Prevalence and Cost of On-Farm Produce Safety Measures in the Mid-Atlantic

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Abstract. We use data from a survey of leafy greens and tomato growers in the Mid-Atlantic region to investigate the prevalence and cost of produce safety practices required under the proposed Produce Rule implementing the Food Safety Modernization Act. Majorities of our respondents currently employ most of the food safety practices that would be required under the proposed Produce Rule. But the Produce Rule will nevertheless require changes on the part of a large number of growers. We find no evidence that the use of any of these practices is correlated with farm size. We do find some evidence that the shares of product sold to grocery/retail and to restaurants are positively correlated with the probability of testing water, soil amendments or product, consistent with theoretical literature suggesting that traceability increases incentives to take precautionary measures. We find that all of these practices exhibit substantial increasing returns to scale, implying that the burden of complying with the provisions of the Produce Rule is much lower for large operations than small ones. Our estimates suggest in addition that compliance costs are likely to be burdensome only for a handful of practices, notably testing of soil amendments, employee training, facility sanitation, and sanitizing harvest containers; further, that burden is likely to be much greater for small and very small operations than for large ones.

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In January of 2011, President Barack Obama signed into law the Food Safety Modernization Act [FSMA], the most sweeping reform of food safety law in over 70 years. Now, for the first time, the Food and Drug Administration [FDA] has 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. The proposed rule for produce safety, *Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption* [Produce Rule] published in January of 2013, sets standards associated with identified routes of microbial contamination, including: (1) agricultural water; (2) biological soil amendments of animal origin; (3) health and hygiene; (4) animals in the growing area; and (5) equipment, tools, and buildings.[1]

The new Produce Rule will undoubtedly require many farms to undergo operational changes in order to adhere to the requirements and to reduce health risks associated with foodborne illness. Impacts on small farms, in particular, have been of special concern. Many small farms fear that these required changes will prove to be too costly and burdensome for small operations and could ultimately put small producers out of business (Farm and Ranch Freedom Alliance 2013).

Very little information exists about the extent to which produce growers currently employ the food safety actions required by the Produce Rule, the costs of those actions, and potential burden requiring those actions would place on operations of different sizes. There have been only a handful of studies on the prevalence and cost of food safety measures used in produce to

[1] The Produce Rule is one of five proposed rules to establish a food safety framework; the other four rules are the Preventive Controls for Human Foods, the Foreign Supplier Verification Program, the Preventive Controls for Animal Food, and the Accredited Third Party Certification Program. In addition, the proposed Produce Rule includes specific provisions related to sprouts.

date, each addressing a limited set of practices. Rangajaran et al. (2002) use data from a survey of 213 New York state fruit and vegetable growers to study the prevalence of safety practices such as testing of irrigation water and sanitation of water used for postharvest processing. Cohen et al. (2005) use data from a survey of 297 New England fruit and vegetable growers to study the prevalence of safe food handling practices. Hultberg, Schermann, and Tong (2012) use data from a survey of 246 Minnesota vegetable growers to investigate the prevalence of equipment and employee sanitation practices. Hardesty and Kusunose (2009) use data from a survey of 49 California growers to estimate the costs of compliance with food safety requirements imposed by the Leafy Greens Marketing Agreement, which are similar to those required under the proposed Produce Rule. Becot et al. (2012) used data from a survey of 17 Vermont vegetable and apple growers to estimate the costs of compliance with Good Agricultural Practice (GAP) requirements.

This paper provides a baseline understanding of the prevalence and cost of produce safety practices by growers of tomatoes and leafy greens in the Mid-Atlantic region. We use data from a grower survey to estimate current prevalence of produce safety practices among the growers in our sample. We also break down the sample by the operation size classes specified in the Produce Rule, and examine prevalence of actions by operation size. We then analyze statistically how the use of those practices varies by operation size and by marketing channel, and how the costs of those practices vary by operation size.

The commodities we investigate, leafy green and tomatoes, number among the highest risk produce items and are thus a target of special interest under FSMA. Leafy greens, in particular, are of special concern. Using data from outbreak-associated illnesses from 1998-2008, the Centers for Disease Control and Prevention recently concluded that more foodborne illnesses

were attributed to leafy vegetables (22%) than to any other single commodity, including poultry and meat (Painter et al. 2013). Additionally, we focus on Mid-Atlantic growers because Mid-Atlantic agriculture represents an important sector of the industry as it serves a large, dense population with multiple urban centers (Washington, DC; Baltimore, MD; Philadelphia, PA; New York, NY) and a growing interest in local food.

The Food Safety Modernization Act and the Proposed Produce Rule

The proposed FSMA Produce Rule addresses microbiological risks from a wide variety of agricultural inputs. Specifically, the rule would set standards associated with agricultural water, biological soil amendments, animals in the growing area, health and hygiene, and equipment, tools, and buildings. With regards to agricultural water, the rule would establish specific requirements for the quality of agricultural water used for certain specified purposes, including provisions requiring periodic inspection and analytical testing of such water (with some exemptions for the use of public water); require treatment of agricultural water if there is reason to believe that the water is not of adequate sanitary quality for its intended use; and lastly, require documentation and recordkeeping of all scientific data, testing, and treatment. With regards to biological soil amendments, the rule would establish requirements for the treatment of soil amendments of animal origin with scientifically valid processes that satisfy specific microbial standards; establish application requirements for treated and untreated soil amendments; and require records of application and harvest dates, documentation of treatment, and relevant scientific data, such as periodic test results. With regards to animals in the growing area, the rule would require an adequate waiting period between grazing and harvesting in any growing area that was grazed, and if there is reasonable probability of contamination due to animal intrusion, the rule would require monitoring of areas immediately prior to harvest and as needed during the

growing season. With regards to health and hygiene, the rule would establish hygienic practices, require training for all personnel who handle produce or food-contact surfaces, and require documentation of required training. Lastly, with regards to equipment, tools, and buildings, the rule would establish sanitary standards for buildings, pest control, hand-washing and toilet facilities, sewage, trash, plumbing and any equipment and tools that make contact with produce, along with requiring recordkeeping related to any such sanitation measures.

