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Price and Welfare Effects of the Food Safety Modernization Act Produce Safety Rule

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We estimate the cost of compliance with the US Food Safety Modernization Act (FSMA) Produce Safety Rule by commodity and own- and cross-prices elasticities of demand for 18 fruits and 20 vegetables. These are used as inputs in an equilibrium displacement model that simulates the price and welfare effects of the rule. We find that consumer and farm prices increase by 0.55% and 1.69% for fruits and 0.15% and 0.59% for vegetables. Costs associated with implementation are estimated to reduce producer welfare by 0.63% for fruits and 0.51% for vegetables (as a share of revenue). If the rule's provisions were enacted unilaterally by growers of individual commodities, producer welfare losses would be 0.93% of total revenue for fruits and 0.31% for vegetables.

Key words: Food Safety Modernization Act, fruits, vegetables, producer welfare, food safety, regulation

Introduction

The 2011 passage of the Food Safety Modernization Act (FSMA) marked the most comprehensive legislative change to the authority of the Food and Drug Administration (FDA) to regulate food since the 1930s (Johnson, 2011). The law empowered the FDA to impose new regulatory requirements on food producers and handlers, to expand requirements for and inspections of imports, and to issue mandatory recalls of food. Additionally, for the first time, the FDA was empowered to regulate production practices at the farm level. While certain retailers and producer groups have independently coordinated heightened requirements for improved food safety in production (Calvin et al., 2017; Adalja and Lichtenberg, 2016), the FSMA Produce Safety Rule is broadly applicable to nearly all produce—both imported and domestically produced—that is sold fresh (unprocessed) in the United States. A detailed description and analysis of the Produce Safety Rule can be found in Bovay, Ferrier, and Zhen (2018).

The costs of compliance with the FSMA Produce Safety Rule are substantial but vary across commodities and decrease as a share of revenue with increases in firm size (Bovay, Ferrier, and Zhen, 2018). This suggests that implementing the Produce Safety Rule will have differential effects across different types of producers and important implications for the relative prices of foods sold at retail. This article uses retail grocery store data at the national level to estimate demand systems for 18 fresh-fruit and 20 fresh-vegetable commodities affected by the FSMA Produce Safety Rule. Using existing estimates of supply elasticities, farm prices as shares of retail prices, and new estimates of

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Table 1. Estimated Average Costs of Implementing the FSMA by Category

	Regulatory Component	Estimated Annual Costs of Compliance	Share of Total Cost
1.	Agricultural water	$49 million	13.70%
2.	Fertilizer compost of animal origin	$9 million	2.50%
3.	Worker health/hygiene measures	$81 million	22.60%
4.	Animal intrusion measures	$38 million	10.60%
5.	Sanitary standards (equipment, tools, buildings)	$59 million	16.50%
6.	Recordkeeping and other costs	$122 million	34.10%
	Total (excluding sprouts rule)	$358 million	100%

Source: US Food and Drug Administration (2015b).

the compliance costs of the FSMA as they vary by farm size (Bovay, Ferrier, and Zhen, 2018), we then estimate cost pass-through and welfare effects of the Produce Safety Rule. Fruit and vegetables are often thought to be substitutes in demand (Durham and Eales, 2010; Okrent and Alston, 2011). Accepting that this assumption holds and that the adoption of food-safety measures does not affect demand, producer groups that adopt cost-raising food-safety measures suffer a larger producer welfare loss when adopting the measures unilaterally than when all producer groups must adopt the measures. We find this to be the case and show that this difference in producer welfare cost can be directly related to the benefit a producer group might receive from a commodity-specific exemption.

More generally, the differential costs of compliance with the FSMA across commodities imply that growers of some regulated commodities will gain offsetting benefit at the expense of others, as consumers shift to relatively inexpensive commodities. However, our empirical analysis suggests that these benefits associated with substitution in demand are small in magnitude and that the main benefit a commodity group might gain from exemption from the Produce Safety Rule would stem primarily from avoiding the direct costs of compliance rather than through the higher prices of other fruits and vegetables. To our knowledge, this is the first article to analyze the economic impacts of the FSMA on the fruit and vegetable complex as a system.

