground beef only to buyers in commercial markets and were not approved to sell ground beef to NSLP. AMS suppliers and commercial suppliers underwent testing for *Salmonella spp* by FSIS for products to be sold in the commercial market. Both groups were held to the same standards as those discussed under FSIS regulation. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedure.
Source: USDA, Economic Research Service estimates based on FSIS data.

beef sold to NSLP, including a zero-tolerance standard for *Salmonella spp*. If the establishment fails to meet AMS standards, then it cannot sell that product to any USDA food program. The net result is lower revenue since the meat must be sold for a lower value use, such as cooked-only or rendered product, or else discarded. Plus, the higher costs incurred in preparing ground beef for sale to NSLP must be absorbed by the establishment.

Starbird (2005), Golan et al. (2004), and others have written about asymmetric information in the market for food safety—namely, that suppliers have more information about the food safety of the products they sell than do their buyers. AMS suppliers of ground beef know their expectations about the safety of the meat they produce and the costs they would face to improve its safety before AMS offers contracts for bidding. This asymmetric information allows AMS suppliers to act strategically

in their bidding behavior. Establishments that are not performing well on *Salmonella spp* performance tests may ship products to wholesalers on the spot market where food safety is not as strictly monitored as it is for ground beef sold to NSLP. Establishments performing well on *Salmonella spp* performance tests may bid on NSLP contracts if they could expect to gain a higher price in that market. Hence, we expect that active AMS suppliers are likely to have lower *Salmonella spp* levels on products sold in the commercial market than inactive AMS suppliers that do not bid on AMS contracts. In the paragraphs that follow, we examine the performance of active and inactive AMS suppliers on FSIS *Salmonella spp* performance tests. As before, FSIS-only establishments—those that are not authorized to bid on NSLP contracts and sell only in the commercial market—are the reference group.

Table 4 repeats the definitions of variables shown in table 2 and gives definitions for active and inactive AMS suppliers. Three columns of summary statistics include 60 observations of active AMS suppliers that have FSIS *Salmonella spp* test data and 51 observations of inactive AMS suppliers that have FSIS *Salmonella spp* test data. The last column is discussed below.

Figure 2 and the first row of table 4 show the mean share of samples testing positive for *Salmonella spp* using FSIS data. These data illustrate food safety performance for the commercial market since all meat tested by FSIS is destined for sale to commercial buyers and not to AMS. The data show that all ground beef establishments easily met the FSIS tolerance for *Salmonella spp*, and that all plants were approximately as likely to have met the FSIS tolerance. However, the data also show that levels of *Salmonella spp* for active AMS suppliers were lower than half that of inactive AMS suppliers. Table 4 also shows that active AMS suppliers performed better than inactive AMS suppliers on meeting *Salmonella spp* tolerance standards equal to one-half, one-fourth, or one-tenth the FSIS standard.

A probit regression was used to econometrically examine the data to gain more conclusive evidence of differences in performance on *Salmonella spp* tests. We again used a Huber sandwich and test for heteroskedasticity. The test for multiplicative heteroskedasticity suggested that the model using the one-fourth tolerance for *Salmonella spp* suffered from heteroskedasticity. Subsequent tests showed that the interaction terms *Post_2009* × *Active AMS supplier* and *Post_2009* × *Inactive AMS supplier* were the sources of heteroskedasticity. We dropped these two interaction terms, giving a model in which heteroskedasticity did not exist and proceeded with the analysis.

Regression results using FSIS *Salmonella spp* test data are shown in table 5. Chi-square statistics show that the models were highly statistically significant (fourth row from the bottom). Table 5 shows that inactive AMS suppliers had significantly lower food safety performance than did commercial suppliers (active AMS suppliers and FSIS-only establishments) at tolerances equal to one-half, one-fourth, and one-tenth that of FSIS. However, all groups of producers greatly exceeded the FSIS performance standards. No significant difference in food safety performance existed between active AMS suppliers on products they shipped in general commerce and FSIS-only (commercial) suppliers. Other regression results were similar to those shown in table 3. The results suggest that (1) there is no difference in food safety performance between active AMS suppliers and FSIS-only (commercial) suppliers on products sold in the commercial market and tested for *Salmonella spp* by FSIS and (2) inactive AMS suppliers had lower performance on *Salmonella spp* testing than did other establishments. All groups of suppliers easily met FSIS standards for *Salmonella spp* content.

