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Food safety, reputation, and regulation

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Abstract

This article reviews the empirical economics literature on food safety, reputation, and regulation. Producers have strong private incentives to provide safe food, largely related to reputation, especially the negative demand effects seen in response to food-safety problems. Mandatory disclosure of information about food safety can change demand and improve safety outcomes. Private incentives led producers and marketers to adopt private and collective standards for produce safety prior to the implementation of similar government regulations in the United States. Private and collective standards and government regulations all have distributional effects. The article concludes with some policy suggestions informed by the literature.

KEYWORDS

collective standards, food safety, information disclosure, regulation, reputation

JEL CLASSIFICATION

I18, Q13, Q18

Globally, food-borne diseases cause about 600 million cases of illness and 420,000 deaths per year (World Health Organization, 2015). Food-borne illnesses can cause discomfort and lead to lost productivity and income, and hospitalizations, in addition to death. The burden of illness is particularly high in developing countries. Jaffee et al. (2018) estimate that the economic cost of food-borne illness (in terms of lost productivity and medical treatment) in lower- and middle-income countries is about $110 billion per year in 2010 dollars.[1] Residents of lower- and

middle-income countries in South Asia, Southeast Asia, and Sub-Saharan Africa, which constitute 41% of the global population, suffer 53% of all food-borne illnesses and about 75% of all food-borne illness related deaths and lost disability-adjusted life years (DALYs) (Jaffee et al., 2018). In the United States, the annual cost of illness associated with 15 major pathogens is about $15.5 billion in 2013 dollars (Hoffmann et al., 2015).[2]

Public interest in reducing the cost of food-borne illness and improving public health should motivate food-safety regulations. If government can take actions to reduce the public-health costs of food-borne illness, and the benefits (reduced costs) exceed the economic burden to regulators, producers, sellers, and consumers, then intervention and increased regulation may be justified. Therefore, one essential prerequisite for cost–benefit analysis of food-safety regulations is to understand the baseline welfare impacts of food-borne illnesses. This could help to inform whether and how additional regulations can be more efficient in improving illness outcomes; and more generally, whether food safety is under- or over-provided relative to the socially optimal level, and in what contexts.

However, it is challenging to directly link food-safety practices and regulations with reductions in food-safety risks or improvements in health outcomes. The best data on food-borne illnesses (including numbers of cases; numbers and extent of outbreak events; cases and events by pathogen and food product) have relatively poor precision. Scallan, Griffin, et al. (2011) and Scallan, Hoekstra, et al. (2011) estimate that pathogens acquired in the United States cause approximately 48 million food-borne illnesses annually, but the papers' 90% credible interval for their estimate is approximately 26–74 million.[3] The imprecision suggests more broadly that researchers should be careful in interpreting results when using data on the number of lab-confirmed or estimated total food-borne illnesses. Since we cannot measure precisely the number of food-borne illnesses, it is especially hard to analyze the costs and benefits associated with reducing illness and assess where we stand with respect to the social optimum.[4]

This article reviews the empirical literature on food safety, focusing on the roles of reputation and regulation and interactions between the two. The first two sections of the review cover the empirical evidence on (wholly) private incentives for firms to provide safe food. There is little evidence that positive information about food safety boosts demand for products or brands, at least in developed countries. On the other hand, incentives to provide safe food are often generated by negative demand shocks that result from food-safety problems including recalls, scandals, and scares. In short, the bulk of the evidence suggests that bad reputations for food safety are more important than good reputations in determining demand and therefore profit.

The third and fourth sections of the article describe interactions between reputation, regulations, and private and collective standards. First, I discuss how mandatory disclosure of information about food-safety inspections can affect demand, and thereby create incentives for producers to improve safety outcomes. In this way, government can intervene to ensure better safety outcomes even without increasing the stringency of inspections or regulations.

I then discuss reputation, private standards for food safety, and regulation in the context of the U.S. fresh produce industry. Private standards are often more stringent than mandatory (government) standards and regulations, and can also influence regulations. I review the evidence on adoption of private and collective standards in the fresh produce industry, and discuss how large firms might benefit from additional regulations that raise rivals' costs and at the same time protect the reputation of the industry as a whole. I also review some literature on the distributional welfare impacts of the U.S. Food Safety Modernization Act (FSMA), under which some producers are expected to gain welfare and some to lose, and discuss implications of FSMA for consumer welfare. I then provide new evidence that food-safety outcomes

in the produce industry have not improved since the FSMA Produce Safety Rule was implemented.

The last section presents some concluding thoughts and general policy suggestions.

Table 1 outlines the structure of the review and briefly summarizes some of the studies described in each section of the review.

This article is not intended to be a comprehensive review of the economics of food safety. Antle (2001) develops microeconomic frameworks to characterize demand for and supply of food safety attributes, and discusses issues related to imperfect information and vertical integration. Pouliot and Wang (2018) focus on incentives for firms to produce safer food, and describe approaches to benefit–cost analysis of food-safety regulations, reviewing both conceptual and empirical studies. Hoffmann et al. (2019) review the empirical evidence on food safety in low- and middle-income countries, from consumers up through the supply chain to producers. Hoffmann, Ashton, and Ahn (2021) review the historical development of food-safety regulations in the United States and categorize 30 potential research areas within the economics of food safety. This article complements the others by focusing on empirical analysis of food-safety regulations and reputation, mainly in the context of the United States. It should also complement Winfree (2022), which reviews both theoretical and empirical literature on collective reputation and food, including several examples related to food safety.

DEMAND RESPONSE TO POSITIVE INFORMATION ABOUT FOOD SAFETY

As discussed above, increasingly stringent food-safety regulations may improve social welfare if the cost of illness is high and the cost of reducing illness is low; however, estimating the number of illnesses and the impacts of policy on illnesses (and the cost of illness) is difficult. It is certainly possible that food is less safe than optimal in the United States and elsewhere, and that lax regulations contribute to the sub-optimal outcome. However, it remains unclear whether food safety in the United States (or anywhere else) is underprovided or overprovided, that is, whether the marginal costs of improving safety outcomes are smaller or larger than the marginal benefits of doing so. Another potential cause of (possibly) sub-optimal safety outcomes is low consumer demand for safety, that is, that consumers do not value food-safety assurances in the marketplace. Therefore, another key question is whether (and under what circumstances) consumers and other food buyers are willing to pay more for food produced with greater safety assurances.

