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# Economic Incentives to Supply Safe Chicken to the National School Lunch Program

Michael Ollinger, John Bovay, Casiano Benicio, and Joanne Guthrie

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## Abstract

This report examines the food safety performance of establishments supplying raw chicken to the National School Lunch Program (NSLP) through the U.S. Department of Agriculture's (USDA) Agricultural Marketing Service's (AMS) Poultry Products Purchase Program over 2006–12. This report focuses on the effectiveness of reputation as an incentive for producers to control *Salmonella*. To sell chicken through the Poultry Products Purchase Program, establishments must be registered with AMS and be in compliance with the standards imposed on all slaughter establishments by the USDA, Food Safety and Inspection Service (FSIS). Suppliers may exceed the FSIS standard, depending on their incentives. Raw chicken suppliers to AMS for the NSLP have an incentive to attain strong performance on *Salmonella* tests in order to ensure that they do not suffer product recalls, which, being associated with a highly visible customer, could harm their reputations for food safety and adversely affect profitability. However, suppliers also have an incentive to reduce costs, including those associated with food safety practices, to improve their profit margins. Findings indicate that AMS supplier concerns about increased scrutiny and the associated reputation effects when supplying the NSLP offset any incentive to underinvest in food safety to lower the costs of production.

**Keywords**: food safety, chicken, *Salmonella*, National School Lunch Program, regulation, probit analyses

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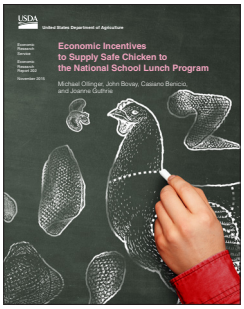


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# Economic Incentives to Supply Safe Chicken to the National School Lunch Program

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## What Is the Issue?

The Agricultural Marketing Service (AMS) of the U.S. Department of Agriculture (USDA) purchases chicken and other agricultural commodities for USDA food programs, including the National School Lunch Program (NSLP). Chicken products have been the source of foodborne illness outbreaks and subject to recalls in recent years, although they have not been identified as a source of foodborne illnesses in schools.

This report focuses on the effectiveness of reputation as an incentive for producers to supply chicken to AMS for the NSLP that exceeds industry averages on food safety tests. Suppliers of raw chicken to AMS for the NSLP must meet the same standards imposed on all slaughter establishments by USDA's Food Safety and Inspection Service (FSIS). Raw chicken suppliers, however, vary in the degree to which they exceed those standards. On the one hand, they have an incentive to reduce costs, including those associated with food safety controls, because it allows them to be more competitive in bidding on contracts and increases their profit margins. On the other hand, they have an incentive to reduce *Salmonella* levels in their products to lower the risk of causing foodborne illness outbreaks and, therefore, being forced to recall products. These reputation effects may be especially important with regard to high-profile customers such as the NSLP. Economists have found that suppliers suffered significant declines in stock prices and lost sales after recalls of meat and poultry damaged their reputations for food safety. Anecdotal evidence also indicates that some firms incurred high liability costs for recalls affecting human health.

## What Did the Study Find?

Using *Salmonella* and other data covering the 2006–12 period, this study examined the performance on *Salmonella* spp. tests by suppliers of raw chicken to AMS for the NSLP relative to commercial-only chicken slaughter establishments, which supply the commercial market and are not registered with AMS to supply the NSLP. It then evaluated separately the performance of inactive AMS suppliers (those eligible to bid on raw chicken contracts that do not bid during a given year) and of active AMS suppliers, relative to commercial-only suppliers.

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Findings suggest that AMS supplier concerns about increased scrutiny and the associated reputation effects when supplying the NSLP encouraged modestly better performance on *Salmonella* tests, offsetting incentives to underinvest in food safety to lower the costs of production.

Among the findings:

- Suppliers of raw chicken to AMS for the NSLP had modestly better performance on *Salmonella* spp. tests (a measure of food safety performance) than commercial chicken slaughter establishments.
- The performance on *Salmonella* spp. tests of active AMS raw chicken suppliers modestly exceeded that of inactive AMS raw chicken suppliers and commercial-only suppliers not registered with AMS to supply AMS.
- The performance on *Salmonella* spp. tests of inactive AMS raw chicken suppliers (AMS-registered suppliers not bidding on AMS contracts) was roughly the same as that of chicken slaughter establishments not registered to supply AMS over 2006-12.
- Reputation effects appear to incentivize modest improvements in performance on *Salmonella* spp. tests of raw chicken suppliers.

These findings may shed light on the food safety benefits associated with a less stringent and lower cost approach that relies on reputation for food safety enforcement, compared with a more costly approach relying on enforceable standards.

## How Was the Study Conducted?

Probit regressions using data covering the 2006-12 period were employed to compare the performance of three groups of chicken slaughter establishments—active AMS suppliers, inactive AMS suppliers, and commercial-only suppliers—on *Salmonella* spp. tests. Hypothetical test standards, more stringent than the FSIS tolerance levels, were used. Data were obtained from FSIS and AMS. The FSIS data included *Salmonella* spp. test results, USDA administrative data, and information on establishment characteristics provided by Dun & Bradstreet, Inc. to FSIS. AMS data included *Salmonella* spp. test results and contract bidding data.

# Economic Incentives to Supply Safe Chicken to the National School Lunch Program

## Introduction

The U.S. Department of Agriculture's (USDA) National School Lunch Program (NSLP) provides subsidized and free meals to over 31 million qualified students across the United States each school day (USDA, FNS, 2013). Chicken is a major component of the meals served to students. Some of that chicken is purchased through typical commercial channels, but schools can also obtain it via the Poultry Products Purchase Program, which is administered by USDA's Agricultural Marketing Service (AMS). The NSLP used about $9 million worth of raw and $240 million worth of processed chicken products in the 2009-10 school year (USDA, FNS, 2012). Most of the processed chicken used in the NSLP was purchased by AMS as raw product and then further processed by State agencies prior to distribution to schools. Like all chicken sold in interstate commerce, the chicken purchased by AMS for the NSLP must meet Federal food safety standards, including tolerances for *Salmonella* spp. established by the USDA's Food Safety and Inspection Service (FSIS).[1]

Proper cooking and handling of raw chicken can reduce the risk of foodborne illness by killing *Salmonella* and other pathogens. Nevertheless, *Salmonella* remains the second-most-common cause of foodborne illness in the United States, causing an estimated 1 million illnesses, 19,000 hospitalizations, and 380 deaths each year (Scallan et al., 2011). Schools generally use processed (precooked) products such as chicken nuggets, fajita strips, etc., in school meals (Hecht et al., 2008). Processing kills harmful pathogens if it involves cooking the meat to more than 165° Fahrenheit (Burr et al., 2005). Some school systems, however, contend that processing removes some control over the nutritional content of school meals, and purchase the raw commodity (Stanley and Conner, 2013).

Both raw and processed chicken products have been recalled in recent years for food safety reasons. Between 2009 and 2012, there were six recalls of processed chicken due to *Salmonella* contamination, amounting to nearly 8 million pounds. Processed chicken products have also been recalled due to contamination with *Listeria monocytogenes*, allergens, and other reasons. Additionally, Foster Farms recently recalled over 1 million pounds of raw chicken products due to excessive *Salmonella*. However, to our knowledge, there have been no product recalls of raw or processed chicken products purchased by AMS for the NSLP.