Table 4

**Mean values of selected economic variables of active and inactive AMS suppliers on meat sold in the commercial market[1] and meat sold to NSLP[2]**

| Variable | Definition | Active AMS supplier: commercial market[1] | Inactive AMS supplier: commercial market[1] | Active AMS supplier: NSLP[2] |
|---|---|---|---|---|
| Share of samples positive for *Salmonella spp* | Share of samples testing positive for *Salmonella spp*a | 0.016 | 0.041*** | 0.007*** |
| Just meets *Salmonella spp* standard | One if share of meat samples testing positive for *Salmonella spp* is less than FSIS standard, zero otherwise | 0.983 | 0.901 | 0.993** |
| One-half *Salmonella spp* standard | One if share of samples testing positive for *Salmonella spp* is less than one-half FSIS standard, zero otherwise | 0.883 | 0.647*** | 0.954*** |
| One-fourth *Salmonella spp* standard | One if share of samples testing positive for *Salmonella spp* is less than one-fourth FSIS standard, zero otherwise | 0.733 | 0.412*** | 0.881*** |
| One-tenth *Salmonella spp* standard | One if share of samples testing positive for *Salmonella spp* equals one-tenth FSIS standard, zero otherwise | 0.550 | 0.196*** | 0.781*** |
| HACCP_PASS0 | One if establishment has no noncompliance reports (deficiencies) for HACCP tasks, zero otherwise | 0.633 | 0.549 | 0.437 |
| SSOP_P_PASS0 | One if establishment has no deficiencies for Pre-Operation SSOPs, zero otherwise | 0.450 | 0.392 | 0.344 |
| SSOP_O_PASS0 | One if establishment has no deficiencies for operational SSOPs, zero otherwise | 0.400 | 0.509 | 0.444 |
| Establishment employees | Employees per establishment | 263 | 330 | 271 |
| Establishment age | Current year minus year meat Federal Grant of Inspection issued | 15.8 | 22.8 | 16.6 |
| Slaughters cattle | One if slaughters cattle, zero otherwise | 0.350 | 0.392 | 0.543 |
| Does further processing | One if establishment further processes meat, zero otherwise | 0.200 | 0.392 | 0.225 |
| Multi-establishment firm | One if establishment is part of a multi-establishment firm, zero otherwise | 0.113 | 0.020 | 0.179 |
| Post_2009 | One if year after 2009, zero otherwise | 0.567 | 0.412 | 0.543 |
| Observations | | 60 | 51 | 151 |

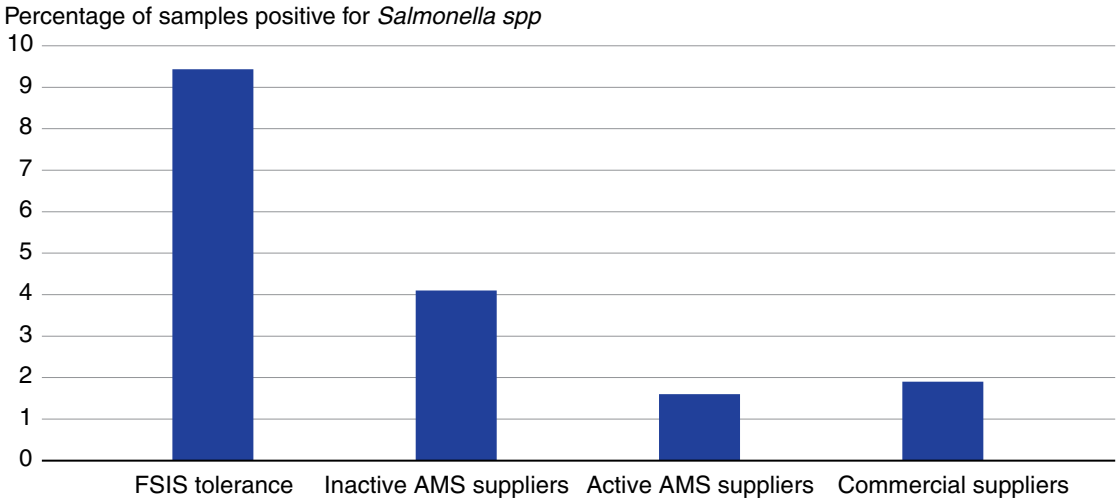
Note: *, **, *** = 0.10, 0.05, and 0.01 levels of significance, respectively. Statistical significance is not shown for the control variables. Active and inactive U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS) suppliers were approved by AMS to supply ground beef to the National School Lunch Program (NSLP). Active AMS suppliers bid on contracts to supply ground beef to NSLP during the current year (only they were tested by AMS), while inactive AMS suppliers did not bid on any NSLP contracts during the current year. Commercial suppliers (USDA, Food Safety and Inspection Service (FSIS)-only establishments) sold ground beef only to buyers in commercial markets and were not approved to sell ground beef to NSLP. Active and inactive AMS suppliers also sold in commercial markets and, like commercial suppliers, underwent testing for *Salmonella spp* by FSIS; active AMS suppliers also underwent testing by AMS since they supplied NSLP. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedure.
Source: USDA, Economic Research Service estimates based on FSIS data.