Evidence for a positive demand response to positive information about food safety remains limited, largely because consumer demand for food safety is difficult to estimate. In most contexts, studying willingness to pay (WTP) for safe food is not realistic in a laboratory or "lab-in-the-field" setting, or with demand analysis using scanner data, because (1) providing misleading information about food safety to consumers is probably considered unethical, and (2) assurances about food safety are rarely indicated on product labels.[5] Moreover, as noted by Kariuki and Hoffmann (2021), surveys (stated choice experiments) and laboratory studies may both be biased by experimenter demand effects (see De Quidt et al., 2018; De Quidt et al., 2019). Two recent articles (Hoffmann, Moser, & Herrman, 2021; Kariuki & Hoffmann, 2021) avoid these concerns and provide evidence on demand for aflatoxin-safe maize in Kenya using randomized control trials (RCTs).[6]

Kariuki and Hoffmann (2021) gave households information about the negative relationship between aflatoxin levels and the price of maize flour, and the names of two brands most likely

TABLE 1 Outline of the review and summaries of key studies reviewed

Broad topic	Author(s) (year(s))	Detailed topic
Demand response to positive information		
Aflatoxin-safe maize flour in Kenya	Kariuki and Hoffmann (2021)	Tests for aflatoxin and info about safe brands
	Hoffmann, Moser, and Herrman (2021)	Marketing campaign for verified aflatoxin-safe flour
Adoption of collective safety standards	Bovay (2017)	Effects on wholesale demand for fresh tomatoes (United States)
Effects of scares, recalls, and other problems		
Traceability	Zhou et al. (2022)	Adoption of traceability by seafood vendors (China)
Demand response to scares and recalls	Bai et al. (2021)	Tainted infant formula in China on export revenues, spillovers
	Spalding et al. (2022)	*E. coli* outbreak in California lettuce, effects through supply chain
Legal liability	Mahdu (2015)	Jury decisions about food-borne illness lawsuits (United States)
Inspections, information disclosure, and safety outcomes		
Restaurant hygiene inspections	Jin and Leslie (2003, 2009)	Hygiene cards in restaurants on demand and health (LA County)
	Dai and Luca (2020)	Hygiene inspection info on Yelp, demand outcomes (San Francisco)
	Bar and Zheng (2019)	Manufacturer certifiers' leniency and choice of certifier (UK)
	Kovács et al. (2020)	Inspector tenure and leniency (LA County)
	Makofske (2020)	Inspector manipulation of marginal scores (LA County)
Salmonella in chicken carcasses	Ollinger and Bovay (2020)	Public disclosure improves overall test outcomes (United States)
	Bovay (2021)	Public disclosure reduces shirking (United States)
Reputation, private standards, and regulation in the U.S. fresh produce industry		
Good agricultural practices on farms	Astill et al. (2018)	Extent of adoption of GAPs (United States)
	Lichtenberg and Page (2016)	Extent of adoption of GAPs (Mid-Atlantic United States)
	Adalja and Lichtenberg (2018b)	Estimate cost of complying with FSMA based on GAPs adoption
	Adalja et al. (2021)	Outbreaks and collective standards adoption (United States)
Distributional effects of FSMA	Bovay and Sumner (2018)	Fresh tomatoes, effects on producers by size, region (North America)
	Ferrier et al. (2022)	38 fresh fruits and vegetables, producer and consumer welfare (U.S.)

TABLE 1 (Continued)

Broad topic	Author(s) (year(s))	Detailed topic
FSMA and safety outcomes	Bovay (2022) (this article)	FSMA implementation not correlated with improved outcomes

to comply with the regulatory standard; and offered some households the opportunity to have their maize flour tested for aflatoxin. Households that had been offered the test of their own flour were about 8% more likely to consumer higher-quality brands when a follow-up survey was done 9 weeks after the intervention. Hoffmann, Moser, and Herrman (2021) implement a marketing campaign for a particular brand of maize flour that had been tested and verified for aflatoxin, with treatments varying across locations. They find that although some of the treatments increased sales of the target brand by up to 270%, the demand effects were transient and statistically significant for only up to 6 weeks after the interventions. The authors also find that each of the treatments increased shoppers' knowledge about the links between aflatoxin and cancer, 3–5 months after the campaigns ended.

Because the reputation of entire industries can suffer from alleged, perceived, or actual quality problems, many industries have collectively adopted private, voluntary quality standards (Winfree & McCluskey, 2005). In the United States and many other countries, private standards for food safety are often more stringent than government standards (e.g., Bovay, 2017; Fulponi, 2006; Hu et al., 2022; Ollinger et al., 2004). Specifically, many intermediary food buyers require that their suppliers undergo audits for compliance with food-safety standards such as GlobalGAP or the British Retail Consortium global standards (Bar & Zheng, 2019; Hu et al., 2022). Such standards are voluntary, in the sense that government does not require that farms or other suppliers meet them; but suppliers must meet the standards in order to enter certain markets. Hu et al. (2022) provide an excellent overview of the economics of private certification of food-safety standards, and identify several large holes in the literature. They note that private food-safety standards are probably more important in developing countries where public standards are weak or poorly enforced; over 60% of the studies in their comprehensive literature review focus on private standards in non-OECD countries. They also note that the introduction of uniform federal labels for food-safety certification along the lines of the USDA National Organic Program seems politically untenable since there would be a stigma associated with uncertified food. In general, despite the proliferation of private standards, evidence on the economic effects of private standards on prices paid to farmers, farm profits, consumer prices, or food-safety outcomes is quite limited.

In 2007, major tomato growers in Florida and California adopted safety standards that closely resembled the standards that would be eventually required under the U.S. Food Safety Modernization Act (FSMA). In Bovay (2017), I find no evidence that wholesale demand curves for tomatoes from the adopting regions shifted out after the adoption of the food-safety standards. I suggest that if wholesale buyers' demand is unaffected by whether farms have adopted on-farm safety standards, consumers (who are much less informed about food-safety practices and standards) would be similarly unaffected by the implementation of any voluntary, collective, or mandatory safety standards.[7]

The studies discussed in this section show that consumers in Kenya respond to information about food safety, but the effects are limited. Similarly, there is no evidence that wholesale demand for fresh tomatoes in the United States responded positively to the adoption of food-

safety standards by major grower groups. Notably, the evidence from Kenya involved providing information about testing and verification, and not just information about safety practices. Synthesizing, it appears that demand does not shift substantially in response to positive information about food safety. However, much more work could be done to explore this issue in various other contexts. I now consider the more extensive evidence on the other side of the coin: the effects of negative information like scares and recalls on demand and profit.

