The role of third-party certification in food safety outcomes:

empirical evidence from the US meat and poultry industry

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WORK IN PROGRESS – PRELIMINNAY AND INCOMPLETE

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Introduction

The use of private third-party certification in the food industry to disclose product information and regulate food quality is ubiquitous. The global food certification market is estimated to be worth $4.7 billion in 2020 and is expected to grow at a compound annual growth rate of 5.4% (MarketsandMarkets Research Private Ltd. 2020). There were at least 425 international certification standards in 2016 directly relevant to the agri-food industry (Caswell et al. 2017). Food safety certification is one of the most popular types of certifications for agri-food firms. Many large retailers such as Walmart, Kroger, Costco, Target, and Safeway have made third-party food safety certifications mandatory for all of their suppliers.

Despite the widespread adoption of third-party food safety certification schemes, food safety incidents for firms with good audit ratings are not uncommon. For example, in 2019, an outbreak of Salmonella infections linked to ground beef caused 13 people infected with 9 people hospitalized and one death. Some of the ground beef that caused people ill were traced back to a California meat producer, Central Valley Meat Co. Afterward, the company recalled 34,222 pounds of ground beef products due to possible Salmonella Dublin. This is not the first time that Central valley Meat Co. produced products with severe health hazard concerns. In 2013, Central Valley Meat Co. recalled 48,760 pounds of ground beef products that may contain foreign materials. However, ironically, the company has a long-standing third-party certification record with excellent scores A or AA from September 2013.

These food safety incidents naturally lead to the question: Does the information from third-party food safety certifications reflect underlying food safety practices in firms? Typically, the grade from a third-party certification summarizes how well a plant's food safety system complies with a specific food safety standard. If complying with private standards helps companies produce safer food, and the certification grade contains valuable information on the compliance level, we expect to observe a positive relationship between certification scores and food safety outcomes. Large retailers work with thousands of suppliers.[1] It is common for them to use audit scores to select their suppliers. Therefore, it

[1] https://www.forbes.com/sites/jwebb/2018/02/28/how-many-suppliers-do-businesses-have-how-many-should-they-have/#6b956d689bb7

is essential to understand the information value of certification grades, which could help better match sellers and buyers.

Food safety regulation in the US meat and poultry industry provides a unique setting to investigate these questions. In the US, meat and poultry plants are actively monitored by both public and private sectors, which provides two sets of food safety measurements for a plant at the same time. Public inspectors from the Food Safety and Inspection Service (FSIS) conduct on-site inspection tasks when the plant is operating, which provides a more frequent measure of food safety outcomes compared to third-party certification SQF Institute (SQF), which allows plants to get certified on different levels and summarizes the certification result into 4 ratings. I combine public and private third-party records to construct a plant month panel that makes the study possible. It allows a continuous measurement of food safety levels from FSIS and semiannual or annual audit grades for third-party certified plants. From the preliminary analysis, I find evidence that in general, SQF certification ratings signal plants' food safety practice level, but SQF certification levels do not.

This project makes two contributions. First, to the best of my knowledge, the unique dataset mentioned above allows me to empirically test whether certification ratings and levels signal firms' food safety practices, which helps to understand the role of third-party certification on food safety outcomes. Most previous works on third-party certification and food safety regulation use qualitative analysis or surveys (Tanner 2000; Duflo et al. 2013; Castka et al. 2015; Crandall et al. 2017). Few studies provide empirical evidence on the credibility of third-party certifiers and incentives of certified firms using observational data (Albersmeier et al. 2009; Anders, Souza-Monteiro, and Rouviere 2010; Zheng and Bar 2019). Second, this study contributes to the broader literature on the welfare effects of quality disclosure and certification. Third-party certifications could improve food market welfare in two ways, by giving product information to allow consumers to choose the products that best match their preferences (sorting effect), and by incentivizing firms to invest and improve quality (incentivization effect). They rely on the credibility of the signal certification grades provided, which is empirically tested in the paper. Therefore, my research helps understand the practical effects of certification before drawing welfare implications from private third-party certification.

Literature Review

Third-party food safety certification is relatively understudied. Of direct relevance to my research are the following empirical papers on the reliability of the food safety signal. My empirical work extends these topics.

The first strand of the literature suggests certification grade may not be a good signal of food safety level because the objectiveness of certifiers may be jeopardized. Zheng and Bar (2019) empirically tested the linkage between market competition and audit grades using British Retail Consortium (BRC) global food safety standard data and found that a higher level of competition among certification bodies is correlated with higher certification grades. Albersmeier et al. (2009) focused on audit grade patterns alone. They conducted statistical analyses on the German certification system Quality and Safety database and found audit results differed hugely among different certification bodies and auditors. Though they could not establish reasons for the differences, they raised doubts regarding certifiers' competence and economic pressure to conduct objective audits.