Previous research (Ollinger et al., 2014) showed that, from 2006 to 2012, ground beef sold to the NSLP performed better on *Salmonella* spp. tests than ground beef sold to the commercial market. AMS imposes a zero-tolerance standard for *Salmonella* spp. in ground beef, a higher standard than that required by FSIS for ground beef sold in general commerce. This may have incentivized

[1]The Food Safety and Inspection Service (FSIS) is responsible for the food safety of all meat and poultry products sold in interstate commerce in the United States. FSIS tests for *Salmonella* spp., and we use the term *Salmonella* spp. only in the context of testing by FSIS. Since *Salmonella* occurs in foodborne illness outbreaks as any one of a variety of species, we use *Salmonella* alone to refer to any and all species of *Salmonella* that cause illnesses and diseases.

suppliers of ground beef to the NSLP to be more diligent when fulfilling an AMS contract but it also likely raised costs, since suppliers may have taken extra precautions to meet FSIS standards.

AMS does not impose stricter *Salmonella* tolerances for raw chicken sold to AMS for the NSLP relative to the FSIS standard. AMS selects the lowest cost bidder among all AMS-registered suppliers, as long as that bidder meets FSIS standards.[2] The combined effect gives establishments an incentive to invest in food safety up to the point that the establishment just meets the FSIS standard. However, food recalls and other announcements about the safety of food products can affect demand and profit, leading to declines in the stock prices of implicated suppliers (Thomsen and McKenzie, 2001), and in some cases, bankruptcy (Andrews, 2012; Tavernise, 2013). A food safety recall from a school could be particularly costly because the NSLP is a highly visible program and subject to particular scrutiny, potentially resulting in a greater reputation loss than that which would occur in the commercial market for a similar event. Moreover, it may be easier to trace the AMS-purchased chicken served in schools to their suppliers than chicken sold in commercial markets, making a product recall more likely.[3]

Traceability is the ability to identify the supply chain of a product. It enhances food safety because, if a food is linked to a foodborne illness outbreak or other public health threat, then the source can be identified 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.

There are fewer AMS suppliers than suppliers in the broader commercial market since not all chicken plants are eligible to bid on AMS contracts. This smaller number of AMS suppliers facilitates traceability because there are fewer possible sources, and public health officials can inspect shipping records to determine the suppliers most likely responsible for shipping food associated with outbreaks of foodborne illness. Traceability becomes more complicated if the school system buys identical products in the commercial market, since there are more suppliers.

This report investigates the food safety performance of suppliers of raw chicken purchased by AMS for the NSLP. In particular, we examine whether concerns about reputation for food safety encourage AMS suppliers to outperform commercial-only suppliers on tests for *Salmonella* spp. The results could have implications for the AMS purchase specifications and the FSIS food safety program, and may help policymakers and private managers better understand the conditions under which stricter standards may be warranted, and those under which private incentives are sufficient to maintain food safety.

[2]The Agricultural Marketing Service does require additional microbiological tests of the ready-to-eat chicken it buys.

[3]Agricultural Marketing Service labeling specifications require suppliers to provide traceability information on each shipping container (USDA, AMS, 2013b).

# Background

## AMS Purchases of Raw Chicken

School districts spent nearly $600 million on raw and processed chicken products in the 2009-10 school year (USDA, FNS, 2012). About 60 percent of these chicken products came from wholesalers and 40 percent were purchased by AMS and donated to schools participating in the NSLP (USDA, FNS, 2012). Appendix 5 of the *School Food Purchase Study-III* indicates that $249 million worth of donated USDA chicken was used in schools. About 96 percent of that chicken was processed into chicken nuggets, fajita strips, patties, and other products. The remainder—about $9 million worth of product—was raw chicken parts (USDA, FNS, 2012).

AMS requires that establishments applying to supply the NSLP meet FSIS food safety requirements, pass an audit that demonstrates the capacity to meet contractual obligations, and comply with other AMS requirements. Since chicken slaughter suppliers must be in good standing with FSIS to ship products across State lines, these requirements generally are not serious roadblocks to becoming a registered AMS raw chicken supplier. Once registered, any AMS supplier can bid on any contract to supply raw chicken for any school district in the country (i.e., a competitive bidding process). Suppliers offer prices that include shipping costs, and AMS fills contracts by selecting the lowest cost bidder that meets FSIS and AMS requirements (i.e., AMS is not obligated to buy raw chicken if prices are too high). To help ensure product safety, USDA-purchased chicken is produced under the supervision of an AMS grader (USDA, AMS, 2013a), who verifies that the plant meets detailed process requirements on times and temperature. FSIS inspectors are also present to ensure that food safety process controls are performed and operations monitored.

## FSIS Process Controls and Performance Standards

FSIS and its antecedent USDA agencies have regulated the food safety of meat since 1906, when Congress mandated that meat suppliers follow hygienic meat processing practices. Congress greatly expanded USDA's authority for regulating the safety of chicken meat under the Wholesome Poultry Products Act of 1968 and subsequent regulations that established many process controls. These process controls include Sanitation Standard Operating Procedures (SSOPs), which require establishments to perform knife cleaning and other food safety tasks during operations (operating tasks), to disassemble and clean equipment at the beginning or end of a shift (pre-operating tasks), and to comply with regulations regarding building maintenance, cooking times/temperatures, and preparation of fermented, smoked, and other processed products—see Ollinger and Mueller (2003) for further discussion.

FSIS further expanded its regulatory authority when it put forth the final 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 reviews and approves the HACCP plans, and its inspectors verify that the establishments perform all tasks specified in their HACCP plan and implement all SSOPs.

Under the PR/HACCP rule, FSIS requires establishments that slaughter livestock or process ground meat or ground poultry to meet *Salmonella* spp. performance standards. Slaughter establishments

are not evaluated on a fixed schedule; rather, they are randomly selected based on the establishments' volume of production. Under the 1996 PR/HACCP rule, chicken establishments had to have fewer than 12 out of 51 samples test positive for *Salmonella* spp. to be in good regulatory standing. On July 1, 2011, the *Salmonella* spp. tolerance for whole chickens was reduced to fewer than 6 out of 51 bird carcasses testing positive for *Salmonella* spp.

FSIS assigns establishments to one of three food safety categories based on their performance on *Salmonella* spp. tests. If an establishment performs at one-half the tolerance level in consecutive tests, 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. Other establishments with a performance level that meets the tolerance in the most recent test are placed in Category 2, and establishments that test above the tolerance level are placed in Category 3. Establishments in Categories 2 and 3 are tested more frequently than establishments in Category 1. In 2008, FSIS began publishing the names of establishments in Categories 2 and 3 on its website; since establishing stricter *Salmonella* spp. tolerances in 2011, it has only published the names of Category 3 establishments. This policy of publicly disclosing the names of establishments that performed poorly on *Salmonella* spp. tests gave establishments an additional incentive to improve their performance.

## AMS Contracting and Purchasing

AMS selects the lowest cost bid to supply raw chicken to the NSLP (as long as the supplier meets all of its requirements and is in compliance with FSIS regulations). This low-price selection criterion gives suppliers an incentive to bid as low a price as possible while still earning a profit and fulfilling their food safety and other contractual obligations to AMS.