EFFECTS OF SCARES, RECALLS, AND OTHER FOOD-SAFETY PROBLEMS ON DEMAND AND PROFIT

Generally, the food we consume is safe. Even though about 600 million illnesses per year are caused by consuming unsafe food, the probability that an individual will consume illness-causing food on a given day is only about 1 in 5000.[8] It should then come as no surprise that we tend to pay attention to the rare instances when food is unsafe, rather than assurances that products are even safer (in expectations) than usual. In this section, I first discuss the role of traceability in the supply chain in identifying the source of food-safety problems. I then review evidence on how consumer and buyer demand can respond to safety problems, and how poor reputation can spill over to firms not associated with the problem. Next, I review evidence on how commodity prices respond to scares and recalls, even before the problems are public knowledge. Last, I address the threat of legal liability and the extent to which producers must absorb the cost of food-safety problems through liability.

Traceability of food-safety problems to their sources

Food safety is often thought of as a public good (Unnevehr, 2007), and food-safety problems as externalities (Hennessy, 2005; Henson & Traill, 1993). But if outbreaks of food-borne illness can be traced to their sources, then the potential for externalities is considerably reduced, because buyers (intermediaries or consumers) can learn about the outbreaks and buy unimplicated varieties or brands (Pouliot & Sumner, 2013). In 2006 and 2008, major outbreaks of food-borne illness were associated with fresh (bagged) spinach and fresh tomatoes. However, authorities were not able to link either outbreak to its source immediately (Barton Behravesh et al., 2011; Kinsey et al., 2011). Shortly thereafter, major produce industry organizations and companies promoted the Produce Traceability Initiative as a voluntary, collective, solution for improving food safety.[9] Around the same time, the FSMA legislation required the establishment of pilot projects to improve food traceability.[10] More recently, Walmart has made headlines by asking some of its food suppliers to adopt blockchain-based traceability (Corkery & Popper, 2018; Walmart, 2018).

However, none of the initiatives mentioned here have been fully implemented as of the time of this writing.[11] Since 2006, advances in technology for genetic analysis has certainly improved authorities' ability to pinpoint the source of outbreaks. Still, the refusal of regulators or major industry players to require traceability, while relying on (visual) inspections and recordkeeping to document compliance with practices correlated with safety outcomes, is a potential shortcoming. The importance of accurate and quick traceability is underscored by the empirical evidence on reputation spillovers to producers and products not liable for the problems; traceability would greatly reduce misattribution and spillovers.

In July 2020, FDA announced a New Era of Smarter Food Safety blueprint[12]; the first of its four "core elements" is Tech-Enabled Traceability. Later that year, FDA published the FSMA Proposed Rule for Food Traceability Requirements.[13] The proposed rule requires recordkeeping for many commodities, according to risks of chemical and microbiological contamination, with exemptions for very small producers, nonprofits, and certain other categories. However, given the slow timeline for FSMA implementation to date, it may be several years before traceability is mandatory, and then only for certain FDA-regulated commodities.

Meanwhile, what could improve the adoption of private or collective standards for traceability? This question has remained largely unexplored to date. In China, food businesses may be exempt from punishment in the event of food safety problems if they have implemented some form of traceability (Zhou et al., 2022). This exemption from punishment is not a strong incentive to adopt traceability, though: in a sample of over 1100 seafood-market vendors in three Chinese provinces in 2018, Zhou et al. (2022) found that only about one third had adopted traceability. The authors find that vendors are 8–10 percentage points more likely to adopt traceability if both (1) vendors are subject to more frequent inspections and (2) information about inspection results is posted at the gates of markets. Particularly given that these businesses already have incentives to adopt traceability to avoid penalties, the results of Zhou et al. (2022) do not suggest that producers or vendors are eager to adopt voluntary traceability standards. In addition, Krzyzanowski Guerra and Boys (2022) note that for businesses to be able to maximize the benefits from blockchain traceability, they would need all businesses in their supply chains to adopt blockchain traceability, too. There is room for much additional research on the economics of traceability, whether or not blockchain-based.

Scares, recalls, spillovers, and asymmetric information

In a typical year, about 500 food product recalls are overseen by FDA or the USDA's Food Safety and Inspection Service (Page, 2018) and food recalls are also common in other countries. Several articles provide evidence that consumer and buyer demand for products may fall precipitously in the wake of a scare, and spill over to unimplicated products. Moreover, commodity markets have been shown to respond to recalls or scares even before the events are known to the general public.

In September 2008, it became widely known that Chinese dairy products manufacturers were using melamine to mimic protein in infant formula and other products. Numerous firms were identified as producing contaminated milk products, and dozens of countries banned the import of certain dairy products from China. Bai et al. (2021) use a difference-in-differences (DID) regression model and find that dairy exports fell by 68% following the scandal.[14] Breaking down the results to identify spillover effects, the authors find that contaminated firms' export revenues fell by 84% following the scandal, while spillover effects caused the export revenues of firms without contamination to fall by 54%.[15]

Several papers analyze the impacts of recalls on commodity prices by estimating abnormal returns in event-study frameworks, and find evidence suggesting that market participants have private information about pending recalls; price effects often precede recall announcements. Results from some key studies that use the abnormal returns approach are summarized in Table 2.[16] More work remains to explain the early transmission of information and the cost of asymmetric information in the context of food scares.

TABLE 2 Summary of meat recall event studies

Author(s) (year(s))	Market	Maximum price effects and timing
Moghadam et al. (2013)	Live cattle futures market (U.S., 1999–2011)	−1.4 pp, starting 7 days before recall announcements
Pozo and Schroeder (2016)	Stocks of meat and poultry firms (U.S., 1994–2013)	−1.1 pp, not before announcements
Kong et al. (2019)	Stocks of food firms (China, 2008–2016)	−3.8 pp, starting 1 day before announcements
Moon and Tonsor (2020)	Live cattle futures (U.S., 1994–2017)	−1.2 pp, not before announcements
Moon and Tonsor (2020)	Beef products (U.S., 1994–2017)	−4.0 pp, starting 1–7 days before announcements

Note: Effects reported in this table are average maximum cumulative abnormal returns (CAR) (i.e., averaged across recalls), in percentage points (pp). The timing reported in the table reflects the earliest time, with respect to the date of recalls, when average daily abnormal returns were estimated to be statistically significant. CAR effects reached their maximums between 4 days before (Moon & Tonsor, 2020) and 20 days after (Pozo & Schroeder, 2016) recall announcements.