## Food Safety Test Performance of Active AMS Suppliers on Meat Sold to NSLP

AMS suppliers can provide different levels of food safety quality to different markets by using different technologies or practices. For example, they may test product or clean and sanitize more diligently before shipping ground beef to a school district. Figure 3 shows the performance on *Salmonella spp* tests of ground beef shipped by active AMS suppliers to NSLP. The model variables were identical to those shown in table 5. The only difference was that for active AMS suppliers,

Figure 2

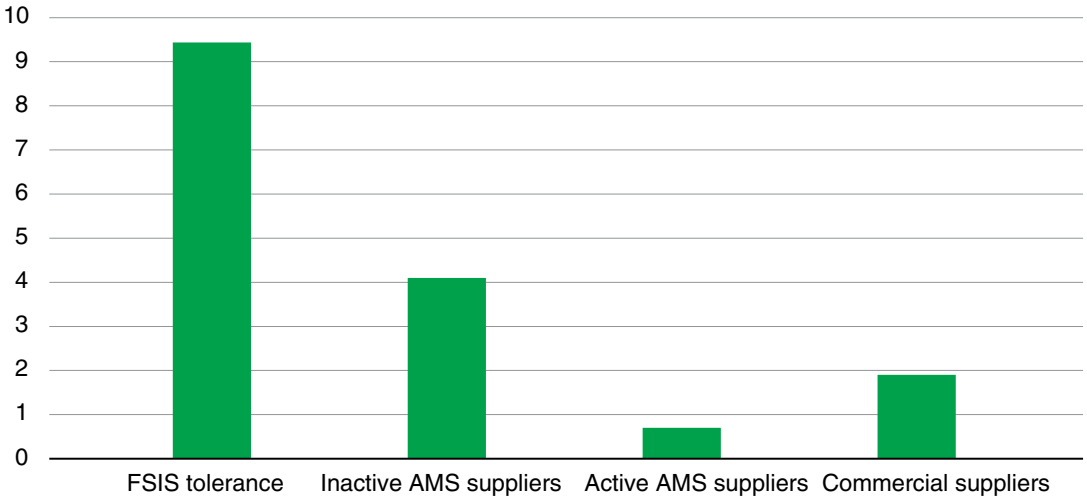
**In products sold in commercial markets, inactive AMS suppliers had many more samples test positive for *Salmonella spp* than did active AMS suppliers and commercial suppliers**




Note: Under the FSIS *Salmonella spp* standard, ground beef establishments must have no more than 5 of 53 samples test positive for *Salmonella spp* (9.4 percent) over a test period that depends on the frequency of production runs. The differences in *Salmonella spp* levels for inactive U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS) suppliers and commercial suppliers and for active AMS suppliers and commercial suppliers are statistically significant at the 0.01 level. "AMS suppliers" includes both active (bidding on contracts) and inactive suppliers. Commercial suppliers supply ground beef only to the commercial market.
Source: USDA, Economic Research Service estimates based on *Salmonella spp* data from USDA, Food Safety and Inspection Service (FSIS).

Figure 3

**In ground beef supplied to the National School Lunch Program, active AMS suppliers had fewer samples test positive for *Salmonella spp* than did commercial suppliers in ground beef supplied to the commercial market**




Note: Under the FSIS *Salmonella spp* standard, ground beef establishments must have no more than 5 of 53 samples test positive for *Salmonella spp* (9.4 percent) over a test period that depends on the frequency of production runs. The differences in *Salmonella spp* levels for inactive U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS) suppliers and commercial suppliers and for active AMS suppliers and commercial suppliers are statistically significant at the 0.01 level. "AMS suppliers" includes both active (bidding on contracts) and inactive suppliers. *Commercial suppliers* supply ground beef only to the commercial market.
Source: USDA, Economic Research Service estimates based on *Salmonella spp* data from USDA, Food Safety and Inspection Service (FSIS).

Table 5
**Marginal effects of food safety performance of active and inactive AMS suppliers on meat sold in the commercial market**

| Variable | One-half tolerance for *Salmonella spp* | One-fourth tolerance for *Salmonella spp* | One-tenth tolerance for *Salmonella spp* |
|---|---|---|---|
| HACCP_PASS0 | 0.046*** (0.017) | 0.033 (0.022) | 0.065** (0.026) |
| SSOP_P_PASS0 | 0.044** (0.018) | 0.067*** (0.022) | 0.043* (0.027) |
| SSOP_O_PASS0 | 0.013 (0.018) | 0.034 (0.026) | 0.068** (0.030) |
| Log (establishment employees) | -0.027*** (0.006) | -0.038*** (0.009) | -0.062*** (0.011) |
| Log (etablishment age) | 0.023*** (0.009) | 0.028** (0.012) | 0.039*** (0.015) |
| Slaughters cattle | 0.027 (0.029) | 0.019 (0.040) | 0.014 (0.046) |
| Further processing | 0.017 (0.021) | 0.005 (0.029) | 0.002 (0.033) |
| Multi-establishment firm | 0.040* (0.022) | 0.033 (0.033) | 0.036 (0.046) |
| Post_2009 | -0.004 (0.020) | 0.032 (0.025) | 0.008 (0.030) |
| Inactive AMS supplier | -0.276*** (0.102) | -0.277*** (0.086) | -0.526*** (0.063) |
| Inactive AMS supplier × Post_2009 | 0.117*** (0.017) | - | 0.405*** (0.047) |
| Active AMS supplier | -0.026 (0.077) | -0.134 (0.100) | -0.163 (0.171) |
| Active AMS supplier × Post_2009 | 0.056 (0.057) | - | -0.092 (0.215) |
| Chi-square | 84.1*** | 68.0*** | 80.1*** |
| Observations | 1,708 | 1,708 | 1,708 |
| Chi-square of likelihood of heteroskedasticity | 0.08 | 0.31 | 0.31 |