Food safety is costly because it requires careful attention to details, frequent sanitation, and innovative processing techniques. Food safety is also difficult to measure, partly because the tests are pathogen-specific while the types of contaminants and food safety risks are many. Often, the safety of food is uncertain until after it is eaten. This difficulty in measuring food safety—combined with the cost-based AMS selection criterion—gives AMS suppliers an incentive to lower their costs by minimizing their food safety efforts. Suppliers can reduce effort by limiting testing, reducing sanitation, limiting oversight, etc., to a level that just meets FSIS standards.

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

Oversight of food safety by FSIS may mitigate some of the effects of adverse selection in chicken slaughter establishments by establishing a minimum acceptable standard. FSIS enforces regulations and will request a product recall if it determines that a product is causing a foodborne illness. The direct costs of a product recall include the costs of communicating with vendors, reimbursing vendors for lost sales and replacement goods, cooking or otherwise reconditioning recalled products for use as rendered products or other lower value items, transporting materials for reconditioning or disposal, and disposing of some recalled products as waste. An indirect cost is that the responsible establishment will suffer a damaged reputation for food safety and suffer lost sales, lower prices (to attract wary consumers), and in some cases, bankruptcy.

Several economic studies have quantified the indirect effects of product recalls on the affected companies. Thomsen et al. (2006) found that sales of branded frankfurter products declined more than 20 percent after product recalls. A number of studies (Piggott and Marsh, 2004; Marsh et al., 2004) determined that negative meat and poultry food safety events led to temporary declines in meat and poultry consumption. Additionally, Thomsen and McKenzie (2001) and Salin and Hooker (2001) found that firms suffered significant declines in stock prices after recalls of meat and poultry.

Starbird and Amanor-Boadu (2006) assert that inspection and product traceability can provide sufficient food safety under some conditions, such as when the supplier bears a high cost for inspection failure. Traceability enhances food safety by making it possible to link any foodborne illness outbreak to the supplier. This association enables offended parties to be compensated for their illnesses and allows legal actions against the producer.

Traceability between the consumer (i.e., the student and school) affected by a foodborne illness and the AMS supplier depends on the number of raw chicken suppliers to the State. AMS suppliers ship raw chicken to State agencies that store commodities in warehouses from which they are later

shipped (with other food products) to school districts.[4] There is a direct link between the AMS supplier and the State but not necessarily the school district. If the State receives raw chicken from many suppliers, then traceability may not be possible in the absence of accurate inventory record-keeping and labeling. However, the number of suppliers to any given State is limited because AMS (and commercial) contract bid prices include shipping costs, giving local producers a cost advantage but also facilitating traceability. This relative ease in tracing raw chicken sold —together with regulatory oversight by FSIS and AMS, and the impact a product recall would have on an establishment's reputation for food safety—should motivate AMS suppliers to achieve a high food safety performance standard.

Establishments registered with AMS to supply the Poultry Products Purchase Program may or may not bid on AMS contracts to supply the NSLP. Establishments that bid on a contract must be aware that a product recall could be devastating to their reputation for food safety and result in lost future sales, and that the probability of tracing a foodborne illness outbreak to its source is higher in a market such as the NSLP, in which supply contracts can be linked to a contaminated food. Therefore, we can assume that active bidders have confidence that their products will not cause a foodborne-illness outbreak.

Starbird (2005), Golan et al. (2004), and others have discussed asymmetric information with respect to food safety—namely, that suppliers have more information about the food safety of the products they sell than their buyers. AMS suppliers of raw chicken know the safety of the chicken they produce and the costs they would face to improve its safety. 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 attribution of a food safety outbreak to a supplier is less likely than it is for the NSLP. Establishments performing well on *Salmonella* spp. performance tests may bid on NSLP contracts if they expect that market to be profitable. Consequently, it may be that active AMS suppliers have lower *Salmonella* spp. levels (better food safety performance) than inactive AMS suppliers (who are eligible for AMS contracts but do not bid on them).

[4]About 96 percent of raw chicken purchased by the Agricultural Marketing Service for the National School Lunch Program is sent to a federally inspected meat processor, where it undergoes a validated cooked step before it is sent to the school district.

# Economic Framework

Establishment managers have the option to sell raw chicken to the NSLP, to some other buyer that requires suppliers to meet more stringent standards, or to a wholesaler or broker on the spot market who selects the lowest cost suppliers without specifying any standards beyond those required by FSIS. Chicken slaughter establishments may find it necessary to adopt stronger food safety measures when they sell their products to the first two of these markets.

Muth et al. (2007), Ollinger and Moore (2008), and Ollinger et al. (2014) examined the impact of plant technology and other factors on performance on *Salmonella* spp. tests. Other research has evaluated 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* (Ollinger and Moore, 2008), and the impact of financial performance on *Salmonella* spp. tests (Muth et al., 2012).

Following Ollinger et al. (2014), we model production with a framework in which food safety (*FS*) is a function of labor devoted to food safety (*L*), plant capital (*K*), plant technology (*t*), establishment characteristics (*Z*), regulatory changes made by FSIS (*R*), and special precautions for food safety made by suppliers to the NSLP (*S*) due to the high visibility of this market.[5]

(1) $FS = FS\,(L, K, t, Z, R, S)$

Equation (1) is represented econometrically as:

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

We use establishment performance on *Salmonella* spp. tests as a measure of an establishment's food safety and as the dependent variable (*FS*) in equation (2). An establishment undergoing FSIS *Salmonella* spp. testing either passes the test or fails testing and undergoes an FSIS review and additional testing. 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, since AMS suppliers make publicly known bids on AMS contracts to supply the NSLP, they are more likely to be associated with any subsequent foodborne illness outbreak. As a result, they may implement their own stricter food safety standards than those maintained by other establishments. It follows that NSLP suppliers may have superior performance on measures of food safety than commercial suppliers. Thus, we evaluated performance on three successively stricter tolerances in which *FS* is defined as one-third, one-sixth, and one-twelfth the 1996 FSIS *Salmonella* spp. tolerance and zero otherwise. The choice of these tolerances is arbitrary except that each tolerance is more stringent than the FSIS tolerance that was established on July 1, 2011 and remains in effect today. The one-sixth tolerance is 2 positive samples out of 51 and satisfies the standard that has been required to attain a Category 1 ranking from FSIS for *Salmonella* spp. performance since July 1, 2011.

[5]Agricultural Marketing Service (AMS) contracting is a two-stage process in which an establishment must be registered with AMS to supply the NSLP to be an AMS supplier; this supplier then has the option to bid on AMS contracts to supply the National School Lunch Program. Only registered suppliers can bid on contracts. We did not incorporate this two-stage process into our empirical model of food safety because neither stage imposes additional food safety requirements on the supplier beyond those required by the Food Safety and Inspection Service. Ollinger et al. (2014) consider both stages for AMS ground beef suppliers because ground beef contracts have specific food safety requirements that must be met.

Equation (2) is now rewritten as the binary choice model given in equation (3):

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

where

$FS_{ey} = 1$ if $FS^*_{ey} \leq$ tolerance, and

$FS_{ey} = 0$ if $FS^*_{ey} >$ tolerance.

The subscripts *e* and *y* represent observations at the establishment-year level. Detailed definitions of the following variables are provided in table 1.

- 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 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) found that greater compliance with SSOPs and HACCP tasks improved performance on *Salmonella* spp. tests.