In November 2018 an outbreak of *E. coli* in romaine lettuce from a single farm in California resulted in a recall and CDC advisory that lasted for several weeks. Spalding et al. (2022) use disaggregated data on prices and quantities sold at all stages of the supply chain and proprietary data from a processor-shipper to estimate the societal cost of the incident—around $300 million. They find that growers were largely insulated from losses because of their contracts with processors while processors bore most of the losses from unsaleable harvests and planted-and-unharvested crop acreage. Similar to studies of recalls in other markets, there is evidence that processors were aware of the contamination incident before the advisory was issued and that they took action to procure safe substitutes (especially iceberg lettuce) in the month leading up to the announcement.

Direct costs of food-safety problems to producers

Food-safety problems that lead to illnesses or other health issues generate externalities, in the sense that the costs of these problems are not paid fully by the parties that caused the problems. These externalities persist in part because of asymmetric information, and because both producers and buyers have incomplete information. Nevertheless, there are at least two channels through which the parties responsible for food-safety problems may be required to absorb some of the costs of the problems (aside from the market forces, namely reputation and demand, discussed above). These are (1) legal liability, and (2) the cost of destroying goods subject to a recall.

Although the threat of legal liability may create incentives for producers and suppliers to increase efforts related to food safety, these incentives are likely limited because responsible parties are so rarely penalized through the courts or settlements. Mahdu (2015) updates analysis by Buzby et al. (2001), and documents that over 1979 to 2014, at least 512 food-borne illness cases were resolved through the court system.[17] Of these cases, about one third resulted in monetary compensation to plaintiffs, with average compensation of about $276,000 in nominal terms. Plaintiffs' total nominal compensation was $49.2 million over the 36-year period covered

by the analysis. Considering that tens of millions of cases of food-borne illness are acquired each year in the United States (Scallan, Griffin, et al., 2011; Scallan, Hoekstra, et al., 2011) at an estimated public cost of over $15 billion (Hoffmann et al., 2015), the threat of legal liability does not seem to function as a major deterrent.

Public data on the cost of recalls to food producers is not generally available. Several studies have estimated the impacts of recalls on firms using stock price data, but this approach may include both direct effects of the recalls and indirect effects, for example, the effects of recalls on investors' perceptions of consumers' perceptions. Since the indirect effects would seem to dominate the direct effects in determining stock price reactions to recalls, I do not review this literature here and merely note that the cost of destroying goods subject to a recall likely serves as an incentive for producers and sellers to ensure they are providing safe food.

INSPECTIONS, INFORMATION DISCLOSURE, AND SAFETY OUTCOMES

Regulations, particularly regulations that require the disclosure of information about food-safety inspections or outcomes, can affect firms' reputations. Because firms desire to protect their reputations, information disclosure can incentivize firms to improve their efforts around food safety, or at least to try to achieve better inspection results. Information disclosure can also drive shifts in consumer demand. However, inspection outcomes may depend in part on the relationships between inspectors and inspected entities, so inspection and information disclosure is not a sure solution for improving food-safety outcomes.

Disclosure of restaurant hygiene inspection results

Some of the most compelling work on the economics of food safety is cast in the context of the economics of (asymmetric) information, focusing largely on hygiene inspection of restaurants. One distinguishing characteristic of this line of research is that the outcomes in the studies are often closely related to the information disclosed, and are carefully measured by inspectors without extrapolation to the number of illnesses caused. The disclosure of information about food safety can drive changes in both food-safety inspection outcomes and consumer behavior. In other words, inspection criteria do not have to be tightened, and penalties or sanctions do not have to be imposed, to incentivize improved safety outcomes. The publication or display of information about food safety affects consumers' assessments of restaurants' reputations and in some cases drives restaurants to improve their inspection outcomes.

In an influential paper, Jin and Leslie (2003) study the effects of mandating that hygiene cards (letter grades) be posted in Los Angeles County restaurant windows. They find that the introduction of grade cards, city-level mandates that grade cards be posted, and each of two changes in inspection criteria significantly increased average restaurant inspection scores. They also find that after grade cards were posted, *A*-grade and *B*-grade restaurants had higher revenues than prior to the posting of grade cards; and that hospitalizations for food-borne illness decreased after the introduction of grade cards. However, their empirical approach and results on hospitalizations are reassessed by Ho et al. (2019) and Jin and Leslie (2019) in two succinct papers, to which interested readers should refer.

In a follow-up, Jin and Leslie (2009) find that non-chain restaurants had greater (positive) hygiene-score responses to the introduction of grade cards in LA County than chain restaurants and that the franchised units had worse hygiene scores than company-owned units. The authors characterize these responses as evidence of chain restaurants, and even more so franchised restaurants, free-riding on the reputations of the larger brands. In another follow-up, Bederson et al. (2018) show that under a voluntary disclosure system in place in Maricopa County, Arizona, many *A*-grade restaurants do not disclose their grades. The authors interpret non-disclosure as evidence of countersignaling—a case where non-disclosure signals higher quality than disclosure by eager medium-quality rivals.

More recently, Dai and Luca (2020) implemented an experiment in collaboration with Yelp and the City of San Francisco to post restaurants' hygiene scores (and, when scores are below a certain threshold, an additional information box) within each restaurant's Yelp page. The authors find that demand responded to hygiene scores and that the demand response was even more dramatic when users were presented with additional (more salient) information in the case of low-scoring restaurants.

Although inspection of restaurants and subsequent information disclosure is effective, a few studies have demonstrated that behavioral adjustments by inspected entities, or improvements in inspection outcomes as the result of repeated interactions between inspectors and inspected entities, could counter this effectiveness. Bar and Zheng (2019) document that under the British Retail Consortium global food-safety standards program, manufacturers are likely to choose certifiers who are perceived to be lenient, and to choose the same certifier as in the previous period. Zheng and Bar (2021) study the same program and find that audit grades are higher when sites have been audited previously. They also find that when certifiers are less concentrated in a local market—reflecting greater competition—audit grades tend to be higher, which points to certifiers' incentives to grade leniently in order to retain customers.

Kovács et al. (2020) find that in LA County restaurant inspections, scores improve with repeated visits by the same inspector. The authors find that with repeat visits, inspectors are more likely to record compliance items as "not observed" and that consumer complaints increase with the tenure of the same inspector. In the same context, Makofske (2020) finds that when inspectors have discretion about how many points to deduct, they are likely to deduct fewer points when the restaurant is "on the margin", that is, near the thresholds that determine letter grades. He estimates that inspectors manipulated grades in 27% of marginal and discretionary cases over 2011–2016.