The second strand of literature analyzes the reliability concerns of third-party food safety certifications from the angle of certified firms' attitudes and behaviors towards third-party certifications. Bar and Zheng (2018) study what influences firms' certification body choices using BRC audit data of US firms. They found that firms tend to choose certification bodies that are geographically close, considered more lenient, and those that have been used in previous years by the firm. Castka et al. (2015) also found that auditing orientation (improvement or mere compliance with the standard) could influence the choice of certifiers and the overall satisfaction with certifications by surveying companies certified to a quality management standard ISO 9000 in Australia and New Zealand. These two studies together suggest that it matters what motivates firms to seek certification; if they do not aim to improve food safety but simply want to pass the audit, they could choose auditors that would allow them to easily obtain good grades. This would be detrimental to the role of certifications in providing a credible signal of a firm's true food safety level.

The third strand of the literature examines the impact of food safety certifications on food safety outcomes and other aspects of company performance. Hu and Zheng (2019) found that firms with food safety certifications are associated with better pathogen tests by combing private food safety certifications and FSIS laboratory test data. However, it is hard to draw causal conclusions due to the sample selection bias.

Overall, the empirical literature in food safety certification lacks data on another set of independent and frequent food safety measurements to reflect the food safety level of the plant, which makes it hard to know how well the audit grades can reflect the level of food safety practice in a plant and test plants' food safety practice directly. My paper builds a unique dataset that includes both a continuous measurement from public inspections and a less frequent food safety measurement from

private third parties to evaluate the reliability of the third-party certification in terms of whether the score or level information of the certification signals the level of plant's food safety practice.

Background

What is private third-party food safety certification?

Food safety certification is a verification of products, processes, or systems in the food supply chain meeting specific accepted food safety standards.[2] Unlike other certifications focusing on quality or other food attributes such as organic, non-GMO, and sustainability, food safety is a common requirement for all participants in the food industry.

The auditing process against specific standards can be done by multiple parties. Different people may categorize first, second, third parties differently according to the particular setting where they are using these words (Tanner 2000; Rosenthal and Kunreuther 2010; US FDA 2016). In this paper, first-party audits refer to internal audits by suppliers themselves to ensure the food produced meets standards specified by the company. Second-party audits mean that purchasers or users inspect and certify the suppliers against the requirements defined in the contract. Third-party audits are performed by accredited independent bodies with expertise against recognized sets of standards. Therefore, the relative advantages of third-party auditing primarily relate to the objectivity, transparency, cost-effectiveness, and professionalism of the auditors.

The three main components of the third-party food safety certification industry are standard owners who set the food safety standards, certification bodies (CBs) who conduct third-party audits, and accreditation bodies (ABs) who are approved by standard owners to accredit CBs. In general, standard owners, ABs, and CBs can be a government, non-government organization (NGO), or a private firm (Boys, Caswell, and Hoffmann 2015). Thus, the word "private" differentiates licensed private companies from public agencies that conduct government regulatory and certification activities according to public food safety standards.[3] The "USDA inspected" logo commonly seen on meat packages in the US is an example of public food safety certification, indicating that the firm conforms to public food safety standards. Unless otherwise specified, third-party food safety certification refers to the private third-party certification.

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[2] Available at https://globalfoodsafetyresource.com/food-safety-certification/, Accessed April 18, 2020.
[3] Tanner (2000) categorizes the food law enforcement agency as the fourth-party.

Private food safety standards

Private food safety standards are the main driver for the development of third-party food safety certification. In the food industry, it is common for large retailers and food processors to impose private food safety standards on suppliers. Third-party auditors have become the primary enforcement tool to ensure suppliers meet those private standards (Hatanaka, Bain, and Busch 2005). In general, governments set and regulate minimum food safety standards. Private companies set more stringent and comprehensive food safety standards in response to consumers' growing food safety concerns and advances in technology and understanding of production practices. The private food safety standard has become a substitute for inadequate public standards and a tool for firms to cover liability risks and protect reputations (Henson and Reardon 2005).

Before 2000, different retailers applied different private food safety standards to their suppliers; some collective industry food safety schemes[4] such as the British Retail Consortium (BRC) emerged. Firms were burdened by all sorts of complex and redundant private standards, which increased trade barriers and costs in the global agri-food system. In the meantime, consumers were losing trust in food safety management in the food industry after several food safety incidents in the 1990s (Weinroth, Belk, and Belk 2018). Against this background, the Global Food Safety Initiative (GFSI) was created in 2000 as a collaboration from major retailers, manufacturers, and foodservice operators to improve the food safety management system, build consumer trust, and harmonize different private food safety standards. GFSI Board members created GFSI guideline documents in 2001 that set the benchmarking requirements for different food safety schemes with the goal of "once certified, accepted everywhere." The GFSI guidelines are frequently updated to keep up with food safety issues and best practices. Currently, there are 12 GFSI-recognized certification program owners (CPOs), and the scope of certification programs covers the entire supply chain from farm to fork (see Table 1 for details).[5]

[Table 1 GFSI-recognized certification program owners (as of April 2020)]

[4] "Scheme in the food safety certification industry, is a term used to define a commercial food safety program that includes an auditable and certifiable food safety standard and a governance and management system." Available at http://mygfsi.com/wp-content/uploads/2019/09/Third-Party-Certification-GFSI-White-Paper.pdf, Accessed on April 15, 2020.