The Produce Rule applies to all produce farms with annual sales over $25,000; farms with produce sales of $25,000 or less are exempt. Also exempt—thanks to a provision of FSMA introduced by Senators Jon Tester and Kay Hagan—are farms that have (1) an average annual monetary value of all food sold of $500,000 or less and (2) an average monetary value of all food sold direct-to-consumer greater than the average annual monetary value of food sold to all other buyers. Additionally, the rule proposes to grant small farms extra time to come into compliance. Farms with annual revenues between $250,000 and $500,000—classified as small farms under the proposed rule—would be granted two years from the effective date of the rule to come into compliance with all provisions except water quality requirements. Farms with revenues between $25,000 and $250,000—classified as very small under the Produce Rule--would be granted three years from the effective date of the rule to come into compliance, again with all provisions except water quality requirements.

Data

We analyze the prevalence and cost of produce safety measures required under the Produce Rule using data from a survey of leafy green and tomato growers collected at two major Mid-Atlantic agricultural conventions: the 2013 Mid-Atlantic Fruit and Vegetable Convention in Hershey, Pennsylvania (January 29-31) and the 2013 New Jersey Agricultural Convention in Atlantic

City, NJ (February 5-7). A booth was set up amongst exhibitors at the conferences, and attendees passing by the booth were asked to participate and complete a food safety research survey in exchange for a free gift – a USB flash drive. Upon consenting to participate, respondents completed a twenty minute survey regarding their farm operation characteristics and food safety actions for the 2012 growing season using tablet computers. In total, 47 growers completed the survey: 32 leafy green growers and 42 tomato growers (27 growers grew both). Respondents were predominantly from Pennsylvania (45%), New Jersey (28%) and Maryland (15%), and a few were from Massachusetts (2%), New York (4%), Ohio (2%), Vermont (2%), and West Virginia (2%).

Generally, the survey sample consists of fewer exempt farms and more large farms than the Mid-Atlantic as a whole (Table 1). Direct consumer sales accounted for the majority of sales by growers in our sample. On average, leafy greens growers in our sample that classified as exempt, very small, and small sold two-thirds or more of their greens directly to consumers (Table 2), while growers classified as large under the Produce Rule sold most of their greens to wholesalers. On average, tomato growers in all size classifications sold most of their tomatoes directly to consumers.

As previously stated, in order for very small and small farms to be qualified for the Tester-Hagan exemption, at least fifty percent of all sales need to be sold directly to qualified end-users. If leafy green and tomato sales are representative of growers' total produce sales, then we estimate 87.5 percent of very small growers in our sample and 100 percent of small growers would qualify for the Hagan-Tester exemption[2]. Thus, from our total sample, 63.4 percent would be exempt from the regulation based on current sales and practices.

[2] We consider the share of sales to qualified end users to be the sum of the shares to direct sales, grocery retailers, and foodservice.

Marketing channel may be important in creating incentives for growers to adopt various food safety practices. Deaths and illness from contaminated food can subject sellers to financial liability and/or loss of reputation (Henson and Caswell 1999, Segerson 1999, Fares and Rouviere 2010). Those losses likely accrue to downstream agents selling raw or prepared products to ultimate consumers, e.g., restaurants, grocery stores, or farm markets, rather than growers themselves. As a result, those downstream agents may find it advantageous to require their suppliers to engage in practices that enhance safety (Hennessy et al. 2001, Henson and Reardon 2005, Fulponi 2006, Carriquiry and Babcock 2007, Rouviere and Caswell 2012). We thus examine the extent to which marketing channels influence growers' propensity to use those practices.

In addition to information collected regarding farm acreage, employment, revenues, expenditures, and marketing channels, the survey also included questions regarding microbial testing, field monitoring, remedial food safety actions, and preventive food safety actions. Microbial testing questions covered whether the farm collected water, soil amendment, and/or crop samples for testing, and if so, at what cost (including employee wages, materials, etc.). Field monitoring questions covered whether the fields were monitored for wildlife encroachment and/or flooding, how often flooding and/or wildlife events were observed, and the costs associated with monitoring the fields. Remedial food safety questions covered whether any remedial actions, such as sanitation, product disposal, water treatment, etc. were taken following test results, flooding, and/or wildlife encroachment, and if so, at what cost (including the value of any disposed materials/crop, value of lost future production, etc.). Lastly, preventive food safety questions covered whether harvest containers were sanitized prior to harvest, whether crops were washed prior to sale, and whether precautions were taken with regards to employee sanitation

and hygiene (e.g, training, protective gear, facility sanitation, etc.). A full copy of the survey is included in the Appendix.[3]

Prevalence of Food Safety Practices

This section summarizes the current prevalence of produce safety practices used by Mid-Atlantic leafy greens and tomato growers in our sample during the 2012 growing season.