Given the evidence, it is important to design inspection criteria that minimize the potential for manipulation and subjectivity. Moreover, policy makers should consider whether restaurant inspections (among other types of food-safety regulations) should focus on safety and health *outcomes* rather than processes or practices.[18] To give a concrete example, even if a restaurant's operators ensure that staff wash hands, refrigerate food properly, and control pests, the restaurant's customers may occasionally suffer food-borne illness because of problems in the restaurant's supply chain. A typical hygiene inspection would reveal no problems with the restaurant if all of the practices were followed. If, instead, ingredients in the kitchen or prepared dishes were randomly sampled for pathogens, problems might become apparent. Given modern technological capacity for rapid genetic analysis, focusing on the outcomes—the presence of pathogens—rather than the correlates of food safety (hygiene practices, refrigeration, dishwasher temperature, etc.) might more efficiently reduce the transmission of food-borne illness in restaurants.

Disclosure of information about food safety in poultry processing

Since 1999, the USDA's Food Safety and Inspection Service (FSIS) has randomly sampled chicken carcasses at slaughter establishments for *Salmonella*.[19] In 2006, FSIS began categorizing establishments according to their results on these tests, according to discrete thresholds. Starting in 2008, category information was made public; several other changes followed to make the thresholds for public disclosure more stringent.

In Ollinger and Bovay (2020) and Bovay (2021, a working paper), we demonstrate that mandatory disclosure of information about *Salmonella* test results improved results on average. Using establishment-year data, Ollinger and Bovay (2020) estimate that the introduction of the category system in 2006 reduced the average share of samples testing positive by 6–10 percentage points; and that the introduction of public disclosure in 2008 reduced the average share of samples testing positive by 3–5 percentage points. In Bovay (2021), I use carcass-level data on *Salmonella* test results and confirm that the introduction of public disclosure in 2008 reduced the average share of samples testing positive by about 5 percentage points; however, a later tightening of standards led poorly performing establishments to perform even worse.

Disclosure of categorical information defined by discrete thresholds may induce shirking or moral hazard, especially among worse-performing entities that would need to work hard to achieve a better categorization outcome. In other words, establishment operators' incentives to ensure food safety depend on how close the establishments are to the thresholds. In Bovay (2021), I use regression discontinuity (RD) approaches to demonstrate that establishments exert effort to attain better categorization and shirk when failing to meet the required thresholds. However, public disclosure mitigates the shirking effect. The pattern of shirking suggests that buyers demanded more information from suppliers than what was publicly disclosed.

REPUTATION, PRIVATE STANDARDS, AND REGULATION IN THE U.S. FRESH PRODUCE INDUSTRY

The U.S. Food Safety Modernization Act of 2011 (FSMA) was the most sweeping change to food-safety regulation in the United States in about half a century. One of FSMA's major components (or rules) mandates practices related to the safety of fresh produce for the first time in the United States. This component, the Produce Safety Rule, is a striking example of the sometimes complex interactions between private standards and government regulations.[20]

Adoption of good agricultural practices

Private and voluntary standards may benefit producer groups in several ways. First, these standards may serve as templates for future regulation (Fulponi, 2007). Second, widespread compliance with voluntary standards may decrease regulators' efforts to enforce existing regulations (Innes & Sam, 2008) and may also decrease public support or politicians' support for more stringent new regulations (Malhotra et al., 2019). In general terms, voluntary self-regulation can crowd out formal government regulation (Kitzmueller & Shimshack, 2012).

Many of the on-farm safety practices required by FSMA were widely adopted by farms prior to passage or implementation of FSMA, especially large farms that supply a significant share of produce to major U.S. buyers (Adalja & Lichtenberg, 2018a, 2018b; Astill et al., 2018; Bovay, 2017;

Bovay & Sumner, 2018; Lichtenberg & Page, 2016; Marine et al., 2016). These voluntary practices are generally known as Good Agricultural Practices (GAPs). Although the evidence is mixed, it does not generally suggest that small growers or direct marketers invest much in food-safety practices. One could surmise that the reputations of small growers and direct marketers do not depend much on food safety. In the event of a food-safety problem originating from a small farm, relatively few consumers are likely to become ill. Thus, authorities are relatively unlikely to identify an outbreak as such, and the farm is unlikely to be identified as the source of the problem.

Lichtenberg and Page (2016), Marine et al. (2016), Adalja and Lichtenberg (2018a), and Astill et al. (2018) survey produce growers to understand the extent to which growers would need to change practices to comply with the FSMA Produce Safety Rule. Lichtenberg and Page (2016) find that mid-Atlantic growers of leafy greens and tomatoes were more likely to sample or test water, soil amendments, or products for microbes if they had more acreage of leafy greens and tomatoes or if they sold to grocery retailers. They also find that direct marketers were less likely to invest in employee protective gear. Marine et al. (2016) find that mid-Atlantic vegetable growers who sold their products wholesale were more likely to have written policies on growing and handling produce, test their irrigation water for contamination, and be GAP-certified than growers who direct marketed. Adalja and Lichtenberg (2018a) find that smaller growers, and growers who were members of "sustainable" grower organizations, were less likely to adopt certain practices required by FSMA, including sampling and testing, field inspections, sanitation and hygiene, and recordkeeping. Astill et al. (2018) find that larger growers were considerably more likely to adopt food-safety practices than smaller growers, while growers eligible for a "qualified exemption" were more likely to adopt than small but non-exempt growers.[21]

The data collected by Adalja and Lichtenberg (2018a) also include information about growers' costs of implementing various groups of practices, which Adalja and Lichtenberg (2018b) use to estimate the costs of complying with FSMA. They find that expenditures on food-safety practices, per acre, decrease with farm size. For example, the costs of record keeping and third-party audits vary little with acreage. In contrast, the cost of treating soil amendments to reduce contamination scales almost linearly with farm acreage. The authors apply their estimates to the distribution of farms by crop type and farm size according to the 2012 Census of Agriculture. They estimate that FSMA implementation will increase costs to vegetable growers by 0.4%; to fruit and tree nut growers by 0.6%; and to berry growers by 1.0%.

Adalja et al. (2021) use detailed data on collective food-safety standards adopted by grower organizations and government-sponsored entities to study the factors that influenced the adoption of standards prior to the passage of FSMA. Their main findings are that organizations whose growers represented a large share of production were more likely to adopt food-safety standards, and that standards were more likely to be adopted by commodity groups in the wake of outbreaks associated with a given commodity that resulted in hospitalizations. Moreover, they find that adoption of collective standards by government-backed organizations reduces recalls for pathogen contamination and hospitalizations and deaths from food-borne illnesses.