Note: *, **, *** = 0.10, 0.05, and 0.01 levels of significance, respectively. Active and inactive U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS) suppliers were approved by AMS to supply ground beef to the National School Lunch Program (NSLP). Active AMS suppliers bid on contracts to supply ground beef to NSLP during the current year (only they were tested by AMS), while inactive AMS suppliers did not bid on any NSLP contracts during the current year. Commercial suppliers (USDA, Food Safety and Inspection Service (FSIS)-only establishments) sold ground beef only to buyers in commercial markets and were not approved to sell ground beef to NSLP. Active and inactive AMS suppliers also sold in commercial markets and, like commercial suppliers, underwent testing for *Salmonella spp* by FSIS. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedure.
Source: Results were based on FSIS *Salmonella spp* testing data.

we used 151 observations of AMS *Salmonella spp* test data for 10,000-pound allotments (lots) of ground beef supplied to NSLP rather than the 60 FSIS *Salmonella spp* observations of ground beef sold in general commerce (table 4, third and fifth columns). FSIS *Salmonella spp* data were used to evaluate the performance of inactive AMS suppliers (table 4, fourth column) and commercial (FSIS-only) establishments (table 2). Note, data for inactive AMS suppliers were identical to those data shown in table 2.

The first row of table 4 shows the mean share of samples testing positive for *Salmonella spp* in lots of ground beef shipped to NSLP by active AMS suppliers shipping to commercial markets, inactive

AMS suppliers shipping to commercial markets, and active AMS suppliers shipping to the NSLP market, respectively. Active AMS suppliers shipped ground beef to NSLP with *Salmonella spp* levels that were less than one-half the *Salmonella spp* level of the ground beef they shipped to the commercial market. Active AMS suppliers shipped ground beef to NSLP with *Salmonella spp* levels less than one-fifth the level of inactive AMS suppliers' shipments of ground beef to the commercial market. Active AMS suppliers also performed much better on the other measures of performance on *Salmonella spp* tests. Figure 3 shows the percentage of samples testing positive for *Salmonella spp* in ground beef supplied to NSLP by active AMS suppliers and ground beef supplied to the commercial market by inactive AMS suppliers and commercial (FSIS-only) suppliers.

Table 6 gives regression results for the same model used in the previous section and with identical data, except that *Salmonella spp* performance data from AMS for ground beef sold to NSLP were used. Chi-square statistics for the regressions show that the regression models were highly significant (table 6, fourth row from the bottom), and the null hypothesis of homoskedasticity was not rejected (table 6, last row). The regression results in table 6 suggest that inactive AMS suppliers were 26 to 55 percent less likely to meet the stringent *Salmonella spp* testing standards shown in the table than were FSIS-only establishments before 2010 and about 15 to 20 percent less likely for 2010 and the years thereafter. Active AMS suppliers were 9 to 23 percent more likely to meet the *Salmonella spp* testing standards shown in the table than were FSIS-only establishments. Other regression results are similar to those reported in table 3. These results are also consistent with results from an alternative, ordered probit regression (see box, "Results from an Alternative Specification of Our Model").

AMS suppliers can sell their ground beef products to many buyers in addition to AMS. In selecting a buyer, suppliers must consider the prices offered, quality standards (including safety and meat quality), shipping and other costs, and sell to the buyer or market that will result in the highest profit. Our results suggest that food safety requirements are important to suppliers' decisions. Some suppliers sell to buyers with very stringent food safety requirements, including AMS and some restaurants. Other suppliers sell to buyers that demand higher meat quality, but perhaps are not as strict in their food safety requirements.

The results can be explained as follows: AMS suppliers must provide products that satisfy AMS standards. If AMS suppliers do not meet these requirements, they could incur substantial costs. Thus, it may be in the interest of establishments to act strategically. For example, an AMS-approved supplier may bid on AMS contracts if its food safety performance for the general commercial market is strong enough that the establishment anticipates meeting the stringent AMS standards and still generating a profit. AMS-approved suppliers may choose not to bid on AMS contracts if they do not believe they can profitably meet AMS standards. We explore this hypothesis further below. The extra precautions necessary may include more stringent sanitation and cleaning or sampling lots of ground beef for *Salmonella spp* and shipping only those lots to NSLP that meet AMS standards.

