Foodborne Illness Outbreaks, Collective Reputation, and Voluntary Adoption of Industry-wide Food Safety Protocols by Fruit and Vegetable Growers

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Abstract. We examine theoretically and empirically the factors associated with commodity organizations' voluntary adoption of stricter food safety guidelines. Our theoretical analysis finds that larger organizations are less likely to require members to invest in food safety procedures due to higher implementation costs. Recalls induce organizations to adopt stricter food safety standards only when expected future gains from improved product reputation outweigh the short run costs of implementing those standards. The same logic holds for organizations representing growers of a product with higher demand, e.g., a larger share of fruit and vegetable sales. Organizations whose members have a larger share of the market for their product are more likely to adopt stricter food safety guidelines when that investment induces members to increase output, a necessary condition for which is that members' current food safety procedures are more protective than the industry average. Our econometric analysis finds that organizations with more members are less likely to adopt food safety guidelines for their members, as our theoretical analysis predicts. Organizations whose members account for a larger share of the market for their product and organizations for commodities representing larger shares of fruit and vegetable sales are more likely to implement food safety guidelines, consistent with considerations of long term profitability increases due to improved reputation for safety outweighing concerns about increases in cost of production. Organizations that have experienced negative shocks to reputation as measured by the number of Class I FDA recalls are also more likely to adopt food safety guidelines, again consistent with considerations of long term profitability due to improved reputation for safety outweighing concerns about increases in cost of production.

Keywords. food safety, collective reputation, minimum quality standard

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The past decade has witnessed outbreaks of foodborne illness that seem unprecedented in contemporary developed countries. In the United States, for instance, the number of reported outbreaks rose from an annual average of 550 during 1993-1997 to 1218 during 1998-2008 (Olsen et al. 2000, Gould et al. 2013). Similarly, recalls of raw food products increased from none in 2003 to almost 100 in 2012. In response, Congress passed the Food Safety Modernization Act [FSMA] of 2011, giving the FDA legislative authority to require comprehensive, science-based preventive controls across the food supply, including the growing, harvesting, packing, and holding of fresh fruits and vegetables. New federal regulations implementing FSMA for raw and processed foods were finalized at the end of 2015. In the meantime, a number of commodity organizations have responded to rising food safety concerns by adopting their own voluntary food safety protocols.

This paper examines the factors that lead commodity organizations to adopt their own voluntary food safety protocols. We develop a conceptual framework explaining the conditions under which such voluntary adoption is optimal for a group of growers. We test hypotheses generated by that conceptual framework using a unique data set that combines information about food recalls with information about industry characteristics.

Information on the extent to which industries self-regulate will be useful in determining the level of regulatory oversight necessary to ensure a safe and wholesome food supply. Moreover, given heterogeneity across commodity organizations, this analysis will also prove informative in determining how differences in the market structure of various commodities may provide either an incentive or disincentive to develop guidelines. Identification of these differences will allow regulators to better target oversight efforts. Lastly, little information currently exists about the impact of recalls on collective producer behavior. This analysis will determine the extent to which the development of industry food safety guidelines following recall events are an effort to demonstrate legitimacy within an industry and promote a collective reputation, while also reducing uncertainty with regards to quality of the collective output.

Theory

The literature to date views adoption of food safety protocols as a form of minimum quality standard designed to enhance and protect firms' reputation for (high) quality (see for example Tirole 1996, Fleckinger 2007, Dranove & Jin 2010, Costanigro et al. 2012, Castriota & Delmastro 2015). Food safety is an experience characteristic—consumers can't observe whether food items they purchase are free of bacterial contamination, toxic compounds, or other harmful adulterants. Reputation becomes important in such cases (Kreps and Wilson 1982, Shapiro 1983, Fudenberg and Levine 1992). Reputation for food safety is primarily collective, pertaining to the commodity as a whole rather than to an individual grower: The prevalence of non-branded raw foods is high and branded products are sourced from multiple growers, many of whom may provide product to multiple packagers. Collective reputation as safe food can thus be viewed as a common pool resource (Winfree and McCluskey 2005, Saak 2012). When firms are identical, minimum quality standards (e.g., food safety protocols) increase collective welfare by expanding market size as well as by increasing willingness to pay (Leland 1979, Shapiro 1983, Falvey 1989, Winfree and McCluskey 2005, Saak 2012, McQuade et al. 2016) and can be implemented by trigger strategies punishing firms in non-compliance. Collective adoption and enforcement of food safety standards is more likely in industries with a smaller number of firms and/or greater concentration because free riding incentives are weaker and the benefits from adoption are greater in such industries (Kandori 1992, Rob and Fishman 2005).