Distributional impacts of the food safety modernization act on producers

As discussed by Ferrier et al. (2022), large growers may particularly benefit from additional regulations governing safety, like FSMA. Produce Marketing Association (PMA), a major U.S.-based fruit and vegetable trade association, repeatedly submitted comments and testimony supporting increased regulation of the industry under FSMA and increased funding support for FDA's food

safety budget (Produce Marketing Association, 2015, 2021).[22] Many of the companies represented by PMA are part of industry groups that adopted collective standards for food safety before FDA finalized the FSMA Produce Safety Rule. Other member companies adopted food-safety practices voluntarily or because of contractual obligations. For example, Bovay and Sumner (2018) and Hu et al. (2022) note that major buyers such as Costco, Safeway, and Walmart require some form of GAPs audits for the farms in their supply chains. There are two potential benefits for the members of an organization like PMA, from additional regulation under FSMA. First, implementation of FSMA would increase costs for rival (non-member) farm companies, especially smaller farms, that had not previously adopted private or collective food-safety standards.[23] Second, food-borne illness outbreaks can harm the collective reputation of all producers of the affected commodity, and many even spill over to other commodities. The comprehensive adoption of food-safety practices under FSMA therefore protects the reputations of all growers, and especially protects the growers that had previously adopted GAPs or similar standards from spillover effects.[24]

Bovay and Sumner (2018) and Ferrier et al. (2022) explore the effects of various producer groups facing differential costs under FSMA on market prices and producer and consumer surplus using equilibrium displacement models (EDMs).[25] In Bovay and Sumner (2018), we focus on the North American fresh-tomato industry as a useful case study to demonstrate distributional impacts of FSMA on various groups of producers differentiated by (a) size, (b) location (United States or foreign), and (c) GAPs adoption prior to the actual implementation of FSMA. The distinction between U.S. and foreign farm locations is important because one FSMA rule requires that importers verify that their suppliers are in compliance with other FSMA rules including the Produce Safety Rule. In our central scenario, we project that U.S. producers' revenue would increase by 5% upon the full implementation of FSMA, while producers in Mexico and Canada would lose 2%–3% of revenue. We anticipate that revenues and market shares increase for only those U.S. growers with more than about $500,000 in annual sales of food (and for extremely small farms that qualify for a complete exemption from FSMA requirements). We also find that U.S. growers who have not already adopted standards similar to the FSMA rule will lose about 30% of revenue in implementing FSMA requirements.

In Bovay et al. (2018), we develop new estimates of the cost of compliance with the Produce Safety Rule for 18 fruit and 20 vegetable commodities. In Ferrier et al. (2022), we estimate own- and cross-price elasticities of consumer demand for each of the 38 commodities. We then use these cost and demand parameters as inputs in an EDM to simulate producer and consumer welfare effects of the rule. Overall, we find that effects are small, with consumer price increases of less than 1% for any individual commodity. Thus, we expect effects on consumption and nutrition to be small. Our simulation results suggest that FSMA implementation will reduce overall producer welfare by only about 0.6%. However, costs of compliance vary by commodity—in our model, a function purely of the distribution of farm sizes and exemption status—with growers of some commodities facing welfare losses of about 2.4%.

These studies show that the effects of implementing FSMA on farm and consumer prices are likely to be small but that some smaller farms will need to incur high costs to remain in the business of growing fresh produce legally. (Noncompliance is an option for some growers, depending on their buyers' requirements, since government audits of FSMA compliance are infrequent.) Farms may also choose to adapt to FSMA by growing a different mix of crops or marketing more of their production directly to final buyers rather than intermediaries to qualify for a near-total exemption from the Produce Safety Rule. The differential costs small, non-GAPs-adopting farms will incur to remain in the business of marketing produce will provide an advantage for larger farmers, particularly those that adopted GAPs several years ago. Given the evidence, the FSMA Produce Safety Rule can be seen in part as a successful lobbying effort by major produce industry organizations like the

Produce Marketing Association, to protect their members' (collective) reputations against outbreaks or scares triggered by (smaller) growers that had not previously adopted GAPs.

Implementation of the food safety modernization act and food-safety outcomes

Will the ongoing implementation of FSMA improve food-safety outcomes? I now present data from CDC's National Outbreak Reporting System (NORS) Dashboard reflecting food-borne illness outbreaks associated with fresh produce over 2011–2019.[26] Although by no means am I claiming causal relationships, the summary statistics show that implementation of the FSMA Produce Safety Rule has not so far been associated with any reductions in food-borne illness outbreaks, illnesses, or hospitalizations.

Figure 1 plots the number of illness outbreaks, illnesses, hospitalizations, and deaths associated with produce over 2011–2019. Recall that the FSMA Produce Safety Rule is being

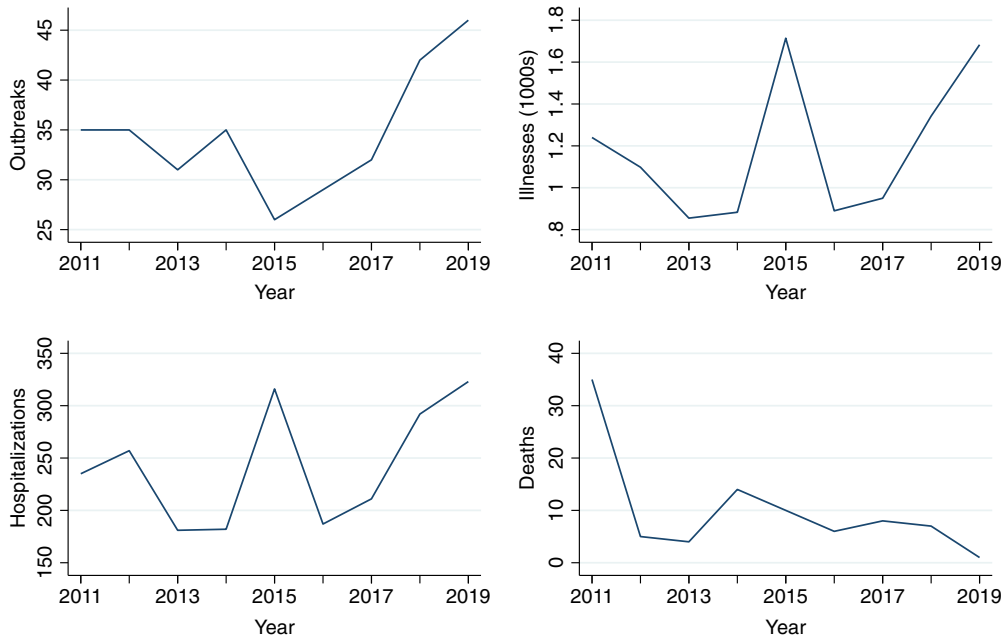

FIGURE 1 Number of food-borne illness outbreaks, illnesses, hospitalizations, and deaths from fresh produce, 2011–2019.