Failure to act strategically may put establishments at financial risk. If an establishment wins a contract from AMS to supply NSLP and fails AMS testing, then the establishment must find less profitable alternative destinations for its products and will have incurred the costs of preparing and shipping products to NSLP. Moreover, the establishment may have to recondition the product into a more marketable form for sale to other buyers and face the possibility of being disqualified as an AMS supplier if performance does not improve. These costs are severe, but a food safety failure could be even more costly if an establishment's products were to cause a foodborne illness outbreak

that was traced back to the AMS supplier. In this case, the AMS supplier would incur severe penalties from AMS, may face product liability lawsuits from consumers, and may lose contracts with buyers in the commercial market.

Table 6
**Marginal effects of food safety performance of inactive AMS suppliers on meat sold in commercial market and active AMS suppliers on meat sold to NSLP**

| Variable | One-half tolerance for *Salmonella spp* | One-fourth tolerance for *Salmonella spp* | One-tenth tolerance for *Salmonella spp* |
|---|---|---|---|
| HACCP_PASS0 | 0.042*** (0.016) | 0.024 (0.014) | 0.054** (0.025) |
| SSOP_P_PASS0 | 0.040** (0.017) | 0.055** (0.022) | 0.037 (0.027) |
| SSOP_O_PASS0 | 0.017 (0.017) | 0.039 (0.026) | 0.078*** (0.029) |
| Log (establishment employees) | -0.027*** (0.005) | -0.038*** (0.008) | -0.059*** (0.010) |
| Log (establishment age) | 0.019** (0.008) | 0.023** (0.011) | 0.034** (0.014) |
| Slaughters cattle | 0.025 (0.027) | 0.036 (0.035) | 0.050 (0.043) |
| Further processing | 0.014 (0.019) | 0.002 (0.027) | -0.001 (0.031) |
| Multi-establishment firm | 0.040** (0.020) | 0.035 (0.033) | 0.056 (0.043) |
| Post_2009 | 0.001 (0.018) | 0.018 (0.024) | 0.011 (0.029) |
| Inactive AMS supplier | -0.261*** (0.100) | -0.425*** (0.116) | -0.550*** (0.068) |
| Inactive AMS supplier × Post_2009 | 0.106*** (0.014) | 0.174*** (0.051) | 0.379*** (0.040) |
| Active AMS supplier | 0.091*** (0.024) | 0.119** (0.056) | 0.230*** (0.070) |
| Active AMS supplier × Post_2009 | 0.057 (0.044) | 0.089 (0.068) | 0.108 (0.106) |
| Chi-square | 91.2*** | 73.7*** | 95.3*** |
| Observations | 1,799 | 1,799 | 1,799 |
| Chi-square of likelihood of heteroskedasticity | 0.64 | 0.27 | 0.03 |

Note: *, **, *** = 0.10, 0.05, and 0.01 levels of significance, respectively. Active and inactive U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS) suppliers were approved by AMS to supply ground beef to the National School Lunch Program (NSLP). Active AMS suppliers bid on contracts to supply ground beef to NSLP during the current year (only they were tested by AMS), while inactive AMS suppliers did not bid on any NSLP contracts during the current year. Commercial suppliers (USDA, Food Safety and Inspection Service (FSIS)-only establishments) sold ground beef only to buyers in commercial markets and were not approved to sell ground beef to NSLP. Active and inactive AMS suppliers also sold in commercial markets and, like commercial suppliers, underwent testing for *Salmonella spp* by FSIS; active AMS suppliers also underwent testing by AMS since they supplied NSLP. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedure.
Source: Results in this table are based on FSIS *Salmonella spp* test results for inactive AMS and commercial suppliers (FSIS-only establishments) and AMS *Salmonella spp* test results for active AMS suppliers.

## Results From an Alternative Specification of Our Model

Alternative model specifications and empirical methodologies can add support to empirical findings. Thus, as a way to evaluate the robustness of the results, an ordered probit model was used to examine two versions of the model in which the performance of active and inactive AMS suppliers had been examined using either FSIS-only or FSIS and AMS *Salmonella spp* data. Ordered probit regressions are used in situations in which there are discrete variables with more than two outcomes. In this situation, we needed only two outcomes (*no difference in performance* or *a difference in performance*), but four possibilities were defined to measure the severity of the performance differences. The four outcomes were greater than one-half the FSIS *Salmonella spp* tolerance; less than or equal to one-half and greater than one-fourth the FSIS *Salmonella spp* tolerance; less than or equal to one-fourth and greater than one-tenth the FSIS *Salmonella spp* tolerance; and less than or equal to one-tenth the FSIS *Salmonella spp* tolerance.

Results were similar to those reported for our binary regressions. Inactive AMS suppliers for the commercial market were most likely to just meet the FSIS standard. Active AMS suppliers, in contrast, were just as likely as FSIS-only (commercial) suppliers to meet any of the four performance categories for products shipped in the commercial market, and most likely to meet a standard equal to one-tenth the FSIS tolerance for products shipped to NSLP.