Sampling & Testing

As published in the Federal Register on January 16, 2013, the Produce Rule requires non-exempt growers to test agricultural water periodically. Some growers may also choose to collect samples of soil amendments and crops for testing even if not required to do so by the Produce Rule; voluntary testing is especially likely if there is reason to suspect contamination. Therefore, growers were asked whether water, soil amendment, and/or crop samples were collected for microbial testing (e.g., testing for pathogens, generic *E. coli*, coliforms, etc.). Twelve of the 32 leafy green growers responding to this question tested water, one tested soil amendments, and four tested crop samples. Thirteen of the 42 tomato growers responding to this question tested water, two tested soil amendments, and three tested crop samples. Water testing appears to be more prevalent among Mid-Atlantic tomato and leafy greens growers today than among New York State fruit and vegetable growers 15 years ago (Rangajaran et al. 2002) but less prevalent than among New England fruit and vegetable growers (Cohen 2005). Large growers and growers with annual sales under $25,000 were more likely to test irrigation water than growers

[3] The survey was administered on-line using Qualtrics software and employed skip logic so that respondents would not have to answer unnecessary questions. For example, if a respondent answered that they did not perform any testing, any subsequent questions regarding testing frequency and testing cost were skipped. Likewise, if a grower did not grow tomatoes and only grew leafy greens, the tomato fields would not be visible.

classified as very small or small under the Rule (Table 3). Lastly, growers indicated that most sampling and testing took place only once during the 2012 growing season.

Field Monitoring

Respondents were asked about whether they inspected their fields in 2012 for wildlife encroachment and flooding. Twenty-three of the 42 tomato growers and 20 of the 32 leafy greens growers conducted some form of field inspection. Fourteen tomato growers and 9 leafy greens growers inspected for flooding, while 19 tomato growers and 19 leafy greens growers inspected for wildlife encroachment. Additionally, 9 tomato growers and 6 leafy green growers conducted field inspections for wildlife encroachment and flooding simultaneously. Broken down by size classifications, three-fifths or more of very small, small, and large leafy greens growers inspected fields for wildlife encroachment (Table 4). Three-fourths of tomato growers classified as small inspected fields for wildlife encroachment and flooding, and less than half of the tomato growers of other size classes did so, as well.

Respondents who reported field monitoring actions were asked about flooding and wildlife encroachment event observations. Amongst leafy green growers, those who monitored for wildlife reported an average of 40 wildlife events in 2012 and those who monitored for flooding reported an average of 2 flooding events. For tomatoes, those who monitored for wildlife reported an annual average of 22 wildlife events in 2012 and those who monitored for flooding reported an average of 2 events. Regardless of farm size, monitoring for wildlife was a far more common practice than monitoring for flooding, likely because wildlife encroachment was a more common occurrence.

Preventive Actions

Respondents were also asked about preventive practices such as whether harvest containers were sanitized prior to harvest, whether crops were washed prior to sale, and whether precautions were taken with regards to employee sanitation and hygiene. Seventy-seven percent of tomato growers and 78 percent of leafy greens growers washed containers prior to harvest. An additional 13 percent of leafy greens growers used new containers for each harvest; none of the tomato growers reported doing so. Washing or using new harvest containers appears more prevalent among Mid-Atlantic leafy greens and tomato growers than among New England fruit and vegetable growers: only 63 percent of the latter reported always or usually washing harvest containers before use (Cohen 2005). All leafy greens growers classified as large under the Produce Rule either washed containers prior to harvest or used new containers, and almost all large tomato growers (89 percent) washed harvest containers, as well (Table 5).

Washing product prior to sale was less prevalent than washing (or using new) harvest containers. Sixty-three percent of leafy greens growers reported washing product prior to sale, while only 41 percent of tomato growers reported doing so. Small growers of both tomatoes and leafy greens were more likely to wash product prior to sale than growers of other sizes (Table 6).

Employee sanitation and hygiene measures –specifically, whether the farm educated or trained employees with regards to food safety, whether protective gear or equipment was provided for employees, and whether facilities were sanitized and cleaned—were more prevalent than both sanitizing harvest containers prior to harvest and washing products prior to sale. Ninety percent of leafy green growers and 80 percent of tomato growers provided food safety education and training for their employees, 42 percent of leafy green growers and 48 percent of tomato growers provided protective gear and/or equipment to their employees, and 81 percent of

leafy greens growers and 65 percent of tomato growers sanitized and cleaned facilities. For all farm sizes, education and training was the most prevalent form of prevention with regards to employee hygiene, closely followed by facility sanitation (Table 7). The prevalence of these sanitation practices among Mid-Atlantic leafy greens and tomato growers appears comparable to that of New England fruit and vegetable growers and Minnesota vegetable growers (Cohen 2005, Hultberg et al. 2012).

Remedial Actions

In terms of remedial actions, respondents who reported some form of testing, wildlife encroachment events, and/or flooding, were asked about any subsequent remedial actions that may have been taken. Wildlife encroachment was the principal impetus for taking remedial action, followed by flooding (Table 8). Remedial action was more common among leafy greens growers than tomato growers, most likely because leafy greens lie closer to the soil surface. Disposal of affected products or materials was the most common form of remedial action taken (Table 9).