[5] "Scope" means the industry sector, which a food safety certification standard program aims to certify. GFSI recognition for a scope means that the CPO are verified that they meet the benchmarking criteria. Available at https://mygfsi.com/how-to-implement/recognition/, Accessed on April 19, 2020

GFSI-recognized food safety standards are internationally accepted by important players in the global food industry. In 2008, Wal-Mart became the first nationwide US grocery chain to request that suppliers get certified against one of the GFSI-benchmarked standards.[6] Later, more retailers started to accept or require food suppliers to be certified by GFSI-recognized standards. For example, Safeway requires all human and animal food, food-contact packaging material to be certified against various food safety schemes with minimum certification score requirements.[7] Costco does not require GFSI certification audits but accepts it along with minimum score requirements similar to those used by Safeway.[8]

Meat & poultry food safety regulation in the US

In the US, the safety of meat and poultry products is regulated by both public agencies and the private sector. In the public sector, the Food Safety and Inspection Service (FSIS) is responsible for inspecting all the meat, poultry, and egg products sold in interstate and foreign commerce for safety, wholesomeness, and proper labeling. FSIS employs 8,000 in-plant and other frontline personnel in over 6000 federally inspected slaughter and processing establishments, in laboratories, and in commerce nationwide (USDA FSIS 2013). FSIS inspection program personnel (IPP) inspect slaughter establishments during production and operations; they also inspect all the meat and poultry processing plants for at least some of the production day to ensure products meet minimum legal requirements.[9] In the private sector, suppliers and buyers tackle food safety problems through industry-wide initiatives and vertical contracts with specific food safety requirements (Pouliot and Wang 2018). GFSI-benchmarked food safety standards, SQF, BRC, and FSSC22000 are the most commonly used international food safety standards in the US meat and poultry industry. My paper focuses on SQF Certification only. Food safety

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[6] Available at https://corporate.walmart.com/newsroom/2008/02/03/wal-mart-becomes-first-nationwide-u-s-grocer-to-adopt-global-food-safety-initiative-standards, Accessed on April 19, 2020

[7] For human and animal and food-contact packaging manufacturing facilities and produce, the minimum acceptable audit scores for BRC, IFS is B, SQF 2000 G or 85%, FSSC 22000 certified, GRMS minimum Level II rating. For produce, the minimum acceptable audit scores for Primus GFS is 90%, Cana GAP is 85%, Global Gap and Asia Gap is minimum scores 100% to major musts, 95% to minor musts, and Harmonized GAP Plus certified. Available at http://suppliers.safeway.com/usa/pdf/supplier_handbook/audit_requirements_vendor.pdf, Accessed on April 19, 2020

[8] Costco requires food and produce suppliers to have at least one third-party food safety audit per year from the approved list of audit companies. Detailed rules for food safety auditing and minimum score requirements available at https://azzule.com/wp-content/uploads/2019/05/Master-Audit-Expectations-V1-0.pdf, Accessed on April 19, 2020

[9] Available at https://www.fsis.usda.gov/wps/wcm/connect/b8f48d28-bda1-4507-836e-857ce140e43f/Grant_of_Inspection_District_Manager_Ltr.pdf?MOD=AJPERES, Accessed on April 25, 2020

regulation in the US meat and poultry industry provides a unique setting to study the role of private food safety certification because of the mandatory public inspections.

FSIS

All meat and poultry plants selling products across state lines have to be inspected by FSIS inspectors while operating in the US. The inspection tasks conducted on a routine, ongoing or planned basis under normal conditions are called routine tasks. The majority of the routine inspection tasks are based on Sanitation Performance Standards (SPS), Sanitation Standard Operating Procedures (SSOP), and Hazard Analysis and Critical Control Points (HACCP) standards. [10] SPS primarily addresses specific sanitary issues within and around the establishment, such as establishment grounds and facilities, equipment and utensils, sanitary operations, employee hygiene, and tagging equipment, rooms, or compartments, to prevent the creation of unsanitary environments. SSOP consists of all procedures a plant must conduct daily, including pre-operational procedures (procedures before production operation) and operational procedures (procedures during production). Facilities must develop, implement, and maintain written SSOPs to prevent direct contamination or adulteration of products. A written HACCP is an analysis of food safety hazards during production and identifies preventative measures that could be used to mitigate potential harms.

FSIS inspectors perform SPS, SSOP (pre-operational and operational), HACCP[11] and other inspection tasks by conducting the recordkeeping, review, and observation activities to ensure implementation and maintenance of the regulatory rules. Noncompliance Records (NRs) are generated if establishments fail to comply with the inspection tasks mentioned above (SPS, SSOP, and HACCP). The NR serves as a notification and documentation of firms' non-compliance with regulatory standards. After receiving NRs, firms need to take corrective actions to reach regulatory requirements. Inspectors then verify their corrective actions and close the NRs. When there is a danger of adulterated, contaminated, misbranded, or hazardous products leaving the establishment, inspectors will follow FSIS Rules of

[10] HACCP Inspection tasks include Hazard Analysis Verification (HAV) tasks and HACCP verification tasks. HAV focuses on reviewing the establishment's hazard analysis. The HACCP verification task focuses on verifying the implementation of the HACCP system. Available at https://www.fsis.usda.gov/wps/wcm/connect/ce7d1057-757a-485b-821f-8e4f3f7cc2d8/18_IM_HACCP_Reg_Process.pdf.pdf?MOD=AJPERES, Accessed on April 26, 2020

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Practice (ROP) to take enforcement actions, such as regulatory control, withholding, and suspension actions. Figure 1 shows the regulatory process of an FSIS inspector.