## Do Establishments Behave Strategically in Their Bidding Practices?

Managers of AMS suppliers and other meat establishments have better information about the food safety quality of their products than do customers (Starbird, 2005; Golan et al., 2004; Antle, 2001). This asymmetric information enables managers of AMS suppliers to use their private food safety information to bid strategically. Economic theory suggests that they would bid on a contract to supply ground beef to NSLP when their food safety performance meets AMS standards, and they would sell their products on the spot market if their products did not meet AMS standards. Note, the price offered by AMS would need to include a premium over the spot market price for ground beef to entice suppliers to sell to NSLP. Otherwise, suppliers would always sell their ground beef on the spot market because it has fewer regulatory requirements.

Equation 4 associates the decision to bid on NSLP contracts ($B$) with the same variables that affect food safety performance (equation 2): effort devoted to food safety process control ($L$), capital ($K$), technology ($t$), and characteristics ($Z$). The model also accounted for experience in the bidding process ($E$) and the most recent performance on *Salmonella spp* tests conducted by FSIS ($LS$). Labor, capital, technology, and characteristics have been discussed. Experience in submitting clear bids to sell products to NSLP should lower bidding cost and encourage bids, because it is costly to learn bidding procedures and AMS-compliant product preparation requirements. The lag of food safety performance is used as an indicator of food safety performance at the time of the bid and is hypothesized to positively affect the bid decision if AMS suppliers base their bid decisions on previous experience. The measures of food safety performance are the same as used earlier (i.e., one-half, one-fourth, and one-tenth the FSIS tolerance for *Salmonella spp*).

$$(4)\ B = \mathrm{S}\ (L, M, K, t, Z, E, LS)$$

The definitions for all variables and the summary statistics for active and inactive AMS suppliers are shown in table 7. Note that the share of samples testing positive for *Salmonella spp* for active AMS suppliers was less than half that of inactive AMS suppliers. Note also that active AMS suppliers were at least 50 percent more likely than inactive AMS suppliers to meet food safety performance levels equal to one-half, one-fourth, or one-tenth the FSIS tolerance for *Salmonella spp.*

The data set included all of the observations of all AMS suppliers over 2007-2012 that underwent FSIS testing. From the original data set used in analysis described above, all observations of commercial suppliers (FSIS-only establishments) were dropped because only AMS suppliers can bid on contracts to supply NSLP. The first year of data for each establishment was dropped because the model included a lag term, which required 1 year of history. Finally, FSIS *Salmonella spp* performance data were used because these data reflect measured performance prior to bidding, and managers must know their food safety performance before bidding.

We used a probit regression because the dependent variable was a binary variable. We did not adjust for heteroskedasticity because tests for multiplicative heteroskedasticity cannot reject homoskedasticity, but a Huber sandwich was used to adjust for possible autocorrelated errors (Beck and Katz, 1997).

Table 7
**Mean values of selected economic variables that may affect whether an AMS supplier bids on NSLP ground beef contracts**

| Variable | Definition | Active AMS supplier | Inactive AMS supplier |
|---|---|---|---|
| Share of samples positive for *Salmonella spp* | Share of samples testing positive for *Salmonella spp* | 0.015*** | 0.037 |
| Lag one-half *Salmonella spp* standard | One if lag of share of samples testing positive for *Salmonella spp* is less than one-half FSIS standard, zero otherwise | 0.846*** | 0.556 |
| Lag one-fourth *Salmonella spp* standard | One if lag of share of samples testing positive for *Salmonella spp* is less than one-fourth FSIS standard, zero otherwise | 0.577** | 0.361 |
| Lag one-tenth *Salmonella spp* standard | One if lag of share of samples testing positive for *Salmonella spp* is less than one-tenth FSIS standard, zero otherwise | 0.269 | 0.167 |
| HACCP_PASS0 | One if establishment has no noncompliance reports (deficiencies) for HACCP tasks, zero otherwise | 0.635* | 0.444 |
| SSOP_P_PASS0 | One if establishment has no deficiencies for pre-operation SSOPs, zero otherwise | 0.403 | 0.361 |
| SSOP_O_PASS0 | One if establishment has no deficiencies for operational SSOPs, zero otherwise | 0.423 | 0.500 |
| Establishment employees | Employees per establishment | 264.8 | 262.9 |
| Establishment age | Current year minus year meat grant issued | 16.8 | 23.8 |
| Slaughters cattle | One if slaughters cattle, zero otherwise | 0.365 | 0.333 |
| Does further processing | One if establishment further processes some meat, zero otherwise | 0.212** | 0.417 |
| Multi-establishment firm | One if establishment is part of a multi-establishment firm, zero otherwise | 0.135* | 0.028 |
| Bid_Last_Year | One if establishment bid last year, zero otherwise | 0.769*** | 0.250 |
| Post_2009 | One if year after 2009, zero otherwise | 0.596 | 0.472 |
| Observations | | 52 | 36 |

Note: *, **, *** = 0.10, 0.05, and 0.01 levels of significance, respectively. Only observations containing U.S. Department of Agriculture (USDA), Food Safety and Inspection Service (FSIS) *Salmonella spp* test results could be used because managers would decide to bid on contracts based on how well their establishments were performing when a contract came up for bid and not their performance when they shipped the product. USDA, Agricultural Marketing Service *Salmonella spp* test data is available only on shipped product. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedure.
Source: USDA, Economic Research Service estimates based on FSIS data.