Our theoretical analysis builds on the reputation-as-common-pool conceptualization of Winfree and McCluskey (2005) and McQuade et al. (2016). Fruits and vegetables are experience goods whose quality is determined only on consumption, as appearance provides only limited information about taste, texture, and other attributes of quality. In the case of food safety, quality is determined only after consumption, as foodborne illness does not take effect immediately. Fruits and vegetables are differentiated by brand only to a limited extent, if at all, so that reputation for safety (or lack thereof) accrues to the product as a whole rather than to a specific seller. Traceability and liability for causing illness range from limited to non-existent, hence the common pool nature of the problem. Consumers thus base their perception of the safety of food products on their own past experience with those products and on the experiences of others they learn about through word of mouth or through publicized incidents like product recalls.

Demand in any period is downward sloping and increasing in perceived food safety R. To simplify the analysis, we use the quasi-linear demand specification of McQuade et al. (2016),

$$p(Q,R) = a + \theta R - U(Q)$$

where $Q = \sum_j q_j + Q_{-j}$ denotes the combined output of the product by members of a grower organization (q_j) and by growers who are not members of the organization (Q_{-j}). Consumers' perception of the safety of consuming a product is subject to Bayesian updating. Perceived food safety at the end of any period is thus a weighted sum of the product's reputation for food safety at the end of the previous period and investment in food safety procedures by members (k_j) and non-members (k_{-j}) of the organization in the current period, with weight equal to market share

$$R_t = \omega R_{t-1} + (1-\omega)\left(\frac{\sum q_j k_j}{Q} + k_{-j}\frac{Q_{-j}}{Q}\right)$$

A recall in this framework is a downward shock to the product's reputation for food safety at the end of the preceding period, $dR_{t-1} < 0$ (see Arnade et al. (2012) for some empirical evidence on the effects of food safety recalls on demand).

Consider a two period problem facing an organization representing grower interests in some way and the growers who are members of that organization. Grower *j* produces output q_j at a constant marginal cost that depends on investment in safety procedures, $c_j(k_j)$. The organization requires its members to adopt a given set of safety procedures. For simplicity, assume that cost of implementing the required safety procedures is the same for all growers, $k_j = k \; \forall \; j$. The organization's cost of developing those procedures and ensuring their adoption by all members is $f(n)e(k)$, where *n* is the number of members in the organization. We assume that the marginal implementation cost is positive and increasing in the stringency of food safety measures, $e'(k), e''(k) > 0$ and in the size of the organization, $f'(n), f''(n) > 0$.

Firms choose output and the grower organization chooses members' investment in safety procedures to maximize current profits taking into account the present value of profits in all future periods, assumed constant and dependent on the product's perceived safety, $\pi(R_1)/\delta$ (where $0 \le \delta \le 1$ is a discount rate), and assumed to be increasing and quasi-concave in perceived safety. Both growers and the grower organization are assumed to be price takers. Neither takes into account strategic considerations of how their choices affect non-member growers' actions, which are treated as exogenously fixed. Let R_0 denote the product's initial reputation for safety, also fixed exogenously.

Grower Profit Maximization

Each grower chooses output q_j to maximize the present value of profit,

$$pq_j - c_j(k)q_j + \delta^{-1}\pi_j\left[\omega R_0 + (1-\omega)\left(k\frac{\sum q_j}{Q} + k_{-j}\frac{Q_{-j}}{Q}\right)\right]$$

The necessary condition for an interior maximum, assuming market clearing, is

$$a + \theta R_0 - U(Q) - c_j(k) + \delta^{-1}\pi_j' \cdot (1-\omega)\frac{1-s}{Q}\left(k - k_{-j}\right) = 0$$

(Here s denotes the organization's market share $\sum q_j/Q$). Each grower equates marginal cost with the sum of the market price of the product and the present value of marginal profit due to changes to the product's reputation for food safety caused by consumers' current experience with the product. If the organization's safety protocols are stricter (require greater investment) than those of non-members ($k > k_{-j}$), organization members will choose output levels greater than that which equates marginal cost with price. In other words, greater than average investment in food safety procedures induces members of the organization to expand output as a means of enhancing the product's overall reputation for safety, thereby increasing their own future profits. Lower than average investment in food safety procedures, in contrast, leads organization members to reduce current output in order to protect the product's reputation and thus their own future profits.

The second order condition for a maximum holds under our assumptions, so if an interior maximum exists, it is unique.

An exogenous shock to the product's reputation for safety (e.g., an FDA recall of the product) has an ambiguous impact on output:

$$\frac{\partial q_j}{\partial R_0} = -\Omega^{-1}\left[\theta + \delta^{-1}\pi_j{}'' \cdot \omega \cdot (1-\omega) \cdot (k - k_{-j}) \cdot Q^{-1}(1-s)\right]$$

where $\Omega < 0$ denotes the second derivative of profit with respect to output. The short run effect of a recall is a reduction in willingness to pay (θ) that gives growers an incentive to reduce output. If the organization's food safety protocols are stricter than the rest of the industry ($k = k_{-j} > 0$), however, increases in current output will help improve the product's reputation for food safety in the future; if the expected increase in future profit is large enough, then a recall will induce members of the organization to increase output in the short run.