Factors Affecting the Prevalence and Cost of Food Safety Actions

As noted above, growers' adoption of food safety practices may be influenced by the channels through which they sell: grocery stores and restaurants may require safe handling practices in order to protect themselves against liability and loss of reputation and growers selling direct to consumers may also have similar incentives to do the same. Additionally, safe handling practices may exhibit economies of scale, making it less costly for larger operators to use them and thus making larger operators more likely to use them. We investigate these possibilities using a set of latent variable models. We assume that the net benefit to grower j of adopting a

specific safety practice i, is a function of farm size and the share of product sold through different marketing channels:

$$s_{ij}^{*} = \beta_{0,i} + \beta_{1,i}\text{ProductAcreage}_j + \beta_{2,i}\text{TotalRevenue}_j + \mathbf{MarketingChannelShare}_{ij}'\boldsymbol{\beta}_{\mathbf{3},i} + \varepsilon_{ij}$$

where ε_{ij} is a white noise error. We measure farm size two ways, by product acreage and by total revenue. Product acreage measures the size of the leafy green and tomato crop operation (the sum of leafy green and tomato acreage) while total revenue measures the size of the overall operation (including revenues from crops other than leafy greens and tomatoes).

The grower is assumed to use safety practice *i* if the net benefits of doing so are positive:

$$s_{ij} = \begin{cases} 1 \text{ if } s_{ij}^{*} > 0 \\ 0 \text{ if } s_{ij}^{*} \leq 0 \end{cases}$$

The probability that grower j uses practice i is $\Phi(s_{ij}^{*})$, where $\Phi(\cdot)$ denotes a standard normal cumulative distribution. The coefficients of the model are thus estimated using probit.

The survey asked growers who used each type of food safety practice how much they spent on that practice during the 2012 growing season. We investigate potential economies of scale by regressing the cost of practice i for both leafy greens and tomatoes incurred by grower j, c_{ij}, on a measure of the size of the specific crop operation. To keep the survey brief (and thus increase question response rates), the survey asked for total expenditures on all forms of testing (water, soil amendments, and product), all types of field monitoring (flooding, wildlife encroachment), and all forms of employee sanitation and hygiene measures (employee education and training, provision of protective gear and equipment, facility sanitation, other). We estimate

the cost of each action by including indicator variables for each type of action undertaken by the grower.[4,5] We use a log-log specification of cost:

$$\ln(c_{ij}) = \gamma_{1i}\ln(\text{ProductRevenues}_j) + \mathbf{TypeofAction}_i'\boldsymbol{\gamma_{2,i}} + \upsilon_{ij}.$$

Here υ_{ij} is a white noise error.

We only observe cost $c_{ij}$for growers who engage in a given practice, so that observations of cost are censored. However, it is quite possible that unobserved factors that influence cost also influence the net benefits of engaging in a given safety practice, i.e., that the errors ε_{ij} and υ_{ij} are correlated, in which case estimates of cost determinants are subject to selection bias. Therefore, we tested this possibility using two-step Heckman models with pooled leafy green and tomato grower data for each set of practices exhibiting a significant amount of censoring: testing, field inspections, harvest container sanitation, and washing product prior to sale. The estimated coefficients of the inverse Mills ratios in all of these models were not significantly different from zero, indicating that we could not reject the hypothesis of no selection bias.[6] We thus estimate the practice adoption and cost models separately; the estimated coefficients of these models are presented in tables 10 and 11.

Impact of Marketing Channel and Farm Size on the Prevalence of Food Safety Practices

The estimated marginal effects of the food safety practice probit models indicate that marketing channel appears to have had little or no effect on growers' use of field monitoring or sanitizing harvest containers: None of the coefficients of the marketing channel indicators were

[4] We estimated a specification of cost that includes the shares of product sold through each marketing channel, as well. Wald tests indicated that we could not reject the hypothesis that all of the coefficients of the marketing channel shares were simultaneously equal to zero. In light of the small number of observations available, we dropped them from the cost models.

[5] The specification for field monitoring also includes indicator variables for whether field monitoring for wildlife encroachment and flooding was conducted simultaneously.

[6] The p-values for this hypothesis were 0.18 for sampling and testing, 0.42 for field monitoring, 0.90 for harvest container measures, and 0.99 for product washing.

significantly different from zero in either of these two models (Table 12). The estimated coefficients of the sampling/testing probit model point to an intriguingly different story, however. In this model, a one percentage point increase in the share of product sold to grocery/retail or foodservice establishments was associated with a 0.6 percentage point increase in the probability of testing by 0.6 percent. While these marginal effects were significantly different from zero only at a 10 percent level (quite possibly due to small sample size), they are consistent with the notion that traceability enhances incentives for taking greater safety precautions, since any outbreaks of foodborne illness due to consumption of products purchased through these local marketing channels could well be traced back to the originating grower. Grocery stores in this area often have separate sections for locally grown produce while restaurants (the principal, perhaps even only foodservice outlet for the growers in our sample) typically buy from a limited number of local growers. Lastly, growers who sold larger shares directly to consumers were more likely to wash their product (leafy greens and/or tomatoes) prior to sale—understandably, since improving the appearance of the product makes it more likely to sell. A one percentage point increase in the share of produce sold direct to consumers increased the probability of washing leafy greens and/or tomatoes by 0.4 percent.

The estimated marginal effects indicated that size had very little discernible influence on growers' use of these food safety practices. The one exception is water, soil amendment, and product testing, where a one acre increase in acreage is associated with a 2.6 percent increase in the probability of water, soil amendment, or product testing. Larger farms do not appear to be any more (or less) likely to use any of the other food safety practices investigated here than smaller operations.