Preliminary regressions included the age variable (*log_age*), but this model did not converge. Since age was a control variable, we dropped it. Results of the final regression model (table 8) showed that establishments that further process meat are less likely to bid on contracts to supply ground beef to NSLP and establishments that are part of multi-establishment firms are slightly more likely to bid on NSLP contracts. Results also showed that experience in the bidding process (*Bid_Last_Year*) had a strong positive effect on placing a bid. Results for performance on previous *Salmonella spp* tests suggested a positive correlation between *Salmonella spp* test results and contract bidding. These results were consistent with the hypothesis that managers may act strategically in bidding on AMS contracts to supply ground beef to NSLP.

In summary, the award of contracts to low-cost bidders incentivizes establishments with low costs and, sometimes, with poor food-safety performance on *Salmonella spp* tests to seek approval to supply NSLP. The establishments that do win contracts to supply NSLP, however, still have to satisfy AMS

standards. Under these requirements, only establishments with cost advantages in supplying ground beef free from *Salmonella spp* contamination have an incentive to submit bids on AMS contracts.

Table 8
**Marginal effects of the impact of past food safety performance on AMS supplier bidding behavior with respect to NSLP ground beef contracts**

| Variable | One-half tolerance for *Salmonella spp* | One-fourth tolerance for *Salmonella spp* | One-tenth tolerance for *Salmonella spp* |
|---|---|---|---|
| HACCP_PASS0 | 0.131<br>(0.131) | 0.114<br>(0.115) | 0.121<br>(0.119) |
| SSOP_P_PASS0 | 0.060<br>(0.190) | -0.000<br>(0.193) | 0.007<br>(0.186) |
| SSOP_O_PASS0 | -0.045<br>(0.159) | -0.047<br>(0.150) | 0.001<br>(0.146) |
| Log (establishment employees) | 0.003<br>(0.022) | -0.028<br>(0.025) | -0.022<br>(0.023) |
| Slaughters cattle | 0.149<br>(0.136) | 0.216<br>(0.147) | 0.177<br>(0.133) |
| Further processing | -0.284**<br>(0.120) | -0.363***<br>(0.104) | -0.322***<br>(0.113) |
| Multi-establishment firm | 0.310**<br>(0.134) | 0.254<br>(0.177) | 0.226<br>(0.187) |
| Bid_Last_Year | 0.428***<br>(0.116) | 0.447***<br>(0.127) | 0.485***<br>(0.119) |
| Post_2009 | -0.339<br>(0.312) | 0.106<br>(0.194) | 0.137<br>(0.133) |
| Lag of performance at one-half tolerance | 0.283*<br>(0.171) | NA | NA |
| Lag of performance at one-half tolerance × Post_2009 | 0.375<br>(0.341) | NA | NA |
| Lag of performance at one-fourth tolerance | NA | 0.294**<br>(0.132) | NA |
| Lag of performance at one-fourth tolerance × Post_2009 | NA | -0.193<br>(0.256) | NA |
| Lag of performance at one-tenth tolerance | NA | NA | 0.156<br>(0.138) |
| Lag of performance at one-tenth tolerance × Post_2009 | NA | NA | -0.192<br>(0.180) |
| Chi-square | 88.1*** | 112.5*** | 89.2*** |
| Observations | 88 | 88 | 88 |

Note: *, **, *** = 0.10, 0.05, and 0.01 levels of significance, respectively.
Food safety performance based on U.S. Department of Agriculture (USDA), Food Safety and Inspection Service (FSIS) *Salmonella spp* testing. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedure. NA = not applicable.
Source: USDA, Economic Research Service estimates based on FSIS data.

# Conclusion

In this study, we examined the impact of food safety standards imposed on suppliers of ground beef to NSLP by AMS, which buys ground beef for NSLP. Our data clearly show that all ground beef suppliers easily met FSIS *Salmonella spp* standards and all groups were approximately as likely to have met the FSIS *Salmonella spp* standards. However, preliminary analyses suggested that establishments AMS approved to supply ground beef to NSLP performed worse on *Salmonella spp* tests than other (FSIS-only) establishments on products they shipped in general commerce.

After splitting AMS suppliers into two groups—active AMS suppliers that bid on NSLP contracts and inactive AMS suppliers that did not bid on these contracts—we find that active AMS suppliers' food safety test performance for ground beef shipped to commercial markets was comparable to that of FSIS-only establishments. In contrast, inactive AMS suppliers performed significantly worse on food safety than did FSIS-only establishments at tolerances for *Salmonella spp* equal to one-half, one-fourth, and one-tenth that required by FSIS. Finally, active AMS suppliers had significantly better food safety performance on products they shipped to NSLP than did FSIS-only establishments. Active AMS suppliers also had significantly better food safety performance on products they sold commercially than did inactive AMS suppliers. Note, again, that all groups of suppliers significantly outperformed the FSIS standards on sales to both AMS and the commercial market.