The organization's imposition of stricter food safety guidelines (requiring greater investment in food safety, $dk > 0$) has a similarly ambiguous effect on output,

$$\frac{\partial q_j}{\partial k} = -\Omega^{-1}\delta^{-1}(1-\omega)Q^{-1}(1-s)\left[\pi_j{}' + \pi_j{}'' \cdot (1-\omega)s\right]$$

In the short run, an increase in food safety investment means an increase in marginal production cost that creates an incentive to reduce output. In the long run, an increase in food safety investment means an enhancement of the product's reputation for safety and thus higher willingness to pay and greater profitability in the future, which creates a countervailing incentive to increase output.

The Grower Organization's Choice of Food Safety Procedures

The grower organization chooses a required level of investment in food safety practices for members k to maximize the present value of its members' profits

$$\sum_j \left\{pq_j - c_j(k)q_j + \delta^{-1}\pi_j\left[\omega R_0 + (1-\omega)\left(k\frac{\sum q_j}{Q} + k_{-j}\frac{Q_{-j}}{Q}\right)\right]\right\}$$

The necessary condition for an interior maximum, assuming market clearing, is

$$\sum_j \{c_j' \cdot q_j + \delta^{-1} \cdot (1-\omega) \cdot s \cdot \pi_j'\} - f(n)e' = 0$$

The organization trades off short term increases in members' costs of production and its own costs of getting its members to implement investments in food safety procedures against the present value of future increases in members' profits due to an enhancement in the product's reputation for safety.

The second order condition for a maximum holds under our assumptions, so if an interior maximum exists, it is unique. An exogenous shock to the product's reputation for safety (e.g., an FDA recall of the product) has an ambiguous impact on investment in food safety procedures:

$$\frac{\partial k}{\partial R_0} = -\mathrm{Z}^{-1}\delta^{-1}\sum\nolimits_j \left\{\pi_j''\omega(1-\omega)s + \{(1-\omega)Q^{-1}(1-s)[\pi_j' + \pi_j''(k-k_{-j})s] - \delta c_j{}'\}\frac{\partial q_j}{\partial R_0}\right\}$$

(Here $Z < 0$ denotes the second derivative of the objective function with respect to food safety investment *k*.) The direct effect of an exogenous reduction in the product's reputation for safety is an incentive to increase investment in food safety procedures as a means of increasing future willingness to pay and, thus, the present value of members' future profits. The organization also takes into account the indirect effect of a reputation shock on the product's reputation for safety along with the effect of greater investment in food safety procedures on members' marginal production costs via impacts on members' output (the term in small curly brackets).

Organizations with larger numbers of members (and, implicitly, greater diversity of members) face higher costs of implementing stricter food safety procedures. Investment in food safety procedures is thus decreasing in membership size:

$$\frac{\partial k}{\partial n} = Z^{-1}f'e' \leq 0$$

The effect of member's share of the product market on the level of investment in food safety required by a grower organization is:

$$\frac{\partial k}{\partial s} = -\mathrm{Z}^{-1}\delta^{-1}(1-\omega)\sum\nolimits_j \{\pi_j' + \pi_j''k(1-\omega)\}$$

That effect is ambiguous: Organizations whose members have a larger current share of the market for a product may or may not require their members to invest more in product safety. On the one hand, members of an organization with a larger market share appropriate a larger share of any gains in future profit due to enhancement of the product's reputation for food safety. At the same time, the magnitude of any such gains is decreasing in market share; diminishing productivity of food safety investments may induce organizations to reduce, rather than increase, investments in food safety procedures. The sign of $\partial k/\partial s$ is the same as the sign of $\partial q_j/\partial k$; thus organizations whose members collectively account for a larger share of the market will require their members to invest more in product safety procedures whenever that investment will induce those members to increase output, and vice versa.

Finally, the effect of greater demand for the product on required investment in food safety procedures is:

$$\frac{\partial k}{\partial a} = \Omega^{-1}\mathrm{Z}^{-1}\delta^{-1}\sum\nolimits_j \left\{\left\{(1-\omega)Q^{-1}(1-s)\left[\pi_j' + \pi_j''\left(k - k_{-j}\right)s\right] - \delta c_j{}'\right\}\right\}$$

An increase in demand for the product increases the output of each member of the organization ($\partial q_j/\partial a = -\Omega^{-1} > 0$). If that increases in output improves the reputation of the product by an amount that exceeds the increase in members' production costs, an increase in demand for the product will induce the organization to require greater investment in food safety procedures.

Extrapolating to the discrete outcome case of whether an organization adopts guidelines that require members to follow stricter food safety procedures, these comparative static results imply that (1) organizations with larger memberships are less likely to adopt stricter food safety guidelines; (2) organizations whose members have a larger share of the market for their product are more likely to adopt stricter food safety guidelines when that investment induces members to increase output, a necessary condition for which is that members' current food safety procedures are more protective than the industry average; (3) organizations representing growers of a product with higher demand are more likely to adopt stricter food safety guidelines when the long run gains from improvements in the reputation of the product outweigh short run losses due to higher production costs; and (4) organizations are more likely to adopt stricter food safety guidelines in response to recalls when they perceive that long run gains from improvements in the reputation of their product outweigh short run losses due to higher production costs and possible losses of members' market share.