Background

The Food Safety Modernization Act was signed into law in early 2011, and the FSMA Produce Safety Rule is one of several major rules developed by the FDA as a consequence of the legislation. In this section, we describe its regulatory requirements and discuss the economic literature on food-safety regulation.

The FSMA Produce Safety Rule

Despite extensive discussion since its 2011 passage, the effect of the FSMA on costs, price, and producer welfare has not been studied extensively in the economics literature. As discussed by Bovay, Ferrier, and Zhen (2018), the Produce Safety Rule mandates that producers (i) test agricultural water periodically, (ii) follow specific practices while using biological soil amendments, (iii) maintain certain worker health and hygienic practices, (iv) monitor and prevent animal intrusion, and (v) document sanitary standards. Table 1 illustrates the FDA's estimates of the costs of compliance by type of cost. The rule applies to both domestically produced and imported foods.

Many FSMA requirements, such as water testing and documenting safety standards, impose fixed costs on firms. As a percentage of total sales, these costs decrease as the firm's sales grow larger. Despite concluding that the cost of compliance with the rule would be 1.1% of sales across all farms, the US Food and Drug Administration (2015b) estimated that same costs would be 6.8% for very small farms, 6.0% for small farms, and 0.9% for large farms, as defined by the value of sales

(Bovay, Ferrier, and Zhen, 2018).[1] For this reason, the FDA allowed most smaller growers to begin implementing the requirements later than larger growers (in 2019 or 2020, rather than 2018) and delayed the implementation of water testing requirements by 4 years after the initial phase-in. The Produce Safety Rule only applies to producers of raw agricultural commodities and exempts farms whose production would undergo processing and certain vegetables rarely consumed raw, including asparagus, beets, and sweet corn (US Food and Drug Administration, 2015a, p. 37). Despite these exemptions, the vast majority of produce sold in the United States is expected to be grown on farms that must comply with the Produce Safety Rule (Bovay, Ferrier, and Zhen, 2018).

While the FSMA's direct benefits in terms of reducing food-borne illnesses accrue to consumers, its effect on producers is less clear. The actions of individual producers, processors, and handlers all affect food safety but cannot be easily inferred by observing the final product, leading to a possible moral hazard problem at multiple points in the supply chain (Hölmstrom, 1979; Starbird, 2005a,b). Food-borne illness outbreaks can severely depress demand, and these effects can spill over across producers and commodity categories, owing to problems of product traceability and misattribution of an outbreak's source (Calvin, 2004; Arnade, Calvin, and Kuchler, 2009; Reuters, 2011; Arnade, Kuchler, and Calvin, 2013). Improved food safety may confer benefits to producers by lessening the frequency and severity of the demand shocks that follow outbreaks of foodborne illness. [2] Moral hazard may act as a separate cause of underinvestment in food-safety improvement because the actions of producers that affect food safety cannot easily be inferred by observing the final product (Starbird, 2005a,b).[3]

For these reasons, some fruit and vegetable producers and retailers have independently developed plans, typically voluntary but nonetheless widespread, to improve food safety and consumer quality assurance. For instance, approximately 99% of California producers subscribed to the Leafy Greens Marketing Agreement developed in response to the 2006 spinach outbreak (Calvin et al., 2017). Also, the the Produce Marketing Association (PMA), a major produce trade association, has repeatedly lobbied for increased funding support for the FDA's food-safety budget and regulation of the industry under the FSMA (Produce Marketing Association, 2015, 2021). Adalja and Lichtenberg (2016) found that producer organizations are more likely to adopt food-safety guidelines if their members represent a larger share of the market or have recently experienced a negative food-safety event. Unfortunately, because food-safety measures are often adopted after outbreaks or recalls, it is difficult to observe how these measures affect unobservable food-safety perceptions and, subsequently, food demand.