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

- There are two plant technology variables. Muth et al. (2007) found that establishment age is correlated with reduced *Salmonella* levels in hog and chicken slaughter, so we include, as an explanatory variable, the number of years since the establishment obtained its Federal Grant of Inspection and entered interstate commerce. The model also accounts for establishments that slaughter more than one type of animal because they have more complicated operations than single-species establishments, making food safety more costly to maintain.

- We also account for whether establishments are a part of multi-establishment firms because firms can influence decisions at the establishment level and may benefit from economies of scale in applying the same management practices across establishments.

- Establishments in different parts of the country process different kinds of chickens and supply markets with different needs—thus, we also account for geographic region.

- There were two regulatory changes during the period lasting from 2006 through 2012. In 2008, FSIS began publishing the names of establishments that failed *Salmonella* spp. testing on its website, and in 2011, FSIS mandated more stringent testing tolerances. However, there was also a transition period from 2006 to 2008 when FSIS established the 1, 2, and 3 category-ranking system and suggested that policy changes were likely. At this time, establishments likely began

to change their food safety process controls. For this reason, we use a time trend to capture the gradual improvement in performance in *Salmonella* spp. tests over time.

- Finally, we include dummy variables for each type of firm: active and inactive AMS suppliers and commercial-only suppliers.

# Data and Methodology

The data include observations on all chicken slaughter establishments whose products were tested for *Salmonella* spp. by FSIS over 2006-12. After dropping observations with missing values and several (very large and very small) outliers, our data set included 872 observations for 212 establishments. Each observation is of one establishment during 1 year. Of these 212 establishments, 50 were AMS suppliers and 162 were commercial-only suppliers.

We define active AMS suppliers as those establishments that bid on at least one contract in a given calendar year. Of the 50 AMS suppliers, 38 were active in some years and inactive in other years, and 45 were active in at least 1 year over 2006–12 for a total of 123 establishment-years. Forty-three registered AMS suppliers were inactive during at least 1 year over 2006–12 for a total of 116 establishment-years. All other observations are of commercial-only establishments.

FSIS randomly selects the establishments it tests for *Salmonella* spp. from a pool of establishments based on the volume of production. Thus, some establishments are selected more often for testing than others, with some being selected at least once a year and others less frequently. Our sample of chicken slaughter establishments is, therefore, representative of the volume of production but may not include all chicken slaughter establishments or all AMS suppliers in every year.

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, name and address information, and the date each establishment began operation. *Salmonella* spp. test results came from FSIS. The FSIS data were available from the pool of randomly selected establishments that FSIS monitored over the course of a year.

Dun & Bradstreet data were used to identify number of employees, 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.

The USDA, AMS (2014) website identifies establishments that are registered with AMS to supply the NSLP, and those establishments bidding on contracts to supply the NSLP. The website also has information about each bid (such as product type, quantity of meat to be supplied, and bid price). The data include temporal and cross-sectional components, which 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 are also panel data with a binary dependent variable, but the maximum duration of the temporal component is seven periods, making a duration dependence model inappropriate. Instead, we used a probit regression.

Beck et al. (1998) showed that autocorrelation cannot be detected in probit models but our data are grouped by establishment with a time-series component. These data are not correlated across establishments but may be correlated over time. Cameron and Miller (2015) show that analyses of these types of data can greatly understate the standard errors and overstate the t-statistics. Thus,

we used a Huber-White heteroskedasticity-consistent estimator to account for these clustered data. This estimator 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 the number of chickens slaughtered because establishment size varies substantially across establishments. Since a Wald test did not reject the null hypothesis that the model is homoskedastic, the model was not adjusted for multiplicative heteroskedasticity.

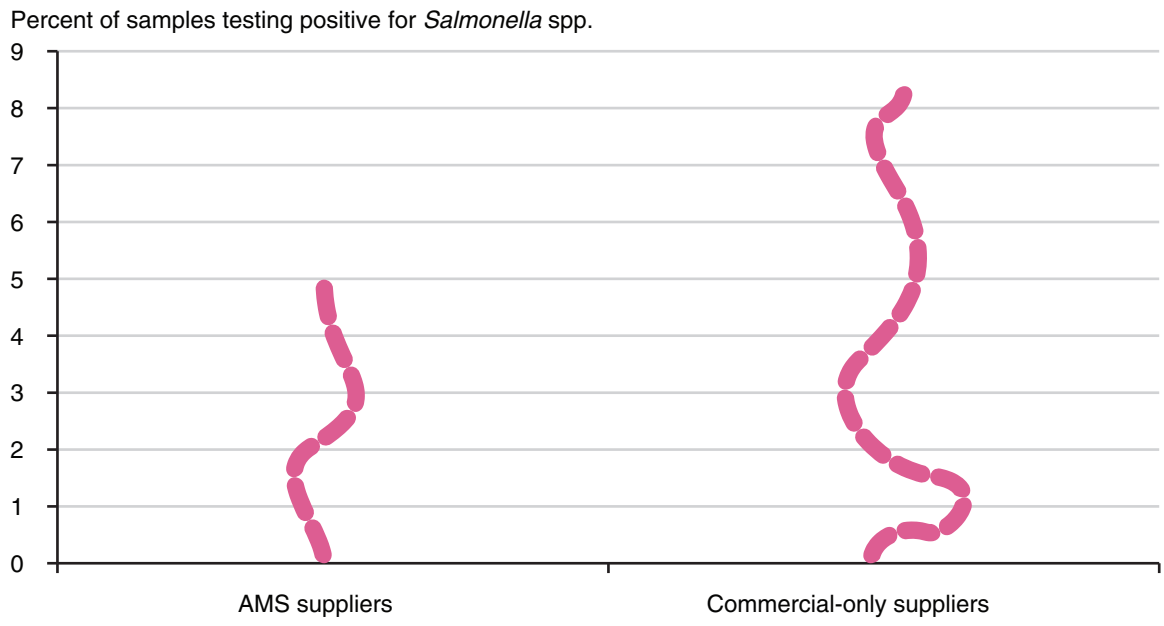
# Results

Empirical results are presented separately for two sets of regression specifications. The first set allows comparison of the performance of AMS suppliers with commercial-only suppliers on *Salmonella* tests, controlling for other establishment characteristics. The second considers separately the performance of active and inactive AMS suppliers.

## Performance of AMS and Commercial-Only Suppliers

Registered AMS suppliers performed better on *Salmonella* spp. tests than commercial-only suppliers (fig. 1), and differences in performance were significant and positive at each of the hypothetical FSIS *Salmonella* spp. tolerance standards (table 1). AMS suppliers were also smaller and had more recently obtained a Federal Grant of Inspection than commercial-only establishments (as indicated by the establishment age variable), were less likely to process more than one type of animal or be owned by a multi-establishment firm, and performed slightly worse on SSOP tasks than commercial-only establishments (table 1). These other characteristics are all significant and may affect performance on *Salmonella* test results, making it necessary to undertake econometric analyses.

Figure 1
**Commercial-only suppliers have a higher percentage of samples testing positive for *Salmonella* spp. than AMS suppliers**




Notes: Agricultural Marketing Service (AMS) suppliers are registered with AMS to supply the National School Lunch Program (NSLP) with raw chicken; they may be active (i.e., bid on NSLP contracts) or inactive in any given year and can also supply the commercial market. Commercial-only suppliers sell only to buyers in commercial markets.
Source: USDA, Economic Research Service.