Data

Commodity Organizations

Our empirical analysis examines the effects of industry composition and reputation shocks on the voluntary adoption of food safety protocols. We have constructed a unique data set that combines information about food recalls with information about industry characteristics. By reviewing USDA and state-level marketing orders, USDA research and promotion programs, state commission laws, as well as through extensive Internet searches for commodity specific trade organizations, we have identified 145 fruit and vegetable commodity organizations operating in the U.S. Table 1 presents summary statistics for these organizations. Slightly less than a third of the commodity organizations originate with USDA or state marketing orders, about an eighth come from USDA or state research and promotion programs, and about a twelfth come from state commission laws. The remaining half is comprised of industry-based trade organizations.

Our data includes descriptive information for each organization, including the type of organization; jurisdiction; commodity; year established; whether or not the organization has authorization for volume control, quality regulation, and/or marketing research and development; and details on any commodity specific food safety guidelines in place. Almost a fifth of all organizations have established commodity specific food safety guidelines, the earliest in 2005 and the most recent in 2013. Of those that have adopted guidelines, just under 60% are industry-based trade organizations, 25% are based on marketing orders, about 10% come from state commission laws, and about 7% originate with research and promotion programs.

We augment these data with industry statistics relevant to the commodity and state jurisdiction of each organization from the USDA-NASS Census of Agriculture and annual USDA-NASS Crop Surveys. The additional data include number of farm operations, acres harvested or bearing fruit, and production value measured in dollars. For most commodities, operation and acreage data comes from the Census, while production value comes from the Crop Survey[1]. These data are collected at the state and commodity level for each wave of the Census and Survey between 2005 and 2013. For each organization, the statistics are aggregated based on its commodity, state jurisdiction, and the year it established food safety guidelines. If an organization has not established food safety guidelines or if those guidelines were established after 2012, we use industry data from 2012 to match our most recent year of FDA recall data. The Census is conducted every five years (most recently in 2012), so in cases without an exact year match based on the above criteria, we use the next closest year for the relevant statistics.

With this information we construct several industry measures for each commodity organization that we use in our econometric analysis. We use number of farm operations as a measure of concentration within each commodity organization. We also calculate each organization's share of national sales for its specific commodity as a measure of market share. Lastly, we compute each commodity's national share of total sales of fruits, vegetables, and tree

[1] There are a few exceptions to this: production value data for total fruit and vegetables, mushrooms, sorghum, and soybeans comes from the Census; acreage data for raisins comes from the Crop Survey; operations data for raisins comes from the California Raisin Board; and production value data for culinary herbs is imputed from the 2011 NASS-USDA Organic Census. For culinary herbs, production value is imputed as follows. The Census provides total acreage data for culinary herbs. We calculate herb production yield (lbs/acre) using national organic production and organic acres harvested. Then, we compute the herb price ($/lb) using national organic sales in conventional markets, measured in dollar and in pounds. Finally, we calculate total production value in dollars as: Acreage * Herb Yield * Herb Price.

nuts in the U.S., which provides a measure of each commodity's relative salience and demand in overall food sales.

FDA Food Recalls

Food recalls represent shocks to commodity reputation (see for example Arnade et al. 2009). We have compiled a novel data set of all FDA food recalls that occurred in the U.S., beginning in 2005. For each recall, our dataset includes basic information about the product(s), recall date, firm location, distribution regions, and brands. We have also collected more detailed information about the severity of reputations shocks as indicated by FDA classification, the reason for the recall, whether the recall was voluntary or mandated, total quantity affected, method of discovery, notification level, and whether enforcement reports and/or press releases were issued.

Table 2 presents yearly FDA recall frequencies for relevant commodities (based on our commodity organization data) in total and by FDA classification, geographic scope, and recall reason. When FDA issues a recall enforcement report, the event is classified into one of three categories, according to the level of hazard, with Class I the most dangerous and Class III the least. For example, food found to contain botulinum toxin would be a Class I recall, a product with undeclared sulfites may be a Class II recall, and food with a minor container defect would be a Class III recall. For some recalls, the FDA did not issue an enforcement report, in which case we do not know how the recall was classified. Across all years, two-thirds of recalls are categorized as Class I, although there is some variability across years. Class II recalls comprise about one-twelfth of the total, and Class III recalls make up less than a twentieth. Recalls with missing enforcement reports comprise about one-fifth of the data.