Note: Outbreaks and associated data are included in this graph if they are associated with ingredients in the following Interagency Food Safety Analytics Collaboration (IFSAC) categories: fruits, fungi, herbs, nuts and seeds, root/underground, seeded vegetables, sprouts, vegetable row crops, and if the etiology (ies) is (are) laboratory confirmed. I exclude two outbreaks associated with cashews and hazelnuts because these nuts are not regulated under the FSMA Produce Safety Rule. I also exclude 14 outbreaks (4% of the sample) with earliest reported symptom onset in January of any year because the date is only provided at the month-year level and the most relevant FSMA compliance dates were January 26, 2017, January 26, 2018, and January 28, 2019; I cannot be sure whether January outbreaks in these years began before or after the FSMA rule components were implemented. The trends observed are similar if non-laboratory-confirmed outbreaks are included and if January outbreaks are included. *Source:* Author's tabulations based on Centers for Disease Control and Prevention (2022).

TABLE 3 Implementation of the U.S. Food Safety Modernization Act (FSMA) and food-borne illness

	Outbreaks		Illnesses		Hospitalizations		Deaths	
Cutoff date	Pre-FSMA	Post-FSMA	Pre-FSMA	Post-FSMA	Pre-FSMA	Post-FSMA	Pre-FSMA	Post-FSMA
2017	31.8	40.0	1113.3	1325.0	226.3	275.3	12.3	5.3
2018	31.9	44.0	1090.0	1512.5	224.1	307.5	11.7	4.0
2019	33.1	46	1121.5	1683	232.6	323	11.1	1

Note: This table reports the average annual number of outbreaks of food-borne illnesses associated with fresh produce, and the number of illnesses, hospitalizations, and deaths associated with each outbreak, in the United States over various time intervals within 2011–2019. The table allows comparison of outcomes before and after the implementation of FSMA. The implementation chronology of FSMA is complicated, with six different implementation dates for various components of the Produce Safety Rule (and various categories of firms and farms) over 2017–2019 and additional implementation dates over 2020–2024. This table reports the average annual numbers before and after each of the major FSMA implementation dates, which occurred at the end of January 2017, 2018, and 2019. Because it is unknown whether January outbreaks began before or after the implementation dates, I exclude January outbreaks in all years (as in Figure 1). For a list of commodities included, see notes to Figure 1.

Source: Author's tabulations based on Centers for Disease Control and Prevention (2022).

implemented over several years starting in 2017, with staggering that does not allow for a clean case study. One might expect that outbreaks of food-borne illness associated with fresh produce should have declined starting sometime in 2018, when large growers who grow and sell the majority of U.S. produce needed to come into compliance. (Or perhaps the expected decline should have been apparent sometime later, when smaller growers needed to begin complying.) The data in Figure 1 show, however, that the number of outbreaks, confirmed illnesses, and hospitalizations trended upward over 2016–2019.[27] The average number of deaths fell after the implementation of FSMA, with only one death recorded in 2019. The same data are summarized in Table 3, comparing outcomes before and after various implementation dates. Note again that this is not a causal analysis, but based on these data, it is unlikely that any causal analysis would conclude that the FSMA Produce Safety Rule has reduced food-borne illness.[28]

It should not be surprising to find that the FSMA Produce Safety Rule has had negligible effects on food-safety outcomes including confirmed cases of illness. Similar to hygiene inspections of restaurants, the Produce Safety Rule focuses on correlates of food safety rather than sampling produce for contamination and issuing fines or (public or private) warnings. If FSMA had required implementation of an automatic and unified system for traceability, the probability of bad actors being discovered would be higher. As it is, smaller growers—who were much less likely than larger growers to have adopted GAPs or similar voluntary standards for produce safety, pre-FSMA—face little risk that outbreaks will be traced to their farms. Private and collective food-safety practices were widely adopted before FSMA implementation, and some of them improved safety outcomes (Adalja et al., 2021). Moreover, practices are merely correlated with outcomes. In addition, since some farms have incentives not to comply with the regulations, FSMA was never likely to result in sea changes in on-farm safety practices.

CONCLUDING THOUGHTS

I now present some concluding perspectives on food safety, reputation, and regulation, and suggestions on the design of future policies.

Generally, food is safe to consume, in both developed and developing countries. Good food-safety outcomes are the result, in part, of private incentives that face food producers and marketers to provide safe food. There is limited evidence that consumers and other buyers are willing to pay more for food produced according to Good Agricultural Practices (GAPs) or other standards, and there may be modest demand for food associated with good food-safety test results. On the other hand, negative information about food safety, especially recalls and scares—has often led to severely negative demand shocks. These negative demand shocks appear to be the major incentive facing producers in the United States because traceability is not required by law nor generally required by market participants and legal liability for food-safety problems has not historically been economically meaningful. In some contexts, government-mandated disclosure of information about food-safety inspections has also been shown to change demand and improve safety outcomes.

Producers and sellers often implement private or collective standards for food safety as an investment in their own reputations. Producers who have invested in such standards can benefit from additional regulations that improve safety because these regulations can further bolster the reputation of the industry and also raise costs for rival firms. Thus, food-safety regulations may have effects on competition and certainly can have differential welfare effects. Similarly, the design of inspection criteria for, for example, restaurants, may also advantage certain types of businesses at the expense of others, although this issue does not appear to have been explored within the economics literature.[29]

Some potential policy changes that could further incentivize the provision of food safety include the following. In contexts where food safety is a persistent concern, information disclosure could affect buyer and consumer demand for relatively safe and unsafe products or brands, and thereby incentivize producers and sellers to provide higher levels of safety. Mandatory traceability policies could allow for faster product recalls and reduce the number of people getting ill from any given outbreak, and through reputation effects would incentivize further improved provision of safety, although the costs and benefits of mandatory traceability should be evaluated. Future economics research could inform the design of policies by considering whether outcome-based regulations are more cost-effective than practice-based regulations.