Trade associations, such as the PMA, have multiple motivations to endorse additional regulation under the FSMA. First, by ensuring that most produce is grown using good food-safety practices, the FSMA protects the reputations of growers, including those who have long adopted food-safety standards but might be subject to demand shocks following outbreaks. Second, the comprehensive implementation of the Produce Safety Rule would increase the cost burden for (nonmember) farm companies that had not yet adopted private or collective food-safety standards.

By simulating the changes in producer surplus that result from comprehensive enactment of the Produce Safety Rule, relative to unilateral (commodity-specific) adoption of produce-safety standards, we shed light on how the FSMA's implementation may have benefited certain growers and industry groups (an outcome that may have been anticipated by the beneficiaries, too). In light of these potential substitution effects, this paper presents estimates of both the value of each commodity's potential exemption from the Produce Safety Rule and the benefit producers of each commodity gain from the rule's comprehensive enactment, relative to a unilateral producer-

[1] Farms with less than $25,000 in fresh produce sales, along with farms selling locally with sales less than $500,000, are excluded from coverage.

[2] Conversely, if, following a outbreak, consumers substitute to other similar commodities (thought to be safe), foods can act as shock substitutes (Arnade, Calvin, and Kuchler, 2009).

[3] Exacerbating the moral hazard problem is the possibility for risks to be introduced at multiple links in the supply chain (Hölmstrom, 1979) and mitigated by consumers. If ignored, potential offsetting behavior by consumers can bias estimates of the effect of regulations on the number of illnesses (Miljkovic, Nganje, and Onyango, 2009; Peltzman, 1976).

group decision to adopt equivalent private standards. Even if the demand for a commodity is entirely unaffected by other producers' food-safety actions, an exempted commodity group may still benefit from the enactment of comprehensive safety rules mandated for other producers through simple price effects that encourage potential substitution to similar, but now relatively lower-priced, commodities. Under these same conditions, commodity groups that undertake such measures would benefit from comprehensive enactment of the Produce Safety Rule because it mitigates the potential for substitution effects induced by changes in relative prices.

Model Setup

We use estimates of the commodity-level costs of compliance with the FSMA within an equilibrium displacement model to estimate the consumer and producer welfare effects and pass-through of those costs for 18 fruits and 20 vegetables.

Equilibrium Displacement Model

Equilibrium displacement models (EDMs) have wide application within applied policy analysis, including analysis of the economic effects of agricultural policies, to allow for comparative static analysis of a market event across upstream and downstream elements of the supply chain (see, e.g., Wohlgenant, 1989; Davis and Espinoza, 1998; Alston et al., 2007; Okrent and Alston, 2012; Zhang, 2021). The EDM allows us to consider the extent to which producers' welfare losses arising from the costs associated with food-safety investments are offset by substitution effects when those costs are undertaken jointly by a wide array of fruit and vegetable producers, as under the Produce Safety Rule, rather than unilaterally, as with commodity specific food-safety programs. To develop the EDM, first, an initial market equilibrium is assumed to hold across the linked markets under consideration where supply and demand relationships are explicitly specified. Next, a reduced form of the model is derived, typically by translating key supply and demand relationships to more easily manipulated elasticity relationships. Then, an exogenous market shock, policy, or restriction is simulated to show how the equilibrium moves from an initial state to new state after the shock. Finally, relevant welfare or policy metrics are developed to describe the event.

In our model, we assume that each retail food product (Q) requires two production inputs, wholesale-level (unprocessed) food (X) and marketing inputs (M). For instance, to sell an apple at the retail level, a grocery store purchases wholesale apples from wholesale processors[4] and marketing inputs (e.g., store space, shelving, cashier labor, electricity, advertising, delivery trucks). We consider N goods in our model, indexed by i in retail food (Q_i), wholesale food (X_i), and marketing input use of retail food (M_i). The prices of Q_i, X_i, and M_i are denoted respectively as P_i, W_i, and W_M, and $\boldsymbol{P}$ and $\boldsymbol{W}$ are $N \times 1$ matrices of these prices. The A_i term captures any potential demand increase associated with food being safer for having adopted the FSMA-mandated measures.