Table 1
**Mean values of selected economic variables for AMS and commercial suppliers**

| Variable | Variable label | Definition | AMS suppliers[1] | Commercial suppliers[1] |
|---|---|---|---|---|
| - | Share of samples positive for *Salmonella* spp. | Share of samples testing positive for *Salmonella* spp. in FSIS testing | 0.050 | 0.085*** |
| FS1 | One-third FSIS *Salmonella* spp. standard | One if share of samples testing positive for *Salmonella* spp. less than one-third FSIS standard, otherwise zero | 0.711 | 0.602*** |
| FS2 | One-sixth FSIS *Salmonella* spp. standard | One if share of samples testing positive for *Salmonella* spp. less than one-sixth FSIS standard, otherwise zero | 0.477 | 0.370** |
| FS3 | One-twelfth FSIS *Salmonella* spp. standard | One if share of samples testing positive for *Salmonella* spp. is less than one-twelfth FSIS standard, otherwise zero | 0.314 | 0.218*** |
| $L_1$ | Share HACCP compliant | Share of HACCP tasks in compliance with FSIS regulations | 0.984 | 0.982 |
| $L_2$ | Share pre-operational SSOP compliant | Share of SSOP tasks performed prior to the operating shift in compliance with FSIS regulations | 0.876 | 0.903*** |
| $L_3$ | Share operational SSOP compliant | Share of SSOP tasks performed during the operating shift in compliance with FSIS regulations | 0.931 | 0.949*** |
| K | Establishment size | Millions of chickens slaughtered per year | 19.28 | 44.04** |
| $t_1$ | Establishment age | Current year minus year poultry grant issued, otherwise zero | 13.0 | 17.1*** |
| $t_2$ | Multi-species establishment | One if processes more than one animal species, otherwise zero | 0.109 | 0.201** |
| $Z_1$ | Multi-establishment firm | One if establishment is part of a multi-establishment firm, otherwise zero | 0.083 | 0.125* |
| $Z_2$ | Atlantic | One if in Delaware, Maryland, Virginia, West Virginia, otherwise zero | 0.130 | 0.070*** |
| $Z_3$ | Midwest | One if in Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Ohio, Wisconsin, otherwise zero | 0.038 | 0.081* |
| $Z_4$ | Northeast | One if in New Jersey, New York, Pennsylvania, Vermont, otherwise zero | 0.042 | 0.079* |
| $Z_5$ | Southeast | One if in Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, N. Carolina, S. Carolina, otherwise zero | 0.502 | 0.427** |
| $Z_6$ | West | One if in California, Colorado, Hawaii, Washington, otherwise zero | 0.017 | 0.066* |
| $Z_7$ | Southwest | One if in Arkansas, Missouri, Oklahoma, Tennessee, Texas, otherwise zero | 0.259 | 0.224 |
| | Observations | | 239 | 633 |

[1]Agricultural Marketing Service (AMS) suppliers are registered with AMS to supply the National School Lunch Program (NSLP) with raw chicken; they may be active (i.e., bid on NSLP contracts) or inactive in any given year and can also supply the commercial market. Commercial-only suppliers sell only to buyers in commercial markets.
Notes: *, **, *** = 0.10, 0.05, and 0.01 levels of significance, respectively. FSIS = USDA's Food Safety and Inspection Service. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedures.
Source: USDA, Economic Research Service.

The econometric results for the model given by equation (3), which controls for establishment characteristics, are in table 2. The dependent variable in the three regressions is whether the establishments met one-third, one-sixth, or one-twelfth of the current FSIS *Salmonella* spp. tolerance, respectively. The $\chi^2$ statistics (in the bottom row of table 2) indicate that all regression models were highly statistically significant.

Of particular interest are the results for AMS suppliers to the NSLP. AMS suppliers performed, on average, about 22 percent better than commercial-only suppliers with respect to the hypothetical *Salmonella* spp. standards at one-third the tolerance in effect before the July 1, 2011 change in tolerances (table 2). However, AMS suppliers performed the same as commercial suppliers with respect to the one-sixth and one-twelfth *Salmonella* spp. tolerances. Other results indicate that:

1. Larger establishments—as measured by the number of chickens slaughtered—were more likely to meet more stringent hypothetical tolerance levels;

2. *Salmonella* spp. test performance across all categories of establishments improved over time;

3. Small establishments that are part of multi-establishment firms performed worse while their large counterparts performed better than other establishments at the one-third and one-sixth *Salmonella* spp. tolerances; and

4. Compliance with HACCP tasks and SSOPs was weakly correlated with improvements in performance on *Salmonella* spp. tests. Four of the nine coefficients related to HACCP tasks and SSOPs were statistically significant and positive.

The other variables were generally not statistically significant. These results are consistent with Ollinger and Moore (2008) and Muth et al. (2007), who found that large chicken slaughter establishments perform better on FSIS *Salmonella* spp. tests. The modest impact of compliance with SSOPs and HACCP tasks on food safety performance is consistent with Ollinger and Moore (2008) and Ollinger et al. (2014). This finding makes sense because chicken establishments rely on the use of automation, chemicals, and heat to control harmful pathogens. Compliance with process-control regulations, such as SSOPs, account for only about 20 percent of *Salmonella* control in chicken processing (Ollinger and Moore, 2008).

Table 2

**Marginal effects of food safety performance of AMS suppliers of raw chicken sold in the commercial market[1]**

| Variable | Variable label | One-third tolerance for *Salmonella* spp.[2] | One-sixth tolerance for *Salmonella* spp.[2] | One-twelfth tolerance for *Salmonella* spp.[2] |
|---|---|---|---|---|
| $L_1$ | Percent HACCP compliant | 1.636** (0.753) | 1.195 (0.938) | 1.127 (0.892) |
| $L_2$ | Percent pre-operational SSOP compliant | 0.377* (0.206) | 0.109 (0.184) | -0.003 (0.170) |
| $L_3$ | Percent operational SSOP compliant | 0.138 (0.306) | 0.550* (0.306) | 0.609** (0.285) |
| K | Log(Establishment size) | 0.031*** (0.016) | 0.055*** (0.014) | 0.032*** (0.014) |
| $t_1$ | Log(Establishment age) | 0.003 (0.015) | -0.040 (0.0164) | -0.006 (0.014) |
| $t_2$ | Multi-species establishment | -0.040 (0.049) | -0.022 (0.058) | -0.012 (0.055) |
| $Z_1$ | Multi-establishment firm | -0.273* (0.139) | -0.321* (0.185) | -0.130 (0.165) |
| $Z_2$ | Atlantic | -0.117** (0.064) | 0.024 (0.060) | 0.049 (0.068) |
| $Z_3$ | Midwest | -0.312*** (0.086) | -0.148 (0.103) | -0.165* (0.094) |
| $Z_4$ | Northeast | -0.198*** (0.093) | -0.113 (0.129) | -0.166** (0.123) |
| $Z_5$ | Southeast | -0.074* (0.046) | 0.041 (0.059) | 0.046 (0.052) |
| $Z_6$ | West | 0.006 (0.091) | 0.126* (0.101) | 0.106 (0.075) |
| S | AMS supplier | 0.227** (0.127) | 0.061 (0.126) | 0.023 (0.113) |
| R | Time trend | 0.080*** (0.008) | 0.068*** (0.010) | 0.057*** (0.009) |
| $Z_1 \times K$ | Multi-establishment firm × Log(Establishment size) | 0.069* (0.036) | 0.078* (0.046) | 0.040 (0.042) |
| $K \times S$ | Log(Establishment size) × AMS supplier | -0.048 (0.035) | 0.018 (0.041) | 0.029 (0.040) |
| $T_1 \times S$ | Log(Establishment age) × AMS supplier | -0.015 (0.029) | 0.006 (0.033) | 0.007 (0.029) |
| | $\chi^2$ | 131.5*** | 111.0*** | 96.7*** |
| | Observations | 869 | 869 | 869 |
| | $\chi^2$ of likelihood of hetero-skedasticity | 0.23 | 0.94 | 0.08 |

[1]Agricultural Marketing Service (AMS) suppliers are registered with AMS to supply raw chicken to the National School Lunch Program (NSLP). They may be active (i.e., bid on NSLP contracts) or inactive in any given year and can also supply the commercial market. Commercial-only suppliers sell only to buyers in commercial markets.