We then provided evidence of strategic behavior using past food-safety performance as an indicator of an establishment's cost-effectiveness in meeting the AMS standards. AMS suppliers were shown to bid on contracts to supply NSLP only if they had significantly better food safety performance than AMS suppliers that did not bid on contracts to supply NSLP. The net result is that establishments sorted themselves into three types: active AMS suppliers that bid on NSLP contracts and had significantly better food safety performance on the ground beef shipped to NSLP; inactive AMS suppliers that did not bid on contracts to supply NSLP and sold ground beef in general commerce that was significantly lower in food safety performance than ground beef shipped by FSIS-only establishments in general commerce; and FSIS-only establishments, which sold only in general commerce and were the reference group. All of these establishments produced ground beef that meets FSIS tolerance standards for *Salmonella spp.*

There are three approaches active AMS suppliers can take to meet AMS *Salmonella spp* standards. First, suppliers can diligently clean and sanitize their production facilities and take other actions to eliminate harmful pathogens. Second, suppliers can remove lymph glands and elastin from carcasses, as required only by AMS, and continue to perform sanitation tasks as is their normal practice. Koohmaraie et al. (2012) found that the hide and lymph nodes are the most likely sources of *Salmonella spp* in ground beef. Thus, removal of lymph glands may reduce the *Salmonella spp* load. Third, suppliers can test each production lot of ground beef for *Salmonella spp* and ship only those lots that meet AMS standards. Suppliers could also do a combination of these. Regardless of the driving force, it is clear that ground beef shipped to NSLP has superior food safety quality relative to other ground beef shipped to the commercial market, which must undergo FSIS *Salmonella spp* testing only.

The compliance with AMS standards for *Salmonella spp* contamination in ground beef is costly. The use of stringent food safety practices requires additional labor and materials expenditures, while prescreening production lots into those that are acceptable to AMS and those that are not requires testing costs and the costs of handling and processing of rejected lots of ground beef. Also, the use

of more stringent food safety practices improves aggregate food safety, but prescreening production into acceptable and unacceptable lots changes only the distribution of ground beef and not aggregate food safety because all ground beef is sold either in commercial markets or to NSLP.

Prescreening may distort the food safety capabilities of ground beef suppliers to NSLP because the ground beef shipped to NSLP would not be representative of the food safety of all ground beef sold by the establishment. This is important because AMS tests only one of the five combo bins available for each 10,000 pound lot. Perhaps recognizing this possibility, AMS recently issued FPPS-GB-2014 (April 2014), which requires suppliers that conduct microbiological testing in addition to that done by AMS to submit relevant information to AMS. If AMS determines that this testing constitutes prescreening, then it disallows it.

It is important to note the broader implications of our results. AMS and some other large buyers, such as restaurants and major grocery store chains, impose stricter standards on their suppliers than those required by FSIS. Establishments that sell meat to AMS or private buyers with strict food safety standards may use the same food safety process controls they used to comply with the demands of their large buyers for all of their production. This situation would lead to spillover effects in which ground beef that is sold in the broad commercial market is processed under more stringent food safety practices than is necessary for that market.

It is also interesting to note the effect of AMS regulations on the market to supply ground beef to NSLP. AMS is required to accept the lowest cost bidder to supply meat for NSLP under Federal contracting rules. This requirement incentivizes only establishments with lower-than-average costs of production—and with worse-than-average performance with respect to food safety—to seek AMS approval to supply NSLP. However, because children are more susceptible to foodborne illnesses, policymakers want to ensure that school food is as safe as possible. Thus, AMS imposes strict standards for harmful pathogens in the ground beef it buys. The effect is that ground beef provided to NSLP exceeds the safety quality of ground beef supplied to the commercial market but is produced by the suppliers that can meet the strict AMS standards for food safety at the lowest cost.

In closing, we note two important caveats. First, hundreds of establishments regulated by FSIS produce ground beef, and around 30 of these are AMS suppliers of ground beef to NSLP. Yet, data were available for only a fraction of these establishments. FSIS randomly selects the establishments it tests for *Salmonella spp* from the pool of establishments that passed testing and are otherwise in good standing with FSIS, suggesting our sample likely represents the larger population of suppliers. Nonetheless, our data set did not include all producers of ground beef nor did it have all AMS suppliers.

Second, this report considered the food safety performance of ground beef sold to NSLP. It did not consider the economic value of the benefits and costs of additional food safety oversight by AMS. Health benefits of better food safety performance are reduced foodborne illnesses among school children as a result of AMS oversight and the food safety effort put forth by NSLP ground beef suppliers. The costs include the cost to industry of using more stringent food safety practices than that required for the commercial market.

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