The EDM assumes that both retail and wholesale markets are competitive. As noted by a reviewer, certain fruit and vegetable processing industries are highly concentrated and food retailers often maintain market power within local areas, suggesting the need for a model that incorporates market power. While new econometric models simultaneously allow for both wholesale and retailer market power, their application has been limited to specific industries such as yogurt or ketchup (Villas-Boas, 2007; Villas-Boas and Zhao, 2005), likely due in part to their heavy data and computation

[4] We use the term "wholesale" in the paper to capture the initial point in which unprocessed fruit and vegetable commodities can be observed. While our cost shifts are estimated on a percentage basis at the farm level, we assume that same percentage cost shift applies at the wholesale level because processor margins for wholesale-level fruits and vegetables are small and those wholesalers also faced costs increases under the FSMA. To the extent that wholesaler markups above farm costs are large and do not also increase in the same proportion as farm costs do under the Produce Safety Rule, the cost shifts used in our model will be overstated when applied to wholesale-level rather than farm-level costs.

requirements to account for specific brand and attribute effects. While acknowledging that market power may be present in parts of the fruit and vegetable supply chains, we believe that the assumption of competitive wholesale and retail markets is appropriate for several reasons. First, as Sexton (2013) notes, the national grocery retail market is substantially less concentrated than local markets, and retailers' pricing decisions in one area are unlikely to affect those in others. Second, Thomassen et al. (2017) show that because retailers sell goods across many product categories, complementary cross-category price effects substantially dampen the market power of retailers in local settings; consumers who prefer to shop at a single store constrain market power more than multi-store shoppers. Third, at the processor level, market power is likely to affect intra-commodity strategies (e.g., Dole adjusts banana prices in response to Chiquita banana prices) rather than cross-commodity strategies. Fourth, at both the retail and wholesale level, the shifts in costs stemming from the Produce Safety Rule's implementation affect the commodities as a whole, rather than being shocks to individual producers. We suspect that a more-or-less uniform cost increase for all processors and retailers of a commodity will have offsetting effects in the application of market power.[5]

For retail food, we define the demand function as Q_i^D in equation (1) and the cost function as C_i in equation (2). Constant average costs are assumed so that C_i equals the cost function per unit $c(W, W_M)$ multiplied by output (Q). Furthermore, if retail markets are competitive, price equals average cost, which implies the latter expression in equation (2). For wholesale foods, we define the demand function as X_i^D in equation (3) and the supply function as X_i^S in equation (4). As an input, wholesale food's demand function can be defined as the derivative with respect to W_i of the retail food cost function in equation (2). The assumptions of competitive markets and constant average costs imply that the producer surplus at the retail level is zero.

The added costs of implementing FSMA regulations for wholesale producers are modeled as a percentage reduction in the prices farmers receive at the wholesale level, denoted h_i. For example, if the cost of implementing FSMA regulations is 2.7% for watermelons, then $h_i = 0.027$ and farmers receive 97.3% of the wholesale price paid (W_i). Hence, we define wholesale food supply X_i^S as a function of W_i and h_i. For marketing inputs, we define the demand function as M_i^D in equation (5) and the supply function as M_i^S in equation (6). Like the demand for individual wholesale foods, the demand for marketing inputs is the derivative of the retail food cost function in equation (2) with respect to W_M. The supply of marketing inputs depends solely on W_M. These equations are collectively:

(1)	$Q_i^D = Q_i^D(P, A)$	Retail food demand
(2)	$C_i = c_i(W, W_M) \times Q_i$ $P_i = c_i(W, W_M)$	Retail food cost
(3)	$X_i^D = X_i^D(W, W_M, Q)$	Wholesale food demand
(4)	$X_i^S = X_i^S(W, W_M, h_i)$	Wholesale food supply
(5)	$M_i^D = M_i^D(W, W_M, Q)$	Marketing input demand
(6)	$M_i^S = M_i^S(W_M)$	Marketing input supply

[5] Related to market power questions is the concern that contract production interferes with the competitive mechanism for pass-through of FSMA costs. However, Bovay (2017) suggests that (i) before the FSMA was implemented, the majority of fresh tomatoes in the United States were still sold through wholesale terminal produce markets and (ii) since 2009, major retailers have increasingly required their suppliers to sign contracts specifying that food-safety standards be met. Since the FSMA Produce Safety Rule largely corresponds to the private food-safety standards specified in these contracts, the economic burden of the rule will fall largely on growers who do not participate in contracts with major retailers. Thus, in studying the portion of the wholesale-to-retail market for fruit and vegetables that is most affected by the implementation of the Produce Safety Rule, we believe the assumption of competitive markets to be quite plausible.