[2]Tolerances were reduced by about 50 percent in the middle of 2011. These fractions are fractions of the tolerance up to 2011 (no more than 12 out of 51 samples can test positive). The later (2011) tolerance is no more than 5 out of 51 samples can test positive for *Salmonella* spp.

Notes: Robust standard errors are in parentheses. $\chi^2$ is a measure of goodness of fit. It is highly significant, as shown by the asterisks. *, **, *** = 0.10, 0.05, and 0.01 levels of significance, respectively. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedures.

Source: USDA, Economic Research Service.

The AMS supplier variable was interacted with the establishment size and establishment age variables, which gives insight into whether size and age affected AMS suppliers differently from commercial-only suppliers. Using the approach of Norton (2007) for marginal effects in probit regressions, we found that the interaction terms were generally not significant, suggesting that the food safety performance of AMS suppliers did not change with establishment size or with establishment age.

## Performance of Active and Inactive AMS Suppliers

We revised the econometric model given in equation (3) to distinguish active from inactive AMS suppliers; the reference group is commercial-only suppliers. Table 3 gives definitions for active and inactive AMS suppliers and summary statistics for the 123 active AMS suppliers and 116 inactive AMS suppliers. The percentage of test samples testing positive for *Salmonella* spp. was about the same for active and inactive AMS suppliers, and the two groups also performed at around the same level with respect to hypothetical *Salmonella* spp. tolerances equal to one-third, one-sixth, or one-twelfth the FSIS standard. Table 3 shows that active AMS suppliers were significantly smaller than inactive AMS suppliers, slaughtering an average of 6.3 million fewer chickens (or 28 percent fewer). On average, both active and inactive suppliers had fewer samples testing positive for *Salmonella* spp. compared to commercial-only establishments (fig. 2).

Table 3

**Mean values of selected economic variables of active and inactive AMS suppliers to the NSLP[1]**

| Variable | Variable label | Definition | Active AMS suppliers | Inactive AMS suppliers |
|---|---|---|---|---|
| - | Share of samples positive for *Salmonella* spp. | Share of samples testing positive for *Salmonella* spp. in FSIS testing | 0.049 | 0.051 |
| FS1 | One-third FSIS *Salmonella* spp. standard | One if share of samples testing positive for *Salmonella* spp. less than one-third FSIS standard, otherwise zero | 0.691 | 0.733 |
| FS2 | One-sixth FSIS *Salmonella* spp. standard | One if share of samples testing positive for *Salmonella* spp. less than one-sixth FSIS standard, otherwise zero | 0.496 | 0.457 |
| FS3 | One-twelfth FSIS *Salmonella* spp. standard | One if share of samples testing positive for *Salmonella* spp. is less than one-twelfth FSIS standard, otherwise zero | 0.325 | 0.302 |
| $L_1$ | Share HACCP compliant | Share of HACCP tasks in compliance with FSIS regulations | 0.987 | 0.982** |
| $L_2$ | Share pre-operational SSOP compliant | Share of SSOP tasks performed prior to the operating shift in compliance with FSIS regulations | 0.870 | 0.883 |
| $L_3$ | Share operational SSOP compliant | Share of SSOP tasks performed during the operating shift in compliance with FSIS regulations | 0.933 | 0.929 |
| K | Establishment size | Millions of chickens slaughtered per year | 16.2 | 22.52** |
| $t_1$ | Establishment age | Current year minus year poultry grant issued, otherwise zero | 12.3 | 13.7 |
| $t_2$ | Multi-species establishment | One if processes more than one animal species, otherwise zero | 0.130 | 0.086 |
| $Z_1$ | Multi-establishment firm | One if establishment is part of a multi-establishment firm, otherwise zero | 0.065 | 0.103 |
| $Z_2$ | Atlantic | One if in Delaware, Maryland, Virginia, West Virginia, otherwise zero | 0.122 | 0.138 |
| $Z_3$ | Midwest | One if in Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Ohio, Wisconsin, otherwise zero | 0.024 | 0.052 |
| $Z_4$ | Northeast | One if in New Jersey, New York, Pennsylvania, Vermont, otherwise zero | 0.073 | 0.009** |
| $Z_5$ | Southeast | One if in Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, N. Carolina, S. Carolina, otherwise zero | 0.545 | 0.457 |
| $Z_6$ | West | One if in California, Colorado, Hawaii, Washington, otherwise zero | 0.008 | 0.026 |
| $Z_7$ | Southwest | One if in Arkansas, Missouri, Oklahoma, Tennessee, Texas, otherwise zero | 0.211 | 0.310* |
| | Observations | | 123 | 116 |

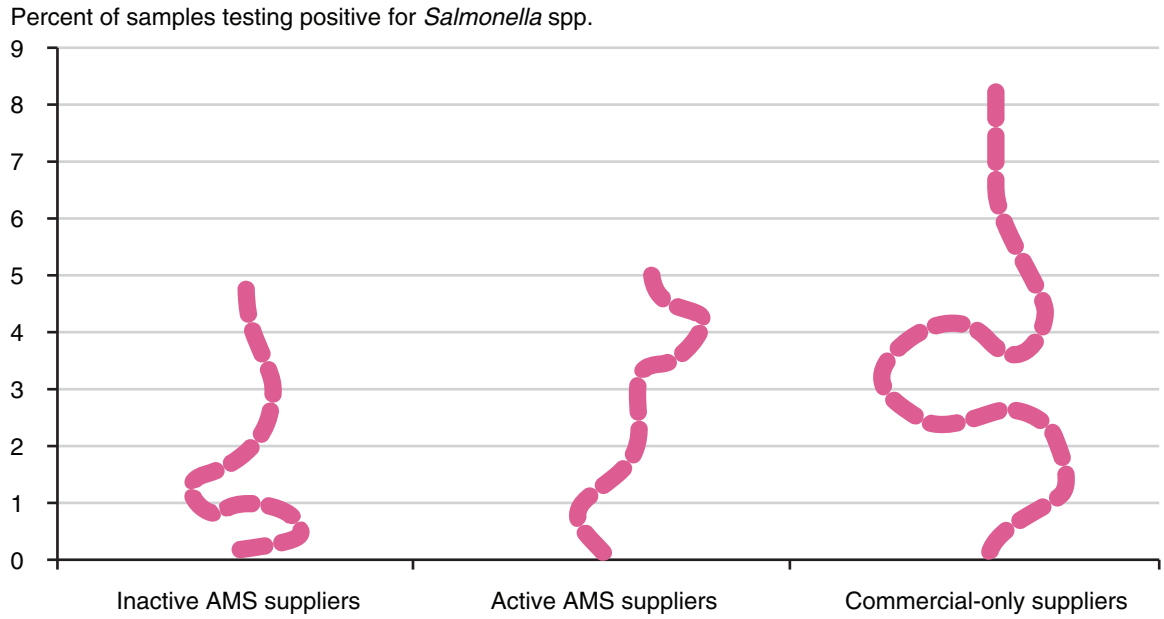
[1]Agricultural Marketing Service (AMS) suppliers are registered with AMS to supply the National School Lunch Program (NSLP) with chicken. They may be active (i.e., bid on NSLP contracts) or inactive in any given year and can also supply the commercial market. Commercial-only suppliers sell only to buyers in commercial markets.