[Figure 1 FSIS inspector regulatory process]

SQF

SQF is a process and product certification standard. It was first developed in Australia in 1997, and the SQF level 2 program became GFSI-benchmarked in 2004. The standard is based on HACCP to control food safety and quality hazards. To keep up with the best practices, SQF upgrades its code requirements on an ongoing basis. SQF Code 7.2 is the edition of the standard applicable during the time range of the study.

To prepare for an SQF certification, firms need first to decide the relevant industry scopes (SQF Food Sector Categories, FSC), the level at which they would like to be certified, and they must document and implement the requirements in the corresponding SQF Code Modules. Module 2: SQF System Elements applies to all industries. Requirements in other modules are based on different FSCs. Suppliers can choose one of the three certification levels in SQF Code 7.2 according to how well their food safety and quality management system have developed and the requirements from their buyers. Level 1 (Food Safety Fundamentals) is an entry-level for new business and only covers Module 2-level1 and other basic requirements. Level 2 (Certified HACCP Based Food Safety Plans) is GFSI-benchmarked, incorporates Level 1 requirements, and adds the HACCP food safety plan and Module 2 – level 2. Level 3 (Comprehensive Food Safety and Quality Management System) incorporates both levels and adds the HACCP food quality plan and Module 2 – level 3.

The typical process of initial certification involves the following steps. Facilities first learn about the SQF code, select relevant modules, and register on the SQF assessment dataset. Then sites designate SQF Practitioners to oversee the development and implementation of the SQF system. Facilities seeking to get SQF certified need to have a minimum of two months of records after implementing the SQF system. Afterward, firms can start to select an SQF licensed CB, ask for price quotes, and schedule an initial audit with their chosen CB on an agreed day. An initial audit includes a desk and a facility audit. Auditors conduct the desk audit to check whether the documentation meets the requirements of the SQF code. The facility audit focuses on whether plants effectively implement what they document. The CB is responsible for the certification decision based on the number and extent of non-compliance with the SQF codes. An audit report and four ratings (Excellent - A, Good - B, Complies - C, Fails to Comply - D)

will be provided to suppliers, which offer an overall evaluation of how well a site complies with the SQF standards. Certification is issued if a facility has a rating A, B, or C, and corrective actions of all the non-compliances are verified by auditors within the required time frame. Grading details are shown in Table 2.

[Table 2 SQF audit score and rating]

To maintain the certification, firms need to be recertified annually on an agreed day within 30 calendar days on either side of the anniversary of the last day of the initial audit. If a firm gets a Complies (C) rating, a surveillance audit shall be conducted within 30 calendar days on either side of the 6 months of the last day of the previous audit. If a plant fails to comply (D), the plant must re-apply for another facility audit.

[Figure 2 SQF certification initial and maintenance audit timeline]

Data

The SQF audit record data are obtained from the SQF standards program. SQF data is on an establishment-date level from July 2014 to December 2019, which contains 8707 unique establishments and 33937 auditing records. The key variables from the datasets are demographics information of the certified plants, and variables related to audits such as SQF level, audit rating, audit start and end date, certification body, and audit type (initial audit or recertification).

FSIS administrative inspection data contains all inspection activities at all 6391 federal inspected facilities (by 2016) from June 2012 to July 2017. I constructed 6 key outcomes of interest: compliance rate (CR) of all routine tasks (including sanitary tasks and others), routine sanitary tasks (including SPS, SSOP, and HACCP tasks), routine SPS tasks, routine pre-operational SSOP (Pre-op SSOP), routine operational SSOP (Op SSOP), and routine HACCP tasks as measurements for plants' food safety practice levels. The compliance rate of overall routine tasks (routine CR) is equal to 1 minus the total number of non-compliance records (NRs) divided by the total number of inspection tasks. The compliance rate of each specific task denoted as Sanitary CR, Pre-op SSOP CR, Op SSOP CR, HACCP CR is calculated the same way but using the number of NRs and inspection tasks in each standard category. The average compliance rate of all tasks and tasks in each category are 98.71%, 97.23%, 99.09%, 95.62%, and 98.88%.

To study whether the SQF level and auditing rating are positively correlated with the FSIS compliance rate of routine tasks, I merged the SQF inspection records with the FSIS dataset to construct a site-month panel containing both FSIS inspection outcomes and SQF auditing outcomes. [12] The SQF-FSIS sample have 915 distinct establishments, 2725 SQF audit records, and 63868 monthly FSIS inspection records from July 2014 to December 2017. In terms of plant demographics, 86.66% of the plants produce both meat and poultry, 4.48% only produce poultry, and 8.86% of plants produce meat only. According to the HACCP size category, there are 12.71% large plants, 73.72% small plants, and 13.57% very small plants. 90.13% are processing plants, and 9.87% of plants conduct both processing and slaughtering.