Farm Size and the Costs of Food Safety Practices

The Produce Rule presupposes that very small and small operations compliance with the new food safety standards will impose a greater burden on smaller operations than on larger ones. The Tester-Hagan Amendment reinforces that presupposition by exempting smaller operations that sell only locally. One possible reason for believing that it would be more difficult for small operations to comply with the Produce Rule is that the food safety measures required by the rule exhibit significant economies of scale. Another is that smaller operations have more limited capacity to finance the costs of compliance with these standards.

We use the coefficients of the log of product revenue in the expenditure regressions to examine the extent to which the provisions of the Produce Rule are more burdensome to smaller operations than larger ones (Table 11). A coefficient equal to one indicates that cost rises proportionally with product revenue or, equivalently, that cost is a constant share of product revenue. In other words, a coefficient equal to one is consistent with constant returns to scale and implies that the burden of complying with the provisions of the Produce Rule is independent of operation size. A coefficient equal to zero indicates that cost is unrelated to product revenue or, equivalently, that cost is fixed. As a result, a coefficient equal to zero indicates increasing returns to scale and thus implies that the burden of complying with the provisions of the Produce Rule decreases with operation size.

The estimated coefficients of product revenue in the equations for costs of sampling and testing, field monitoring, sanitizing harvest containers, and employee sanitation and hygiene measures are all between zero and one and significantly different from both zero and one, indicating that costs vary with operation size and exhibit economies of scale. The estimated coefficient of washing product is also between zero and one. It is significantly different from

one but not zero, indicating that these costs are largely fixed and thus also exhibit economies of scale. The coefficients of the sampling and testing cost, field monitoring cost, and sanitizing harvest container cost models all indicate that cost as a share of revenue falls at roughly the square root of revenue. The coefficient of the employee sanitation and hygiene model indicates that cost as a share of revenue falls less rapidly, at approximately the fourth root of revenue. The coefficient of the product washing model indicates that cost as a share of revenue falls even more rapidly, roughly proportionally to revenue (as one would expect if cost is fixed).

In sum, these estimated coefficients bear out the presupposition that compliance with the provisions of the Produce Rule will place greater burdens on small producers than large ones. They thus provide concrete empirical evidence supporting the exemptions and lengthier phase-in time included in the Produce Rule, at least in principle. But it remains possible that the costs of implementing the food safety measures we study account for small enough shares of revenue that economies of scale will make little or no difference in practice.

We address this latter concern by using the estimated coefficients of our cost models to estimate costs as shares of revenue for average size farms in each size class in the Mid-Atlantic region. We use data from the 2007 Census of Agriculture to calculate average revenue from sales of all vegetables by growers in Pennsylvania and New Jersey, states that account for almost three-fourths of our sample.[7] We assume that costs as shares of revenue scale up from leafy greens and tomatoes to all vegetables, i.e., that costs for all vegetables as a share of vegetable revenues are the same as costs for leafy greens and tomato production as a share of leafy greens and tomato revenues.

[7] We omit Maryland, which accounts for 15% of our sample, because of data not reported due to confidentiality concerns in several size classes.

These calculations illustrate the magnitude of the economies of scale these food safety practices exhibit. The cost burden (that is, cost as a share of revenue) for sampling and testing, field monitoring, and sanitizing containers for the average size Mid-Atlantic large farm are only half as much as for average size small farm, a quarter as much as for the average size very small farm, and a tenth as much as the average size exempt farm (Table 13). The cost burden differentials for washing product are even greater: The cost burden for the average size Mid-Atlantic large farm is only a third as much as the average size small farm, only a seventh as much as the average size very small farm, and only a twenty-fifth as much as the average size exempt farm. The economies of scale for employee sanitation and training are somewhat lower: The cost burden for the average size Mid-Atlantic large farm is two-thirds as much as the average size small farm, half of the average size very small farm, and a quarter as much as the average size exempt farm.

The estimates reported in Table 13 suggest that meeting many of the provisions of the Produce Rule will not impose much of a cost burden on farms of all sizes: The costs of most sampling and testing measures, field monitoring, washing harvest containers, and most employee hygiene and sanitation measures account for relatively small fractions of a percent of vegetable revenue for average size farms in all classes required to comply with the rule. There are some exceptions, notably soil amendment testing and some employee sanitation and hygiene measures.

Testing soil amendments is relatively expensive, accounting for over one percent of the average size Mid-Atlantic large farm's revenue, two percent of the average size small farm's revenue, and over four percent of the average size very small farm's revenue. The relatively high cost of testing soil amendments is not surprising, since there are no standard protocols (in contrast to irrigation water testing, for instance) and soil amendments vary greatly in

composition. FDA's decision to reconsider the soil amendment testing requirements of the Produce Rule could well be at least partially due to their relatively high cost.

Employee education and training and facility sanitation are also relatively expensive, although less so than testing soil amendments. It is possible that our estimate of this cost burden is too high, however: While our survey asked growers to report costs incurred for leafy greens and tomatoes only, it is quite possible that the expenditures they reported applied to all fruits and vegetables grown during the 2012 season, in which case cost would account for a smaller share of revenue than our estimates indicate.

Sanitizing harvest containers is also relatively expensive. Purchasing new harvest containers is more expensive than any other measure included in our survey but is not required under the Produce Rule. Washing harvest containers, which is required, imposes less of a cost burden than testing soil amendments, employee training, and facility sanitation but still involves non-negligible costs.