In terms of geographic scope, slightly more than a fifth of recalls are national in distribution, a little more than half are regional (more than one state), and about a quarter are limited to one state. Across all years, data on the geographic distribution is missing for about 2% of the recalls. As far as the reasons for recalls, about four-fifths of recalls are due to potential pathogenic contamination (e.g. *Salmonella*, *Listeria monocytogenes*, etc.), and one-fifth are attributable to other types of contamination. On a yearly basis, 2009 saw an abnormally large number of recalls. That large number is attributable to a series of recalls on peanuts and peanut butter products from the Peanut Corporation of America that year, which accounted for two-fifths of all recalls in 2009.

We combine this information with our industry data to create a data set linking each commodity organization with relevant FDA food recalls that differ in geographic scope and severity. We calculate the national cumulative number of FDA recalls by commodity on a yearly basis. This data is computed in aggregate as well as separately by FDA class, geographic scope, and recall reason. We merge this data with the commodity organization data based on the relevant commodity and the year the organization established food safety guidelines. As in the case of the industry data, if an organization has not established food safety guidelines or if those guidelines were established after 2012, we use the most recent cumulative FDA recall data from 2012.

Summary Statistics

Based on Table 1, organizations with food safety guidelines are more concentrated (fewer farm operations) and command a greater market share of their commodity, on average. However, the average national commodity share of total fruit and vegetable sales is very similar across organizations with and without guidelines. Somewhat surprisingly, commodity organizations with food safety guidelines, on average, have fewer cumulative FDA recalls nationally for their commodities *prior to* adopting those guidelines, compared to organizations without guidelines.

These statistics point to some interesting differences between commodity organizations that choose to adopt food safety guidelines and those that do not. To isolate systematic differences in the probability of adoption of food safety guidelines across commodity organizations, in the next section we employ a multivariate econometric model to control for confounding factors.

Econometric Model

We model a commodity organization's adoption of food safety guidelines using a standard latent variable-based probit model. We assume that organization *i* obtains an unobserved net benefit V_i from adopting food safety guidelines. Consistent with our theoretical analysis, we treat that net benefit as a function of the number of operations active in the organization, the organization's market share, the commodity's national share of overall sales of fruits and vegetables, and the cumulative number of FDA recalls for that commodity by FDA classification, along with a normally distributed, mean-zero random error term ϵ_i:

(1) $$V_i = \beta_0 + \beta_1 \text{Operations}_i + \beta_2 \text{MktShr}_i + \beta_3 \text{CommShr}_i + \mathbf{RecallsByClass}'\boldsymbol{\beta_4} + \epsilon_i$$

Let I_i be an indicator taking on a value of 1 if organization *i* adopts food safety guidelines and 0 if it does not. We assume the organization chooses to adopt food safety guidelines if the net benefits of doing so are positive:

$$\mathrm{I}_i = \begin{cases} 1 \text{ if } V_i > 0 \\ 0 \text{ if } V_i \le 0 \end{cases}$$

We can express the probability that organization *i* adopts food safety guidelines as

$$\text{Prob}(\mathrm{I}_i = 1) = 1 - \Phi(V_i),$$

where $\Phi(\cdot)$ is a standard normal cumulative distribution.

Commodity organizations that originate from USDA or state marketing orders often have regulatory authority to enforce quality regulation on their members. As such, these organizations may face lower costs of getting members to implement food safety protocols and may therefore be more likely to adopt food safety guidelines. To capture the effect of marketing order authorization on organizations' adoption of food safety guidelines, we estimate two additional model specifications, one including an indicator for marketing order and a second interacting this indicator with FDA recall counts by class in addition:

$$(2) \qquad V_i = \beta_0 + \beta_1 \text{Operations}_i + \beta_2 \text{MktShr}_i + \beta_3 \text{CommShr}_i + \textbf{RecallsByClass}_i' \boldsymbol{\beta_4} + \beta_5 \text{MktgOrderInd}_i + \epsilon_i$$

$$(3) \qquad V_i = \beta_0 + \beta_1 \text{Operations}_i + \beta_2 \text{MktShr}_i + \beta_3 \text{CommShr}_i + \textbf{RecallsByClass}_i' \boldsymbol{\beta_4} + \beta_5 \text{MktgOrderInd}_i + (\textbf{RecallsByClass}_i' \times \text{MktgOrderInd}_i) \boldsymbol{\beta_6} + \epsilon_i$$

In each of the three specifications, we expect the number of firms to be negatively correlated with the likelihood of adoption due to greater incentives for free riding and greater costs of collective organization. We expect the organization's share of sales of the commodity to be positively correlated with the likelihood of adoption due to greater benefits from reputation and because improvements in reputation can lead to greater market share (McQuade et al. 2016). We expect commodities with larger shares of overall raw food spending to have more salience in consumer perceptions so that shocks to reputation are likely to have larger impacts. We expect recalls to act like a one-time negative shock to reputation. Recalls that are more hazardous and involve illnesses are likely more salient and thus represent larger shocks to reputation. We expect marketing order authorization to be positively correlated with an organization's likelihood of adopting food safety guidelines, since these organizations may be able to enforce quality standards more effectively than others. In addition, we expect that marketing orders will be more responsive to food safety recalls.