In the SQF-FSIS sample, only 5 SQF inspection records have rating D (fails to comply), and 1 site has SQF level 1. Therefore, I combine ratings C and D into one single group and drops the plant with SQF level 1 certification. 1076 (39.65%) of the audits get rating A, 1489 (54.86%) get B, and 149 (5.49%) get C or D. 1450 (53.39%) certifications are SQF level 2 and 1266 (46.61%) are SQF level 3. Table 3 shows the transition matrix of grades and SQF levels. It shows that firms do not change their certification level much during the sample period. If a plant chooses to be certified against level 2, the probability of changing to level 3 in the next period is 5.94%. If a plant chooses to be certified in SQF level 3, it only has a 0.6% probability of moving to level 2. In contrast, there are more time variations in ratings, though some persistence of a firm remains at its current grade if it received an A or a B.

[Table 3 Transition matrix of SQF rating and level]

Preliminary Results

To answer the question whether SQF ratings levels signal food safety practice, I compared the average of FSIS inspection results in the SQF audit month among different SQF ratings and levels and test whether a better grade or SQF level is associated with a better food safety practice. The key assumptions are as follows. First, I assume FSIS inspection results and SQF ratings are decided independently. This seems plausible as certification bodies do not require sites to notify them when

[12] The general steps to merge FSIS and SQF dataset are as follows. First, I fuzzy matched the establishment name and addresses in SQF and FSIS dataset to identify the sites that are both inspected by FSIS and certified by SQF. Second, I ensure that the SQF certified food sector category is related to egg products, meat, poulty slughtering and processing. Then, I extracted the month of audit start date of SQF data to covert SQF dataset to be a month-site unbalanced panel. I converted FSIS site-date data into site-month data by aggregating the inspection tasks in each month for each plant. Finally, I merged the two datasets by using the unique month-site id.

USDA issues NRs[13] and FSIS inspectors conduct inspections based on the task lists. Second, I assume FSIS inspection outcomes, measured by the compliance rate of inspection tasks, reflect a firm's food safety practice level. A higher compliance rate indicates a higher food safety level if the standards of SQF food safety and quality management system help a firm effectively manage food safety risks. The measurements are bounded by 0 % and 100%, which may hinder differentiating firms that have 0% or 100% compliance. Lastly, a better rating and higher level in SQF certification mean that the firm conforms with the SQF standards better. This is plausible as SQF Level 3 incorporates all the elements in level 2 and goes beyond addressing food quality risks. The food safety outcomes of firms with SQF level 3 are expected to be at least as good as those with level 2. Under those assumptions, we could conclude that if the SQF certification is a credible signal of a plant's food safety level, a higher rating and SQF level will be associated with a higher compliance rate of routine inspections.

Formally, I calculate the mean compliance rate of routine tasks for each rating and SQF level group at the month of the third-party audits by regressing the compliance rate of routine tasks on rating dummies and level dummies respectively without intercept and denote them by $\beta_A, \beta_B, \beta_{CD}$and $\beta_{level2}, \beta_{level3}$ respectively. Then I conducted four one-sided t-tests to examine the following null hypothesis for different SQF levels and ratings: $H_{0,1}: \beta_A \leq \beta_B, H_{0,2}: \beta_A \leq \beta_{CD}, H_{0,3}: \beta_B \leq \beta_{CD}, H_{0,4}: \beta_3 \leq \beta_2$. If I reject all the null hypotheses, it indicates that higher ratings and levels are associated with higher compliance rates of routine tasks. There is evidence that SQF rating and level can signal food safety practices of plants.

[Table 4 Mean of FSIS compliance rate (CR) of routine tasks by SQF rating and level]

Table 4 shows preliminary results of the OLS regressions and the p-value of the one-sided t-tests. Preliminary analysis shows some interesting patterns of the average FSIS routine task compliance rate. From Panel A of Table 4, we can see that plants with rating A are associated with the highest compliance rate, followed by rating B, and plants with rating CD are associated with the lowest compliance rate. Most of the p-values of the hypotheses 1 to 3 are smaller than 10%, which means that the null hypotheses are rejected with 10% confidence. Plants with rating A have a significantly higher compliance rate of routine SPS tasks and SSOP inspection tasks than plants with rating B, and a significantly higher compliance rate of all the sanitary inspection tasks than plants with Rating C or D. Plants with rating B has significantly higher inspection compliance rate than the ones with rating C or D

[13] https://www.sqfi.com/faq/sqf-code-faqs/

in terms of HACCP inspection tasks. Therefore, overall SQF ratings could help distinguish plants with relatively better food safety practices.