Notes: *, **, *** = 0.10, 0.05, and 0.01 levels of significance, respectively. FSIS = USDA's Food Safety and Inspection Service. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedures.

Source: USDA, Economic Research Service.

Figure 2

**Commercial-only suppliers have a higher percentage of samples testing positive for *Salmonella* spp.**




Notes: Agricultural Marketing Service (AMS) suppliers are registered with AMS to supply the National School Lunch Program (NSLP) with chicken. They may be active (i.e., bid on NSLP contracts) or inactive in any given year and can also supply the commercial market. Commercial suppliers sell only to buyers in commercial markets.
Source: USDA, Economic Research Service.

As before, we used a probit regression and adjusted the regression models for autocorrelation with a Huber sandwich. Tests for multiplicative heteroskedasticity in the number of chickens slaughtered could not reject the null hypothesis that the models are homoskedastic, so we did not adjust for heteroskedasticity.

Results of the three probit regressions are shown in table 4. The chi-square statistic is a measure of model fit and is highly significant in all cases. Table 4 shows that, controlling for other establishment characteristics, active AMS suppliers to the NSLP have significantly better food safety performance than commercial-only suppliers at a tolerance equal to one-third the FSIS standard but had similar food safety performance to commercial-only suppliers at the one-sixth and one-twelfth tolerance levels. Inactive suppliers performed about the same as commercial-only establishments at all tolerance levels. Other coefficient estimates—including those for establishment size, compliance with SSOP and HACCP tasks, and the time trend—had very similar signs, magnitudes, and statistical significance as the results presented in table 2.

The model also includes several interaction terms, which were mostly statistically insignificant. Employing the method of Norton (2007), we found the relative test performance of establishments owned by multi-establishment firms, as reflected in the interaction of multi-establishment firm and establishment size, improved with establishment size. The coefficient estimates imply that establishments owned by multi-establishment firms that processed more than 70 million chickens per year performed better on *Salmonella* spp. tests than establishments not owned by multi-establishment firms. We also found that the interaction of establishment size and active AMS supplier was negative and statistically significant at the one-third tolerance level, meaning that the performance of larger

active AMS suppliers was worse than smaller active AMS suppliers. Taking this interaction term into account, we estimated that about 90 percent of the active AMS suppliers performed better than commercial-only establishments on *Salmonella* spp. tests at the one-third tolerance level. There is no statistical significance at the one-sixth and one-twelfth tolerance levels.

Our finding that active AMS suppliers performed better on *Salmonella* spp. tests than other establishments corroborates our understanding of the market incentives driving *Salmonella* spp. test performance. Discovery is unlikely when chicken slaughter establishments supply chicken to commercial buyers that buy and comingle products from many suppliers because it is difficult to link a culpable producer to the supplier. However, sales to the NSLP can be more easily traced, increasing the likelihood of detection of a food safety failure that could lead to a product recall and its associated costs. Thus, establishments with a comparative advantage in supplying raw chicken with few samples testing positive for *Salmonella* spp. are more likely to bid on AMS contracts to supply the NSLP.

Table 4

**Marginal effects of food safety performance of active and inactive AMS suppliers of raw chicken sold in the commercial market[1]**

| Variable | Variable label | One-third tolerance for *Salmonella* spp.[2] | One-sixth tolerance for *Salmonella* spp.[2] | One-twelfth tolerance for *Salmonella* spp.[2] |
|---|---|---|---|---|
| $L_1$ | Percent HACCP compliant | 1.766** (0.731) | 1.128 (0.932) | 1.068 (0.883) |
| $L_2$ | Percent pre-operational SSOP compliant | 0.364* (0.200) | 0.126 (0.185) | 0.014 (0.171) |
| $L_3$ | Percent operational SSOP compliant | 0.129 (0.301) | 0.542* (0.307) | 0.613** (0.285) |
| K | Log(Establishment size) | 0.030* (0.016) | 0.054*** (0.014) | 0.032*** (0.014) |
| $t_1$ | Log(Establishment age) | 0.004 (0.015) | -0.014 (0.017) | -0.006 (0.014) |
| $t_2$ | Multi-species establishment | -0.034 (0.049) | -0.024 (0.058) | -0.014 (0.054) |
| $Z_1$ | Multi-establishment firm | -0.278** (0.130) | -0.310* (0.182) | -0.120 (0.162) |
| $Z_2$ | Atlantic | -0.123** (0.062) | 0.023 (0.070) | 0.048 (0.067) |
| $Z_3$ | Midwest | -0.321*** (0.085) | -0.149 (0.104) | -0.163* (0.094) |
| $Z_4$ | Northeast | -0.210** (0.092) | -0.121 (0.129) | -0.173 (0.124) |
| $Z_5$ | Southeast | -0.072* (0.046) | 0.038 (0.060) | 0.045 (0.052) |
| $Z_6$ | West | -0.003 (0.092) | 0.122 (0.101) | 0.103 (0.075) |
| $S_1$ | Inactive AMS supplier | 0.030 (0.172) | -0.028 (0.152) | -0.059 (0.137) |
| $S_2$ | Active AMS supplier | 0.378** (0.152) | 0.111 (0.169) | 0.074 (0.143) |
| R | Time trend | 0.079*** (0.008) | 0.068*** (0.010) | 0.056*** (0.009) |
| $Z_1 \times K$ | Multi-establishment firm × Log(Establishment size) | 0.065* (0.036) | 0.076* (0.047) | 0.038 (0.042) |
| $S_1 \times K$ | Inactive AMS supplier × Log(Establishment size) | 0.002 (0.055) | 0.035 (0.049) | 0.051 (0.050) |
| $S_1 \times t_1$ | Inactive AMS supplier × Log(Establishment age) | -0.041 (0.034) | 0.035 (0.049) | 0.008 (0.045) |
| $S_2 \times K$ | Active AMS supplier × Log(Establishment size) | -0.085** (0.040) | 0.011 (0.059) | 0.015 (0.054) |
| $S_2 \times t_1$ | Active AMS supplier × Log(Establishment age) | -0.042 (0.033) | 0.003 (0.033) | 0.008 (0.030) |
| | $\chi^2$ | 143.0*** | 113.5*** | 98.7*** |
| | Observations | 869 | 869 | 869 |
| | $\chi^2$ of likelihood of heteroskedasticity | 0.23 | 0.96 | 0.09 |

[1]Agricultural Marketing Service (AMS) suppliers are registered with AMS to supply the National School Lunch Program (NSLP) with raw chicken. They may be active (i.e., bid on NSLP contracts) or inactive in any given year and can also supply the commercial market. Commercial-only suppliers sell only to buyers in commercial markets.
[2]Tolerances were reduced by about 50 percent in the middle of 2011. These fractions are fractions of the tolerance up to July 1, 2011 (no more than 12 out of 51 samples can test positive). After July 1, 2011, no more than 5 out of 51 samples can test positive for *Salmonella* spp.