Results

The probit models were estimated using maximum likelihood, and each model converged in ten iterations. All three fitted models offer significant improvements in goodness of fit over the null model, based on the McFadden Pseudo-R^2 statistic (Table 3). The inclusion of interaction terms in Model 3 further improves goodness of fit relative to the other models. Additionally, based on the Adjusted Count Pseudo-R^2, each of the specifications provides greater predictive accuracy than the null prediction (i.e. the most frequent outcome—no adoption of food safety guidelines), with Model 3 providing the greatest accuracy. The estimated coefficients and the associated average marginal effects are stable across specifications and are thus robust to changes in specification (Tables 3 and 4). As is standard for nonlinear models of this kind, we focus on interpreting the marginal effects rather than the raw probit coefficients in the following discussion.

The sole unambiguous implication of our theoretical analysis is that organizations with more members will face larger costs of implementing stricter food safety procedures and will thus be less likely to adopt food safety guidelines. That prediction is borne out by our empirical analysis: The number of operations represented by an organization is negatively correlated with the probability of adopting food safety guidelines. The effect of organization size is not large: The addition of 1000 operations is associated with a decrease in the probability of adopting food safety guidelines of only 1.4 percentage points.

Our theoretical analysis indicates that under some conditions organizations whose members account for a larger share of the market for their product will be more likely to adopt food safety guidelines. Intuitively, a larger market share means a larger share of the benefits of improvements in a product's reputation; when those benefits outweigh increases in members' production costs, adopting stricter food safety guidelines will be in the organization's interest. In all three specifications, we find evidence that commodity market share is positively correlated with the likelihood of adopting food safety guidelines. In each case, the average marginal effects for commodity market share are positive and statistically significantly different from zero at conventional significance levels, consistent with the notion that the benefits of improvements in reputation outweigh increases in production cost.

Each commodity's share of overall fruit and vegetable sales is a measure of the magnitude of demand for the commodity. Our theoretical analysis indicates that under some conditions greater demand is associated with a higher likelihood of adopting food safety guidelines. We find that a commodity's overall fruit and vegetable market share is positively correlated with the likelihood of adoption, with positive and statistically significant average marginal effects for each specification. This suggests that organizations that deal in commodities that are more salient and occupy a greater portion of consumers' budgets are more likely to adopt food safety guidelines.

A food safety recall can be viewed as a one-time negative shock to reputation. Under some conditions, such a shock is likely to induce grower organizations to mandate increased investment in quality and thus make adoption of food safety guidelines more likely. In all three models, we find evidence that FDA Class I recalls—those associated with adverse health effects and thus those with the greatest negative effect on product reputation—are associated with a greater likelihood of adopting food safety guidelines; the estimated average marginal effects are positive and statistically significantly different from zero. These results imply that severe food safety recalls may incentivize organizations to adopt food safety guidelines in an effort to protect collective reputation. The effect of a Class I recall is reasonably large: Each additional Class I recall experienced increases the probability of adopting food safety guidelines by 1 percentage point, a 5% increase over the average adoption rate of 0.19. FDA Class II recalls, in contrast, are associated with decreased likelihood of adoption, suggesting that the incentives may be reversed for less hazardous recalls. Lastly, the estimated average marginal effects for FDA Class III recalls as well as recalls with missing enforcement reports are not statistically significantly different from zero in any specification, so the impacts of these types of recalls on guideline adoption is not immediately clear.

We hypothesized earlier that marketing orders might face lower costs of implementing investments in food safety procedures, making them more likely to adopt food safety guidelines or be more responsive to food safety recalls. In fact, the estimated marginal effects of our probit models indicate that marketing orders are *less* likely to adopt food safety guidelines. There is some indication, however, that they are more responsive to recalls. The interaction between the marketing order indicator and the number of Class I recalls is positive and substantial in magnitude: The marginal effect of a Class I recall in particular is 65% greater for marketing orders than other types of grower organization.

Conclusion

Heightened concerns about food safety led to the passage of FSMA in 2011, which strengthens FDA's ability to regulate food safety practices and remove unsafe foods from channels of trade. FDA regulations implementing FSMA for fresh produce went into effect in late 2015. FDA's expanded recall authority went into effect immediately. But even before the passage of FSMA, a number of commodity organizations adopted guidelines for food safety practices for their members to implement. And several others adopted stricter food safety requirements for their members after the passage of FSMA but before mandatory regulations went into effect. We examine theoretically and empirically the factors associated with commodity organizations' voluntary adoption of stricter food safety guidelines.

Our theoretical analysis examines the effects of organization size, market size, market share and experience with recalls on organizations' requirement that members implement costly food safety procedures. We find that larger organizations are less likely to require members to invest in food safety procedures due to higher implementation costs. Recalls induce organizations to adopt stricter food safety standards only when expected future gains from improved product reputation outweigh the short run costs of implementing those standards. The same logic holds for organizations representing growers of a product with higher demand, e.g., a larger share of fruit and vegetable sales. Organizations whose members have a larger share of the market for their product are more likely to adopt stricter food safety guidelines when that investment induces members to increase output, a necessary condition for which is that members' current food safety procedures are more protective than the industry average.