Appendix A of the online supplement (available online at www.jareonline.org) shows that equations (1)–(6) can be represented in terms of

- $\boldsymbol{\eta}$, the Marshallian demand elasticities for retail food;
- $\boldsymbol{\gamma_X}$, the Hicksian demand elasticities for the wholesale food inputs;
- $\boldsymbol{\gamma_M}$, the Hicksian demand elasticities for the marketing input;
- $\boldsymbol{\varepsilon}$, the supply elasticities for wholesale food; and
- $\boldsymbol{\omega}$, the cost shares of wholesale food in the production of retail food.

In reorganizing equations (1)–(6) into matrix form, $\partial \ln$ denotes the change in a variable's log value (e.g., $\partial \ln P = \frac{\partial P}{P}$). Let $\boldsymbol{\beta}$ be an $N \times 1$ matrix with each element equaling $\beta_i = (1 - h_i)$. We assume that $\frac{\partial Q_i^D}{\partial A_i} = 0$ for all commodities[6] and that the supply of marketing inputs is perfectly elastic (a specification that allows us to eliminate an equation from the matrix solution). As shown in Appendix A of the online supplement, under the assumptions of the model, we obtain equations (7)–(11):

$$\partial \ln Q - \boldsymbol{\eta} \partial \ln P = 0 \tag{7}$$

$$\partial \ln P - \boldsymbol{\omega} \partial \ln W = 0 \tag{8}$$

$$\partial \ln X - \boldsymbol{\gamma_X} \partial \ln W - \partial \ln Q = 0 \tag{9}$$

$$\partial \ln X - \boldsymbol{\varepsilon} \partial \ln W = \boldsymbol{\varepsilon} \ln \beta \tag{10}$$

$$-\partial \ln Q - \boldsymbol{\gamma_M} \partial \ln W + \partial \ln M = 0. \tag{11}$$

The γ_{X_i} and γ_M can specified as $-(1 - \omega_i)\sigma_{X,M}$ and $(1 - \omega_i)\sigma_{X,M}$, respectively, where $\sigma_{X,M}$ is the elasticity of substitution between X_i and M for each Q_i. Note that when product i faces no cost increases (i.e., it is exempt from the FSMA) both h_i and $\ln \beta_i$ are 0.

Equations (7)–(11) can then be represented as $AZ = D$, where:

$$\mathbf{A} = \begin{bmatrix} I_N & -\eta^N & 0_N & 0_N & 0_N \\ 0_N & I_N & 0_N & -\omega_N & 0_N \\ -I_N & 0_N & I_N & (I_N - \omega_N)\sigma_{X,M} & 0_N \\ 0_N & 0_N & I_N & -\varepsilon_N & 0_N \\ -I_N & 0_N & 0_N & -(I_N - \omega_N)\sigma_{X,M} & I_N \end{bmatrix}, \tag{12}$$

$$\mathbf{Z} = [\partial \ln Q \quad \partial \ln P \quad \partial \ln X \quad \partial \ln W \quad \partial \ln M]', \text{ and} \tag{13}$$

$$\mathbf{D} = [0 \quad 0 \quad 0 \quad \varepsilon \ln \beta \quad 0]'. \tag{14}$$

Each element of $\mathbf{A}$ is an $N \times N$ matrix; each element of $\mathbf{Z}$ and $\mathbf{D}$ is $N \times 1$ in dimension. $\boldsymbol{I_N}$ is an identity matrix; $\boldsymbol{\omega_N}$, $\boldsymbol{\sigma_N}$, and $\boldsymbol{\varepsilon_N}$ are diagonal matrices of wholesale budget shares, elasticities