Conclusion

The enactment of the Food Safety Modernization Act gave the Food and Drug Administration authority to regulate the growing, harvesting, packing, and holding of fresh fruits and vegetables. The FDA has proposed a rule aimed at reducing health risks associated with foodborne illness from consumption of fresh produce. That rule will require operational changes in many farms that could be costly. Small farms in particular worry that the costs of complying with the new rule could put them out of business.

There is very little publicly available information on the current prevalence and likely cost of the actions required under the proposed rule. We use data from a survey of leafy greens and tomato growers in the Mid-Atlantic region to help fill that information gap. Our survey

focuses on leafy greens and tomatoes in light of their association with a large number of foodborne illness outbreaks in recent years.

Majorities of our respondents currently employ most of the food safety practices that would be required under the proposed Produce Rule. Majorities of farms classified as large by FDA currently employ all of the other practices that would be required under the Produce Rule as currently proposed. Majorities of farms classified as small or very small currently employ many of those practices as well, the exceptions being testing water samples and providing protective gear for employees in addition to testing soil amendments and testing crop samples. While majorities of growers of all sizes currently employ many of these food safety practices, the Produce Rule will nevertheless require changes on the part of large numbers of growers: Between a tenth and a half of growers of all sizes in our sample reported not currently using one or more of the protective measures included in the Produce Rule.

We use probit models to investigate whether farm size and marketing channel are associated with the use of these food safety practices. We find no evidence of scale effects: Combined acreage of leafy greens and tomatoes is uncorrelated with the likelihood that a grower uses any of these practices. We do find some evidence of marketing channel effects: the shares of product sold to grocery/retail and to restaurants are positively correlated with the probability of testing water, soil amendments or product. These results are consistent with theoretical literature suggesting that traceability increases incentives to take precautionary measures, since locally grown produce is typically separated out in grocery stores in this region while restaurants typically buy from a limited number of local growers.

We use regression models to investigate the presence of economies of scale. We find that all of these practices exhibit increasing returns to scale, so that cost rises less than proportionally

to operation size. Thus, the burden of complying with the provisions of the Produce Rule, measured by cost as a share of revenue, is much lower for large operations than small ones—a result that provides some justification for the exemptions and extended phase-in time proposed by FDA. Our estimates suggest in addition that compliance costs are likely to be burdensome only for a handful of practices, notably testing of soil amendments, employee training facility sanitation, and sanitizing harvest containers; further, that burden is likely to be much greater for small and very small operations than for large ones.

The inferences that can be drawn from our survey data are limited by geographic region and by sample size. Our sample consists mainly of commercial growers from Pennsylvania, New Jersey, and Maryland. These growers are important sources of local supply for a substantial share of the US population as a whole but by no means account for the majority of produce consumed nationwide or even in the Washington-New York corridor. Our sample size is large relative to others in the literature but is still small in absolute terms. Data covering a wider geographic range and a larger number of respondents would be helpful in testing the robustness of broader applicability of our findings.

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Table 1. Revenue Distributions

Economic Class	PRIA Estimates (%)	Mid-Atlantic Agricultural Census (%)[†]	Sample (%)[††]
Exempt $25,000 or less	46	50.5	18.2
Very Small $25,001 to $250,000	50	37.3	40.9
Small $250,001 to $500,000		5.7	11.4
Large More than $500,000	4	6.5	29.5

[†] Source: 2007 USDA Agricultural Census for the states of Maryland, New Jersey and Pennsylvania – Vegetable, Melons, Potatoes and Sweet Potato Operations
[††]Note: Three operations (6%) chose not to report revenue.

Table 2. Average Share of Sales to Various Marketing Channels of Surveyed Leafy Green and Tomato Growers

Economic Class	*Leafy Greens* (%)					*Tomatoes (%)*				
	Direct Sales	*Grocery Retailers*	*Foodservice*	*Produce Wholesalers*	*Other*	*Direct Sales*	*Grocery Retailers*	*Foodservice*	*Produce Wholesalers*	*Other*
Exempt $25,000 or less	60.0	0.0	40.0	0.0	0.0	77.4	0.1	22.5	0.0	0.0
Very Small $25,001 to $250,000	70.6	7.5	7.3	6.9	7.7	53.7	18.3	6.9	15.6	5.6
Small $250,001 to $500,000	68.8	16.3	3.8	0.0	11.3	71.3	9.3	1.3	12.5	5.8
Large More than $500,000	33.9	17.8	6.1	42.2	0.0	67.2	9.1	8.9	14.8	0.0

Note: Respondents were also asked about marketing products to mass merchandisers, exporters, and/or brokers; however, none of the respondents reported sales to these outlets.

Table 3. Testing and Sampling by Size

Economic Class	*Leafy Greens*				*Tomatoes*			
	Water Samples	Soil Amendment Samples†	Crop Samples	No Samples	Water Samples	Soil Amendment Samples†	Crop Samples	No Samples
Exempt $25,000 or less	3 (60%)	0 (0%)	1 (20%)	2 (40%)	3 (38%)	0 (0%)	1 (13%)	5 (63%)
Very Small $25,001 to $250,000	2 (15%)	1 (8%)	1 (8%)	9 (69%)	4 (22%)	1 (6%)	1 (6%)	12 (67%)
Small $250,001 to $500,000	1 (25%)	0 (0%)	1 (25%)	3 (75%)	1 (25%)	0 (0%)	0 (0%)	3 (75%)
Large More than $500,000	5 (56%)	0 (0%)	1 (11%)	4 (44%)	4 (44%)	1 (11%)	1 (11%)	3 (33%)
TOTAL	11	1	4	18	12	2	3	23

†Only respondents that indicated that they used soil amendments containing animal manures or animal products were asked whether they tested soil amendments. For leafy greens, 16 respondents used soil amendments, and for tomatoes, 23 respondents used soil amendments.
Note: One leafy green operation (3%) and three tomato operations (7%) chose not to report revenue.