Our econometric analysis finds that organizations with larger numbers of members are less likely to adopt food safety guidelines for their members, as our theoretical analysis predicts. Organizations whose members account for a larger share of the market for their product and organizations for commodities representing larger shares of fruit and vegetable sales are more likely to implement food safety guidelines, consistent with considerations of long term profitability due to enhancement of reputation for safety outweighing concerns about increases in cost of production. Organizations that have experienced negative shocks to reputation as measured by the number of Class I FDA recalls are also more likely to adopt food safety guidelines, again consistent with considerations of long term profitability due to enhancement of reputation for safety outweighing concerns about increases in cost of production.

Our findings are consistent with the proposition that reputational considerations provide an incentive for grower organizations to implement voluntary collective actions aimed at enhancing food safety. The effects of reputational considerations appear to be significant but not necessarily very large. Moreover, we cannot rule out competing incentives for voluntary industry-wide adoption of food safety procedures such as potential pre-emption of regulation, threats of restrictions on international or interstate trade due to safety concerns, or pressure from FDA. Exploring these additional considerations is a subject for future work.

References

Arnade, C., Calvin, L., & Kuchler, F. 2009. Consumer Response to a Food Safety Shock: The 2006 Food-Borne Illness Outbreak of E. coli O157: H7 Linked to Spinach. *Applied Economic Perspectives and Policy*, *31*(4), 734–750.

Castriota, S., & Delmastro, M. 2015. The Economics of Collective Reputation: Evidence from the Wine Industry. *American Journal of Agricultural Economics*, *97*(2), 469–489.

Costanigro, M., Bond, C. A., & McCluskey, J. J. 2012. Reputation Leaders, Quality Laggards: Incentive Structure in Markets with Both Private and Collective Reputations. *Journal of Agricultural Economics*, *63*(2), 245–264.

Dranove, D., & Jin, G. Z. 2010. Quality Disclosure and Certification: Theory and Practice. *Journal of Economic Literature*, *48*(4), 935–963.

Falvey, R. E. 1989. Trade, Quality Reputations and Commercial Policy. *International Economic Review*, *30*(3), 607.

Fleckinger, P. 2007. Collective Reputation and Market Structure: Regulating the Quality vs Quantity Trade-of. *CECO-1694*. <hal-00243080>

Fudenberg, D., & Levine, D. K. 1992. Maintaining a Reputation when Strategies are Imperfectly Observed. *The Review of Economic Studies*, *59*(3), 561.

Gould, L.H, Walsh, K.A., Vieira, A.R., Williams, I.T., Hall, A.J. & Cole, D. 2013. Surveillance for Foodborne Disease Outbreaks—United States, 1998-2008. *Morbidity and Mortality Weekly Report* 62, 1-34.

Kandori, M. 1992. Social Norms and Community Enforcement. *The Review of Economic Studies*, 59(1), 63–80.

Kreps, D. M., & Wilson, R. 1982. Reputation and imperfect information. *Journal of Economic Theory*, *27*(2), 253–279.

Leland, H. E. 1979. Quacks, Lemons, and Licensing: A Theory of Minimum Quality Standards. *Journal of Political Economy*, *87*(6), 1328–1346.

McQuade, T., Salant, S. W., & Winfree, J. 2016. Markets with untraceable goods of unknown quality: Beyond the small-country case. *Journal of International Economics*, *100*, 112–119.

Olsen, S.J., MacKinon, L.C., Goulding, J.S., Bean, N.H. & Slutsker, L. 2000. Surveillance for Foodborne Disease Outbreaks—United States, 1993-1997. *Morbidity and Mortality Weekly Report* 49, 1-34.

Rob, R., & Fishman, A. 2005. Is Bigger Better? Customer Base Expansion through Word- of-Mouth Reputation. *Journal of Political Economy*, *113*(5), 1146–1162.

Saak, A. E. 2012. Collective Reputation, Social Norms, and Participation. *American Journal of Agricultural Economics*, *94*(3), 763–785.

Shapiro, C. 1983. Premiums for High Quality Products as Returns to Reputations. *The Quarterly Journal of Economics*, *98*(4), 659.

Tirole, J. 1996. A Theory of Collective Reputations (with Applications to the Persistence of Corruption and to Firm Quality). *The Review of Economic Studies*, *63*(1), 1–22.

Winfree, J. A., & McCluskey, J. J. 2005. Collective Reputation and Quality. *American Journal of Agricultural Economics*, *87*(1), 206–213.