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[6] We assume that $\frac{\partial Q_i^E}{\partial A_i} = 0$ for all commodities because a trivial share of consumers is even aware of the FSMA Produce Safety Rule. Given this, an even more trivial share of consumers (i) expects that the Produce Safety Rule would improve food-safety outcomes and make their food safer and (ii) therefore increases their demand for fruits and vegetables. Our evidence is as follows: We examined Google Trends for the terms "produce safety rule" and "salmonella" since 2004. "Produce safety rule" never reached 1% of the peak popularity of "salmonella" as a search term. Moreover, Bovay (2017) finds that wholesalers' demand for fresh tomatoes did not increase after major members of the US industry adopted food-safety standards that closely resembled the eventual FSMA Produce Safety Rule. If wholesalers' demand did not increase then, we do not believe that consumers' demand will increase following full implementation of the FSMA. Hence, we assume that $\frac{\partial Q_i^E}{\partial A_i} = 0$.

of substitution, and wholesale supply elasticities, respectively. In our model, the FSMA regulations cause the $\boldsymbol{\beta}$ terms to shift from 0 to $\ln(1-h_i)$. As shown in Appendix C of the online supplement, $\boldsymbol{A}$ is invertible so that the solution for $\boldsymbol{Z}$ is

$$\boldsymbol{Z} = \boldsymbol{A}^{-1} \times \boldsymbol{D}. \tag{15}$$

The solution for $\boldsymbol{Z}$ can be used in conjunction with the initial equilibrium (Q_0, P_0, X_0, W_0, and M_0) to calculate new equilibrium retail quantities ($(1+\partial \ln Q) \times Q_0$) and prices ($(1+\partial \ln P) \times P_0$), wholesale (farm) quantities ($(1+\partial \ln X) \times X_0$) and prices ($(1+\partial \ln W) \times W_0$), and marketing inputs ($(1+\partial \ln M) \times M_0$).

Welfare Changes

The new equilibrium values are also used to calculate the welfare changes in terms of the (retail) consumer surplus (CS_i) and (farm) producer surplus (PS_i). Our assumption that the supply of marketing inputs is perfectly elastic, which precludes the possibility of a marketing input supplier surplus. The general formulas for the producer and consumer surplus are

$$\Delta CS_i \approx E_{0,i} \times (\partial \ln P_i \times (1 + 0.5\partial \ln Q_i)), \tag{16}$$

$$\Delta PS_i \approx R_{0,i} \times (\partial \ln W_i - h_i)(1 + 0.5\partial \ln X_i), \tag{17}$$

where $E_{0,i}$ is consumer expenditure on the ith good and $R_{0,i}$ is farm revenue from the ith good. Summing across all N goods, equations (16) and (17) yield

$$\Delta CS \approx E_0 \sum_{i=1}^{N} (w_i \times (\partial \ln P_i \times (1 + 0.5\partial \ln Q_i))) \tag{18}$$

$$\Delta PS \approx \sum_{i=1}^{N} R_{0,i} (\partial \ln W_i - h_i)(1 + 0.5\partial \ln X_i), \tag{19}$$

where E_0 is the sum of consumer expenditure across all N goods and w_i is the average share of consumer expenditure for the ith good.

Cumulatively across all goods, the changes in consumer surplus as a share of all consumer spending ($cs \approx \sum_i \Delta CS_i / E$) and producer surplus as a share of all farm revenue ($ps \approx \sum_i \Delta PS_i / R$) are

$$\Delta cs \approx \sum_{i=1}^{N} -(\partial \ln P_i \times (1 + 0.5\partial \ln Q_i)), \tag{20}$$

$$\Delta ps \approx \sum_{i=1}^{N} ((\partial \ln W_i - h_i)(1 + 0.5\partial \ln X_i)). \tag{21}$$

Cost Pass-Through

For an individual commodity, the cost of implementing the FSMA on farms is borne by both retail consumers, who pay higher prices, and farm producers, who incur additional costs not recouped through increased demand. Specifically, the shares of that price increase transmitted to consumers and producers are CPT and FPT, or

$$CPT_i \approx \Delta \ln P_i / h_i, \tag{22}$$

$$FPT_i \approx -\Delta \ln W_i / h_i. \tag{23}$$

Typically, CPT will be smaller than FPT as the potential for consumer substitution away from a good further mutes the initial price change. However, in some cases, substitution effects may potentially cause demand substitution to a particular good. As a matter of theory, CPT can be greater than FPT.