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ENDNOTES

[1] Jaffee et al. (2018) assign the economic cost of disease as per capita income multiplied by the number of disability-adjusted life years (DALYs) related to food-borne illness in each country or region for which data are available.

[2] Hoffmann et al. (2015) include only 15 major pathogens, which cause about 19% of food-borne illnesses (see Hoffmann et al., 2015, p. 2). Also, Hoffmann et al. (2015) assume the cost of death is the value of a statistical life, which is substantially greater than the DALYs valuation assigned by Jaffee et al. (2018). Hence, the $15.5 billion estimate reported by Hoffmann et al. (2015) is not comparable with the $110 billion estimate reported by Jaffee et al. (2018).

[3] Scallan et al. (2011a) and Scallan et al. (2011b) provide separate estimates for the number of cases of food-borne illness caused by 31 "major pathogens" and an unknown number of "unspecified agents." Here, I sum

the means of the two estimates, the lower bounds of the two estimates, and the upper bounds of the two estimates, to provide an approximate mean and credible interval for the total number of illnesses from all agents.

[4] In this discussion, I focus on the cost of illness, but another approach to valuing safety improvements is estimating willingness to pay, for example, through choice experiments. I do not focus on such approaches because if people were really willing to pay a premium for food-safety assurances beyond the existing mandatory or voluntary standards, we would expect the market to allow them to do so, especially given the proliferation of food choices and information about food available to consumers in developed countries.

[5] An exception is McFadden and Huffman (2017), who implemented auctions to estimate consumers' WTP for new genetically modified potatoes and potato products with lower levels of acrylamide, which is probably carcinogenic.

[6] For additional background on RCTs, please refer to articles such as List (2011) and Banerjee et al. (2017).

[7] The data used in Bovay (2017) are imperfect, as described on page 796 of that paper. I use weekly data from USDA's Agricultural Marketing Service on quantities of fresh tomatoes shipped from various points within the United States (including ports and border points) and prices paid for fresh tomatoes at terminal markets. The two data sets do not link together as nicely as one would hope, partly because the lag times between shipment and terminal market sales are unknown. More importantly, it appears that shipments from a particular origin often appear in the quantity data but not in the price data, or vice versa. Given these shortcomings, I caution against linking the AMS price and quantity data for fresh fruits and vegetables. However, the data quality might have improved since then, or might improve in the future.

[8] 7.8 billion $\times$ 365/600 million $=$ 4745.

[9] See https://www.producetraceability.org.

[10] See 124 STAT. 3930, https://www.govinfo.gov/content/pkg/PLAW-111publ353/pdf/PLAW-111publ353.pdf.

[11] According to Collart and Canales (2022), a handful of private companies have adopted blockchain-based traceability with origin information accessible to consumers through QR code scanning, for a limited number of products. These programs are not focused on food safety.

[12] See https://www.fda.gov/media/139868/download.

[13] See 85 CFR 59984, https://www.federalregister.gov/documents/2020/09/23/2020-20100/requirements-for-additional-traceability-records-for-certain-foods.

[14] In DID-type approaches, a treatment variable (discrete or continuous) is introduced at a certain point in time (or multiple points in time) and outcomes for treated and untreated (or, more treated and less treated) units are compared. DID-type methods are rapidly evolving. Several recent papers provide guidance on how to specify empirical models when the classical two-period two-group empirical setting does not apply. See papers such as de Chaisemartin and d'Haultfœuille (2018, 2020), Sun and Abraham (2020), Borusyak et al. (2021), Callaway and Sant'Anna (2021), and Callaway et al. (2021).

[15] In another context, Arnade et al. (2009) find that demand shocks associated with the 2006 outbreak of *E. coli* in fresh, bagged spinach spilled over to bulk spinach and persisted for about 6 months.

[16] Under the abnormal returns approach, daily returns are defined as the log of the ratio of daily prices for a commodity, for days t and $t-1$. Daily returns are predicted using a linear regression with pre-event data; abnormal returns are the difference between daily returns post-event and the predicted value of daily returns. Using a different event-study approach, Carter and Smith (2007) explore the effects of a non-safety food scare, in which genetically modified StarLink corn, which was not approved for human consumption, was found in the human food-corn supply chain. The authors find that the StarLink event reduced the price of corn by 6.8%, relative to the price of sorghum, for a six-week period starting July 17, 2000, which was 2 months before news reports first mentioned the StarLink event.

[17] Mahdu (2015) offers the caveats that (1) liability cases dropped or settled out of court are not included in his data set, and (2) the data set was created on the basis of private, subscription-based legal databases and therefore may not represent the universe of resolved court cases.

[18] Josling, Roberts, and Orden (2004, p. 23) note that product standards—a type of outcome-based regulation—can in some cases be more efficient than process standards.

[19] A slaughter "establishment" may also be thought of as a facility, plant, or slaughterhouse.

[20] Implementation of the FSMA Produce Safety Rule started in 2017, but is being slowly phased in and has been delayed at least once, so the rule will not be fully implemented until 2024. See https://www.fda.gov/media/106390/download.

[21] For more information about qualification for exemptions from the FSMA Produce Safety Rule, see Bovay et al. (2018) and Appendix B of Astill et al. (2018).

[22] PMA, which merged with United Fresh effective in 2022, is now known as the International Fresh Produce Assocation (IFPA).

[23] Salop and Scheffman (1983) discuss how product standards can raise rival firms' costs and show that if dominant firms' average cost curves rise by less than their residual demand curves, then dominant firms' price–cost margins, and hence profits, will rise.

[24] Collective adoption of quality standards may improve producer welfare in contexts other than safety. Winfree and McCluskey (2005) model collective reputation as a dynamic common property resource problem and show that implementing minimum quality standards can be Pareto improving because firms acting individually would provide products with quality lower than optimal for the group. See Winfree (2022) for additional examples and discussion.

[25] EDMs use estimated parameters including supply and demand elasticities to simulate market outcomes following some shifts in supply or demand.

[26] Data from 2020 to the present are excluded from the presentation and discussion here because COVID may have confounded diagnosis and reporting, and also changed the way that people acquire their meals.

[27] The data in both Table 3 and Figure 1 are assigned to their respective years based on the years of earliest date of reported symptom onset. Some outbreaks may have spanned periods before and after the dates when specific FSMA components were implemented.

[28] One explanation for rising numbers of outbreaks, illnesses, and hospitalizations associated with produce commodities might be improvements in technology for traceability and genetic analysis; illnesses associated with food-borne disease might have been easier to detect in 2019 than in 2015.

[29] I thank a referee for lending insight on this point.

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