Table 1. Commodity Organization Summary Statistics

Statistic	**Organizations Without Food Safety Guidelines**	**Organizations With Food Safety Guidelines**
Unique Commodities	34	22
Total Number of Commodity Orgs	117	28
Marketing Order based Orgs	37	7
Research & Promotion Program based Orgs	16	2
Commission Law based Orgs	10	3
Commodity Specific Trade Orgs	52	12
General Trade Orgs	2	4
Avg Org Acreage	985370	248425
Avg Org Number of Farm Operations	5497	4268
Avg Org Sales ($MM)	1065.85	946.55
Avg Org Market Share of Nat’l Commodity	39.00%	69.53%
Avg Nat’l Commodity Share of Fruit and Veg	6.82%	6.75%
Avg Cumulative FDA Recalls (Nationally)	38.51	21.00

Table 2. FDA Recall Frequency Statistics

Statistic	Recall Year								
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Total**
Unique Commodities	12	11	13	8	20	18	19	20	35
Total Number of Recalls	26	32	32	49	280	67	102	156	744
Class I Recalls	10	12	18	40	174	57	70	111	492
Class II Recalls	1	4	5	3	6	4	18	21	62
Class III Recalls	3	3	5	3	4	2	6	6	32
Recalls with Enf. Report Missing	12	13	4	3	96	4	8	18	158
National Recalls	6	11	10	15	71	7	14	26	160
Regional Recalls	11	15	15	23	125	37	61	99	386
Single-State Recalls	9	5	7	11	71	23	27	28	181
Recalls with Scope Missing		1			13			3	17
Recalls due to Pathogens	5	17	18	40	266	57	75	124	602
Recalls for Other Reasons	21	15	14	9	14	10	27	32	142

Table 3. Estimated Coefficients for Probit Regression Models

Variable	**(1)**	**(2)**	**(3)**
No. of Operations	-0.000033	-0.000052	-0.000087**
	(0.000031)	(0.000034)	(0.000038)
Commodity Mkt. Share	0.015251***	0.017463***	0.025295***
	(0.004393)	(0.004726)	(0.006268)
Fruit and Veg. Mkt. Share	0.053739*	0.059052**	0.115729***
	(0.028065)	(0.028681)	(0.037253)
Cumulative Class I Recalls	0.049884***	0.050796***	0.062580***
	(0.017364)	(0.017735)	(0.021394)
Cumulative Class II Recalls	-0.649487***	-0.656136***	-1.276801***
	(0.211890)	(0.193244)	(0.462769)
Cumulative Class III Recalls	0.101398	0.076593	-0.093216
	(0.180373)	(0.180135)	(0.242508)
Cumulative Enf. Report Missing Recalls	-0.017351	-0.023026	0.056506
	(0.044337)	(0.040758)	(0.078181)
Mktg. Order Dummy		-0.607550*	-1.517122***
		(0.358008)	(0.527781)
Mktg. Order X Class I			0.039581
			(0.078638)
Mktg. Order X Class II			0.658903
			(0.590889)
Mktg. Order X Class III			1.326200**
			(0.589278)
Mktg. Order X Enf. Report Missing			-0.155126
			(0.130196)
Log Likelihood	-49.408	-47.796	-41.468
McFadden Pseudo-R^2	0.306	0.328	0.417
Adj. Count Pseudo-R^2	0.107	0.143	0.286
Num. obs.	145	145	145

Note: Robust standard errors are reported in parentheses. Asterisk (*), double asterisk (**), and triple asterisk (***) indicate significantly different from zero at the 10, 5 and 1 percent level, respectively.

Table 4. Average Marginal Effects on the Probability of Food Safety Guideline Adoption

Variable	**(1)**	**(2)**	**(3)**
No. of Operations	-0.000006	-0.000009	-0.000014**
	(0.000006)	(0.000006)	(0.000006)
Commodity Mkt. Share	0.002838***	0.003185***	0.003984***
	(0.000706)	(0.000739)	(0.000854)
Fruit and Veg. Mkt. Share	0.009999**	0.010770***	0.018227***
	(0.003956)	(0.004083)	(0.003697)
Cumulative Class I Recalls	0.009282***	0.009264***	0.009856**
	(0.003424)	(0.003506)	(0.003870)
Cumulative Class II Recalls	-0.120851***	-0.119662***	-0.201097***
	(0.027933)	(0.024462)	(0.047746)
Cumulative Class III Recalls	0.018867	0.013968	-0.014682
	(0.026213)	(0.029018)	(0.028229)
Cumulative Enf. Report Missing Recalls	-0.003229	-0.004199	0.008900
	(0.008379)	(0.007556)	(0.011535)
Mktg. Order Dummy		-0.102558	-0.207829***
		(0.063346)	(0.063224)
Mktg. Order X Class I			0.006234
			(0.008762)
Mktg. Order X Class II			0.103778*
			(0.060765)
Mktg. Order X Class III			0.208878***
			(0.080296)
Mktg. Order X Enf. Report Missing			-0.024432
			(0.015066)

Note: Robust standard errors are reported in parentheses. Asterisk (*), double asterisk (**), and triple asterisk (***) indicate significantly different from zero at the 10, 5 and 1 percent level, respectively.