From Panel B of Table 4, we do not see that plants with level 3 are associated with a higher routine compliance rate. For HACCP inspection tasks, SQF level 2 certification sites are even associated with a significantly higher compliance rate than sites with SQF level 3 certification. However, the average routine HACCP compliance rates for both level 2 and level 3 sites are very high, above 99%. Therefore, in general, level 2 and level 3 have similar FSIS routine compliance rates, which makes intuitive sense since SQF level 3, in general, builds upon level 2 and emphasizes more on the food quality system. That is why we may expect levels 2 and 3 have very similar food safety levels.

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Table 1 GFSI-recognized certification program owners (as of April 2020)

Certification program owner (CPO)	Industry scopes covered in GFSI-benchmarked standards[14]	# of certified sites		# of CBs		Score
		World	Us	World	Us	
Food Safety System Certification 22000 (FSSC 22000)	C, D, EI, EII, EIII, EIV, F, L; J; M	23366	1445	128	20	Certified or not, not graded
SQF Institute (SQF)[15]	AI, BI; C, D, EI, EII, EIII, EIV, F, L; M; J	10054	7161	38	28	Excellent, good, complies, fails
British Retail Consortium (BRC)	C, D, EI, EII, EIII, EIV, F, L; J; M; N	29871	2715	97	28	AA, A, B, C, D, not certified; if unannounced, add + after letter grades
International Featured Standards (IFS)[16]	C, D, EI, EII, EIII, EIV, L; J; M; N	16800*	35*	132	11	Level of compliance in percentage, not certified (final score <75%)
Global Good Agricultural Practices (Global GAP)[17]	AII, BI	18000+*	Na*	145	Na*	Certified or not, not graded
Primus GFS Standard (Primus GFS)	BI, BII, D, EII, EIII, EIV, J	Na	Na	14	9	Percentage scores: audit percentage score > 90%; module percentage scores > 85%
Global Aquaculture Alliance (GAA)	EI	83	2346	7	7	Certified or not; 1 to 4 start designation logo means the seafood was bap-certified all the way from feed, farm, hatchery and processor.
Global Red Meat Standard (GRMS)	C, EI	46	0	4	0	Level i, ii, iii
CANADAGAP	BI, D	43	2193	2	2	Certified (>85% & fail in implementing corrective actions) or not, not graded
Japan Food Safety Management Association (JFSM)	EI, EIII, EIV	897	0	10	0	Certified or not, not graded
ASIAGAP	BI, BII, D	400	0	6	0	Certified or not, not graded
Freshcare	BI, D	Na	Na	7	Na	Certified or not, not graded

Source: GFSI, CPO websites and personal contacts

Note: * represents the number of certified sites and CBs are not available directly from publicly available records on current CPO websites. The notes below address how to i get the numbers.

[14] Industry Scope Code: AI Farming of Animals, AII Farming of Fish, BI Farming of Plants, BII Farming of Grains and Pulses, C Animal Conversion, D Pre Processing Handling of Plant Products, EI Processing of Animal Perishable Products, EII Processing of Plant Perishable Products, EIII Processing of Animal and Plant Perishable Products, EIV Processing of Ambient Stable Products, F Production of Feed, J Provision of Storage and Distribution Services, L Production of (Bio) Chemicals, M Production of Food Packaging, N Agents and Brokers

[15] SQF # of certified sites are calculated by adding the current certification number of SQF Food Safety Audit 8.1 and 8.0 on SQF websites; SQF # of CBs are from personal contact with SQF

[16] IFS does not have public available certification data. IFS # of US certified sites are the number of IFS Food 6 suppliers from https://www.ifs-certification.com/index.php/en/ifs; # of world certified sites are from the estimated IFS certificates per year data from https://www.ifs-certification.com/index.php/en/ifs

[17] # of Global G.A.P. certified sites is 18000+*, North America comprises 1.4%. Available at https://www.globalgap.org/export/sites/default/.content/.galleries/Documents_for_Mailings/170712_GG_IntroPPT_EN_Session_KM.pdf