Notes: Robust standard errors are in parentheses. $\chi^2$ is a measure of goodness of fit. It is highly significant as shown by the asterisks. *, **, *** = 0.10, 0.05, and 0.01 levels of significance, respectively. HACCP = Hazard Analysis and Critical Control Point. SSOP = Sanitation Standard Operating Procedures.
Source: USDA, Economic Research Service.

## AMS Supplier Performance and FSIS Category Ratings

The USDA's Food Safety and Inspection Service (FSIS) assigns chicken slaughter establishments as Category 1, 2, or 3 based on performance on *Salmonella* spp. tests. Some private buyers require their chicken suppliers to achieve large reductions in *Salmonella* that surpass or are comparable to a Category 1 rating. Walmart, for example, is now demanding a 4-log (99.99 percent) reduction in *Salmonella* from its suppliers (Crewes, 2015). We consider how active Agricultural Marketing Service (AMS) chicken suppliers perform on *Salmonella* spp. tests relative to FSIS's rating on *Salmonella* spp. tests.

The FSIS tolerance until July 1, 2011 was that 12 out of 51 samples could test positive for *Salmonella* spp. Effective July 1, 2011, this tolerance was reduced so that no more than 5 out of 51 samples could test positive for *Salmonella* spp. Our results indicate that active AMS suppliers were significantly more likely to achieve a Category 1 rating before 2011 (the pre-2011 Category 1 threshold being essentially equivalent to the one-third tolerance standard in our analysis). Our statistical analyses are unable to provide evidence on whether active AMS suppliers met a Category 1 rating after July 1, 2011, because the Category 1 threshold was significantly reduced at that point. Our empirical estimates do show that active AMS suppliers were no more likely than other establishments to meet the one-sixth FSIS tolerance (our weakest measure of performance on *Salmonella* spp. tests that does meet FSIS tolerance after July 1, 2011).

The raw data show that before 2011, 84 percent of active AMS suppliers, 82 percent of inactive AMS suppliers, and 70 percent of commercial-only suppliers performed at a Category 1 level over a 1-year observation period. After July, 1 2011, 71 percent of active AMS suppliers, 84 percent of inactive AMS suppliers, and 64 percent of commercial-only establishments performed at a Category 1 level over a 1-year observation period. Thus, AMS suppliers were about 10 percent more likely to perform at the Category 1 level compared to commercial-only establishments.

# Conclusion

This paper examines the food safety performance of chicken slaughter establishments that supply raw chicken products to AMS for the NSLP under the USDA's Poultry Products Purchase Program. These chicken establishments must be registered with AMS to supply the NSLP, and meet FSIS food safety standards to be eligible to bid on contracts. In our analysis, we used *Salmonella* spp. tests conducted by FSIS as a measure of food safety and evaluated the performance on *Salmonella* spp. tests of all AMS suppliers relative to the performance of other establishments that sell to restaurants, grocery stores, brokers, and other commercial buyers. We found that AMS suppliers had better test performance than commercial-only chicken suppliers at a level equal to one-third the FSIS tolerance (but not at one-sixth or one-twelfth the FSIS tolerance). We also analyzed the *Salmonella* spp. test performance of active AMS suppliers (those that bid on at least one contract during a given year) and inactive AMS suppliers. The analysis showed that active AMS raw chicken suppliers had significantly better test performance than commercial-only establishments at a level equal to one-third the FSIS tolerance but not at other levels; the performance of inactive AMS raw chicken suppliers was no different from commercial-only establishments at any tolerance.

Bid prices are a strong determinant of the award of contracts for products sold to the NSLP, giving rise to the possibility of adverse selection—i.e., that low-cost (and possibly lower quality) suppliers may be more likely to bid on contracts. Our empirical findings showing that active AMS suppliers performed modestly better on *Salmonella* spp. tests than other establishments suggests that suppliers' concerns about their reputation not only mitigated any incentives for adverse selection created by the AMS's low-cost selection criterion but also incentivized establishments to improve food safety performance.

This report and an earlier report on the food safety performance of ground beef suppliers to the NSLP (Ollinger et al., 2014) suggest three important mechanisms that influence food safety across meat and poultry markets: (1) food safety regulatory standards, (2) reputation effects, and (3) buyer and seller contracts.

Federal food safety standards are regulatory mechanisms mandated by FSIS. These regulations establish minimum food safety process controls for all meat and poultry establishments. The other two mechanisms—reputation effects and buyer and seller contracts—are market-based mechanisms and offer food safety protections beyond that which comes through regulations.

Establishments' reputations may be at risk if their products are linked to foodborne illnesses or recalled. A lost reputation for food safety results in lost sales and declining profitability. Chicken sold to the NSLP is a highly visible market with few suppliers, making reputation a strong force in determining food safety. However, reputation-based incentives to provide safe food are limited in their effectiveness because most foodborne illnesses go unreported or are not traced to the source, so culpable producers generally do not incur costs. Greater public awareness of suppliers' performance on *Salmonella* tests would enhance the reputation effect. For example, making public announcements about suppliers' food safety performance allows buyers to incorporate food safety information into their purchasing decisions and penalize poor performers. One market-based solution used by FSIS between 2008 and 2011 was to publish the names of establishments not meeting a pathogen tolerance equal to one-half the FSIS tolerance for *Salmonella*.

A stronger set of food safety outcomes than that which can be achieved through the threat of a lost reputation may be employed if food safety is uncertain and products serve a vulnerable population, or if the buyer is highly risk averse. Under these conditions, strict, enforceable contracts or standards may be necessary. Contractual requirements for food safety, which are agreed upon by the buyer and seller, ensure that establishments do not reduce their cost of production by reducing their efforts devoted to food safety process controls. However, buyer contracts that specify food safety practices or test requirements may lead to higher costs. Thus, buyers need to weigh the added costs against the expected improvement in food safety performance.

Many major buyers, including all of the major fast food restaurants and AMS in its purchases of ground beef for the NSLP, use raw ground beef and impose strict standards on their suppliers.[6] In other contexts, such as the production of processed chicken products that are fully cooked and then frozen, there is more confidence in the food safety of the product. Under these conditions, strict standards may not be necessary to achieve the same food safety outcomes as for products that reach consumers raw.

Buyers must also consider the recent and expected regulatory environment when considering the added costs of a stringent private standard. In recent years, the gap between the most stringent food safety standards and the regulatory requirements mandated by FSIS have narrowed. Starting in 2006, FSIS began instituting regulatory changes that resulted in a reduction by more than one-half in the allowable tolerance for *Salmonella* and has recently imposed standards for another pathogen—*Campylobacter*, which is a leading cause of foodborne illnesses and common in chicken.

[6]There have been no major food safety outbreaks at a fast food restaurant in more than 20 years. Moreover, information reported in the National Academies of Science (2010) table 1 shows that the microbiological specifications required by major ground beef buyers are stricter than those required by the Food Safety and Inspection Service. The Agricultural Marketing Service (AMS) imposes similar standards to those mandated by other major buyers of ground beef, and Ollinger et al. (2014) show that the strict food safety standards imposed by AMS on ground beef suppliers to the National School Lunch Program sharply reduced *Salmonella* levels in their ground beef suppliers.

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