Table 4. Field Monitoring by Size

Economic Class	*Leafy Greens*			*Tomatoes*		
	Wildlife Encroachment	Flooding	No Monitoring	Wildlife Encroachment	Flooding	No Monitoring
Exempt $25,000 or less	2 (40%)	0 (0%)	3 (60%)	4 (50%)	1 (13%)	4 (50%)
Very Small $25,001 to $250,000	8 (62%)	3 (23%)	4 (31%)	8 (44%)	6 (33%)	8 (44%)
Small $250,001 to $500,000	3 (75%)	3 (75%)	1 (25%)	3 (75%)	3 (75%)	1 (25%)
Large More than $500,000	5 (63%)	3 (33%)	4 (44%)	3 (33%)	4 (44%)	4 (44%)
TOTAL	18	9	12	18	14	17

Note: One leafy green operation (3%) and three tomato operations (7%) chose not to report revenue.

Table 5. Harvest Container Sanitation by Size

Economic Class	*Leafy Greens*			*Tomatoes*	
	Washed Containers	Used New Containers	No Action	Washed Containers	No Action
Exempt $25,000 or less	3 (75%)	0 (0%)	1 (25%)	5 (71%)	2 (29%)
Very Small $25,001 to $250,000	11 (92%)	0 (0%)	1 (8%)	14 (78%)	4 (2%)
Small $250,001 to $500,000	2 (50%)	1 (25%)	1 (25%)	2 (50%)	2 (50%)
Large More than $500,000	6 (67%)	3 (33%)	(0%)	8 (89%)	1 (11%)
TOTAL	22	4	3	29	9

Note: One leafy green operation (3%) and three tomato operations (7%) chose not to report revenue, and two leafy green operations (6%) and two tomato operations (5%) chose not to disclose harvest container practices.

Table 6. Crops Washed by Size

Economic Class	*Leafy Greens*		*Tomatoes*	
	Crops Washed	No Action	Crops Washed	No Action
Exempt $25,000 or less	3 (60%)	2 (40%)	2 (25%)	6 (75%)
Very Small $25,001 to $250,000	8 (62%)	5 (38%)	8 (44%)	10 (56%)
Small $250,001 to $500,000	4 (100%)	0 (0%)	2 (50%)	2 (50%)
Large More than $500,000	4 (44%)	5 (56%)	3 (38%)	5 (63%)
TOTAL	19	12	15	23

Note: One leafy green operation (3%) and three tomato operations (7%) chose not to report revenue, and one tomato operations (2%) chose not to disclose crop washing practices.

Table 7. Employee Sanitation and Hygiene by Size

Economic Class	*Leafy Greens*				*Tomatoes*			
	Education/ Training	Protective Gear/ Equipment	Facility Sanitation	No Action	Education/ Training	Protective Gear/ Equipment	Facility Sanitation	No Action
Exempt $25,000 or less	4 (100%)	1 (25%)	4 (100%)	0 (0%)	7 (100%)	2 (29%)	4 (57%)	0 (0%)
Very Small $25,001 to $250,000	11 (85%)	6 (46%)	11 (85%)	1 (8%)	13 (76%)	8 (47%)	12 (71%)	1 (6%)
Small $250,001 to $500,000	4 (100%)	1 (25%)	3 (75%)	0 (0%)	3 (75%)	2 (50%)	2 (50%)	0 (0%)
Large More than $500,000	8 (89%)	5 (56%)	6 (67%)	0 (0%)	7 (78%)	6 (67%)	7 (78%)	1 (11%)
TOTAL	27	13	24	1	30	18	25	2

Note: One leafy green operation (3%) and three tomato operations (7%) chose not to report revenue, and one leafy green operation (3%) and two tomato operations (5%) chose not to disclose employee sanitation and hygiene practices.

Table 8. Remedial Actions

Remedial Actions following:	*Leafy Greens*		*Tomatoes*	
	No. of Producers	(%)	No. of Producers	(%)
Testing	1/13	7.7	1/16	6.3
Wildlife Encroachment	5/9	55.6	2/8	25.0
Flooding	1/1	100.0	2/4	50.0
TOTAL	6		5	

Note: One leafy green grower (7%) and one tomato grower (5%) that performed sampling and testing, did not report taking or not taking remedial actions. Also, one leafy green grower (10%) that reported wildlife encroachment events, did not report taking or not taking remedial actions.