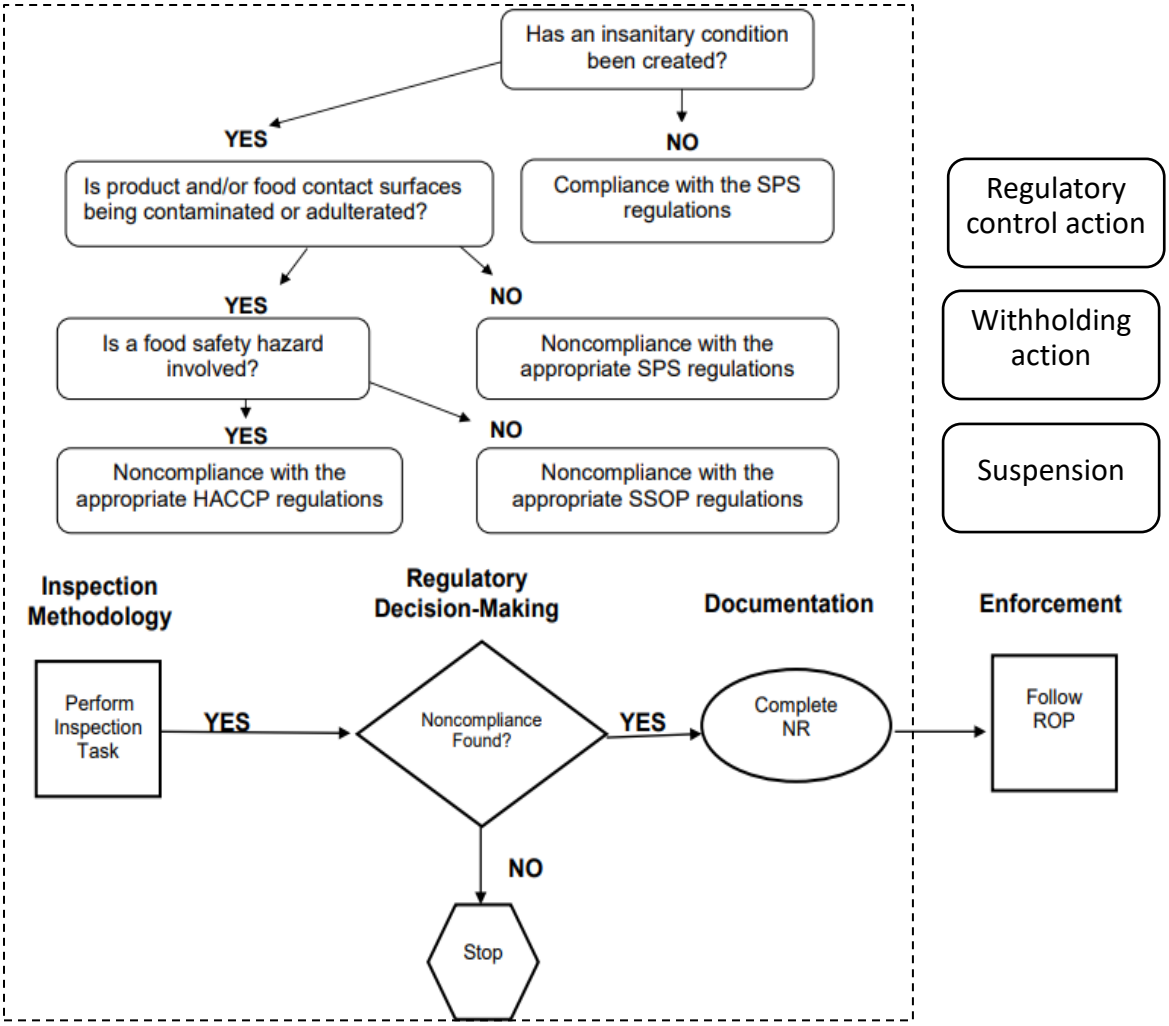

Figure 1 FSIS inspector regulatory process

Source: adapted from the notes of inspection methods training course https://www.fsis.usda.gov/wps/wcm/connect/178fff43-2e63-4807-b962-17f5889268d1/4_im_reg_process.pdf?mod=ajperes, accessed on April 25, 2020

Table 2 SQF audit score and rating

Panel A. Audit score

Types of non-conformity	Severity level	Assigned points for each non-conformity type (N)
Minor- non-conformity	May lead to a risk to food safety and quality but not likely to cause a system element breakdown.	1
Major non-conformity	Carry a food safety or quality risk and likely to result in a system element breakdown.	10
Critical non-conformity	Breakdown of control(s) at a critical control point, a pre-requisite program, or other process step and judged likely to cause a significant public health risk and/or where a product is contaminated.	50

Panel B. Audit rating

Score (100 - N)	Rating[18]	Critical	Major	Minor	Audit Frequency
96 - 100	A (Excellent)			4 or fewer	12 monthly recertification audit
86 - 95	B (Good)			5-14	12 monthly recertification audit
			1	4 or fewer	
70 – 85	C (Complies)			15-30	6 monthly surveillance audit
			1	5-20	
			2	10 or fewer	
			3		
0 - 69	D (Fails to comply	1 or more			Reapplication within 6 months of the last audit date: if with the same CB, only desk audit is required. Reapplication after 6 months of the last audit date or with a new CB, both desk and facility audits are required.

Source: SQF Code Edition 7.2 https://www.sqfi.com/wp-content/uploads/2018/08/SQF-Code_Ed-7.2-July.pdf

[18] To be consistent with BRC rating, recode Excellent, Good, Complies, Fails to comply, to A, B, C, D. Certification requires facility to have rating A, B, C and that all major non-conformities are closed out within fourteen (14) calendar days and minor non-conformities within thirty (30) calendar days of the completion of the facility audit. If a facility fails to comply, the plant has to re-apply for another facility audit. A desk audit is required if the reapplication happens after six months of the last audit date and the facility uses a new certification body (CB).

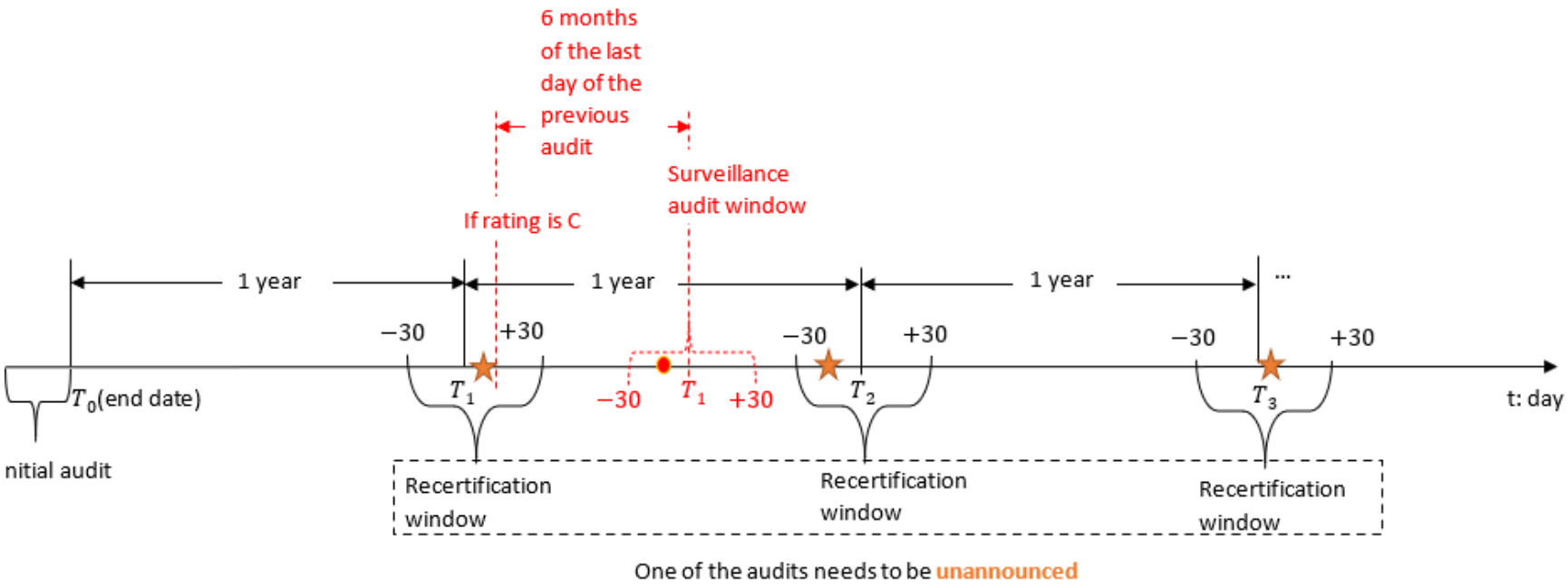

Figure 2 SQF certification initial and maintenance audit timeline

Table 3 Transition matrix of SQF rating and level

Panel A. SQF Rating

	Current inspection		
Previous inspection	A	B	C/D
A	67.90%	30.46%	1.63%
B	27.67%	67.40%	4.93%
C/D	16.07%	56.25%	27.68%

Panel B. SQF Level

	Current inspection	
Previous inspection	2	3
2	94.06%	5.94%
3	0.60%	99.40%

Table 4 Mean of FSIS compliance rate (CR) of routine tasks by SQF rating and level

Panel A. Mean of CR by SQF rating

	(1)	(2)	(3)	(4)	(5)	(6)
	CR of all inspection tasks	CR of sanitary inspection tasks	CR of HACCP inspection tasks	CR of Pre-Op SSOP inspection tasks	CR of Op SSOP inspection tasks	CR of SPS inspection tasks
Rating A	0.990***	0.988***	0.993***	0.970***	0.993***	0.966***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)
Rating B	0.989***	0.986***	0.993***	0.967***	0.990***	0.956***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)
Rating CD	0.982***	0.978***	0.985***	0.961***	0.988***	0.947***
	(0.003)	(0.003)	(0.004)	(0.007)	(0.003)	(0.012)
Number of observations	2705	2700	2669	2651	2676	2620
$H_{0,1}$: $\beta_A \leq \beta_B$	0.068	0.019	0.382	0.178	0.017	0.006
$H_{0,2}$: $\beta_A \leq \beta_{CD}$	0.002	0.001	0.033	0.089	0.062	0.052
$H_{0,3}$: $\beta_B \leq \beta_{CD}$	0.009	0.010	0.040	0.176	0.247	0.209

Panel B. Mean of CR by SQF level

	(1)	(2)	(3)	(4)	(5)	(6)
	CR of all inspection tasks	CR of sanitary inspection tasks	CR of HACCP inspection tasks	CR of Pre-Op SSOP inspection tasks	CR of Op SSOP inspection tasks	CR of SPS inspection tasks
Level 2	0.989***	0.986***	0.995***	0.967***	0.991***	0.960***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)
Level 3	0.989***	0.986***	0.991***	0.968***	0.991***	0.960***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)
Number of observations	2709	2704	2673	2655	2680	2624
$H_{0,4}$: $\beta_3 \leq \beta_2$	0.330	0.342	0.000	0.595	0.429	0.543