Table 9. Remedial Actions

Remedial Actions	*Leafy Greens*		*Tomatoes*	
	No. of Producers	(%)	No. of Producers	(%)
Sanitary Surveys/Sanitation	2/6	33.3	3/5	60.0
Additional Testing	0/6	0.0	0/5	0.0
Water Treatments	0/6	0.0	0/5	0.0
Use of Substitutes for Contaminated Materials	0/6	0.0	1/5	20.0
Material Disposal	2/6	33.3	1/5	20.0
Product Disposal	5/6	83.3	4/5	80.0
Delayed Future Production on Site	3/6	50.0	2/5	40.0
Other	1/6	16.7	1/5	20.0

Table 10. Estimated Coefficients of the Safety Measure Adoption Probit Models

Variables	*Sampling & Testing*	*Field Monitoring*	*Harvest Containers*	*Washing Product*
Product Acreage	0.090 (0.057)	0.001 (0.004)	0.006 (0.056)	-0.001 (0.002)
Total Revenues (in millions)	0.057 (0.625)	0.038 (0.185)	1.297 (1.202)	-0.044 (0.160)
Direct Sale Share	0.011 (0.010)	-0.004 (0.006)	0.007 (0.008)	0.010* (0.006)
Grocery/Retail Share	0.019 (0.012)	0.001 (0.010)	0.006 (0.012)	0.005 (0.009)
Foodservice Share	0.020 (0.013)	0.003 (0.010)	--[†] --	0.014 (0.011)
Constant	-1.811* (0.986)	0.393 (0.575)	-0.150 (0.759)	-0.427 (0.556)
No. of Observations	43	43	32	43
Log Likelihood	-22.043	-27.577	-14.860	-26.121

[†]All growers who sold to foodservice establishments used new or sanitized harvest containers, and the variable was subsequently omitted from the estimation.
Note: Standard errors are reported in parentheses. Asterisk (*), double asterisk (**), and triple asterisk (***) indicate significance at the 10, 5 and 1 percent level, respectively. The variable representing the share of sales to wholesale and other marketing channels was omitted due to collinearity.

Table 11. Estimated Coefficients of the Expenditure Models

Variables	*Sampling & Testing*	*Field Monitoring*	*Harvest Containers*	*Washing Product*	*Employee Hygiene & Sanitation*
ln(Product Revenues)	0.553*** (0.182)	0.498** (0.172)	0.461*** (0.137)	0.286 (0.217)	0.704*** (0.133)
Water Samples	1.777 (1.546)				
Soil Amendment Samples	3.702** (1.728)				
Product Samples	1.629* (0.796)				
Flooding Inspections		-0.415 (1.198)			
Wildlife Encroachment Inspections		0.004 (1.188)			
Flooding & Wildlife Encroachment Simultaneous Inspections		0.850 (1.074)			
Wash Harvest Containers			0.774 (1.447)		
New Harvest Containers			3.232** (1.527)		
Employee Education/Training					0.621 (0.645)
Protective Gear/Equipment					-0.329 (0.543)
Facility Sanitation					0.611 (0.708)
Employee Hygiene & Sanitation: Other					-3.351*** (0.860)
Constant	-2.962 (3.024)	-0.221 (2.408)		3.424 (2.313)	-1.965 (1.370)
No. of Observations	17	10	26	21	28
R^2	0.650	0.640	0.943	0.083	0.708

Note: Standard errors are reported in parentheses. Asterisk (*), double asterisk (**), and triple asterisk (***) indicate significance at the 10, 5 and 1 percent level, respectively.

Table 12. Marginal Effects of Size and Marketing Channel on the Probability a Safety Measure is Used

Variable	*Sampling & Testing*	*Field Monitoring*	*Harvest Containers*	*Washing Product*
Product Acreage	0.026*	0.000	0.002	0.000
	(0.015)	(0.001)	(0.015)	(0.001)
Total Revenues (in millions)	0.016	0.014	0.338	-0.015
	(0.181)	(0.068)	(0.299)	(0.055)
Direct Sale Share	0.003	-0.001	0.002	0.004*
	(0.003)	(0.002)	(0.002)	(0.002)
Grocery/Retail Share	0.006*	0.000	0.002	0.002
	(0.003)	(0.004)	(0.003)	(0.003)
Foodservice Share	0.006*	0.001	--	0.005
	(0.003)	(0.004)	--	(0.004)

Note: Standard errors (reported in parentheses) were estimated using the delta method. Asterisk (*), double asterisk (**), and triple asterisk (***) indicate significance at the 10, 5 and 1 percent level, respectively. The variable representing the share of sales to wholesale and other marketing channels was omitted due to collinearity.

Table 13. Predicted Annual Food Safety Costs Related to Vegetable Safety for Growers in New Jersey and Pennsylvania

Size Classification	*Exempt* $25,000 or less	*Very Small* $25,001 to $250,000	*Small* $250,001 to $500,000	*Large* More than $500,000
Average Vegetable Revenues[†]	$5,331	$31,440	$128,165	$539,832
Food Safety Measures	Predicted Share of Revenue *(%)*	Predicted Share of Revenue *(%)*	Predicted Share of Revenue *(%)*	Predicted Share of Revenue *(%)*
Sampling & Testing				
Water	1.38	0.62	0.33	0.17
Soil Amendment	9.47	4.28	2.28	1.20
Crop	1.19	0.54	0.29	0.15
Field Monitoring				
Flooding	1.13	0.46	0.23	0.11
Wildlife Encroachment	1.71	0.70	0.35	0.17
Flooding & Wildlife Encroachment Simultaneous	2.65	1.09	0.54	0.26
Harvest Containers				
Wash	7.43	2.85	1.34	0.62
New	86.85	33.36	15.64	7.20
Washing Product				
Washing Product	25.09	7.06	2.59	0.93
Employee Hygiene & Sanitation				
Employee Education/Training	3.58	2.12	1.40	0.92
Protective Gear/Equipment	1.39	0.82	0.54	0.35
Facility Sanitation	3.55	2.10	1.39	0.91
Employee Hygiene & Sanitation: Other	0.07	0.04	0.03	0.02

[†]Source: 2007 Census of Agriculture, Summary by Market Value of Agricultural Products Sold, New Jersey & Pennsylvania