Valuing Exemptions and Comprehensive Enactment

As discussed previously, a few dozen produce commodities are considered "rarely consumed raw" and are consequently exempted from the Produce Safety Rule. We estimate the change in producer surplus if commodities were to be exempted from coverage under the Produce Safety Rule. We also estimate the producer surplus loss from the full implementation of the FSMA Produce Safety Rule, across all commodity groups, relative to a single industry's unilateral decision to require that its members adopt FSMA-like food-safety standards.

The value to producer group i of an exemption from the FSMA is calculated as the difference between the change in producer surplus when $h_i = 0$ and $\beta_i = 1$ while leaving unchanged all the other product's costs shift values ($\beta_j = 1 - h_j$) and the change in producer surplus under ($\beta_i = 1 - h_i$). Specifically, the value of an exemption (VE) for commodity i is

(24) $$VE_i = \Delta PS_i(\beta_j = 1 - h_j, \beta_i = 1) - \Delta PS_i(\beta_j = 1 - h_j, \beta_i = 1 - h_i)\ \forall\ j \neq i.$$

If similar fresh fruits and vegetables are substitutes, then the value of the exemption, in terms of the change in producer surplus, will exceed the savings in costs associated with compliance. If substitute commodities are covered by the FSMA Produce Safety Rule, their prices would rise upon implementation and demand for the exempt commodities would increase.

For similar reasons, comprehensively enacting FSMA regulations across all commodities will have a smaller negative impact on producer welfare (compared to the unilateral adoption of similar standards) if substitution effects are strong. Formally, the value of comprehensive enactment (VCE) for the ith producer group is

(25) $$VCE_i = -[\Delta PS_i(\beta_j = 1 - h_j, \beta_i = 1 - h_i) - \Delta PS_i(\beta_j = 1, \beta_i = 1 - h_i)]\ \forall\ j \neq i.$$

As we discuss in our estimation section and Appendix D of the online supplement, the VC and VCE values are interrelated owing to substitution effects being independent and linear.

Parameters Used for Simulating Supply Shifts

For reasons previously discussed, we have assumed that fruit and vegetable markets are competitive at the processor and retail levels when considered as aggregate commodities. These assumptions have strong implications for how cost shifts at the farm level are transmitted downstream to processor and consumer markets. It excludes the possibility, for example, that in response to a cost shift processors of a commodity foresee the downstream demand response by retailers or consumers and adjust price strategically. The assumption of competitive markets allows us to treat the processor and farm as a single link in the supply chain and to treat both processors and retailers as price takers, assumptions that greatly simplify the modeling of supply response.

We have also assumed that marketing inputs have a perfectly elastic supply. If this is not the case, then as demand for marketing inputs falls in tandem with a decrease in production of most fruits and vegetables, the price of marketing inputs will also fall. Substitution effects (given that the elasticity of substitution, σ, is greater than zero) would increase retailer demand for farm products slightly. Hence, a loosening of our assumption that marketing inputs are supplied perfectly elastically would result in smaller effects on farm output and prices, and these diminished effects would be passed through the supply chain resulting in smaller effects on consumer quantity purchased and consumer prices.

Therefore, both producer surplus losses and consumer surplus losses would be smaller if marketing inputs were not supplied perfectly elastically.

In this section, we draw on estimates of the costs of complying with the FSMA, the farm price shares of retail prices, the price elasticities of supply, and the elasticities of substitution to parameterize the EDM for simulating supply shifts.

Farm Costs of Implementing the FSMA Produce Safety Rule

The FDA's regulatory impact analysis (US Food and Drug Administration, 2015b) estimates differences in compliance costs between farm sizes but not between commodities. In our simulations, we use new estimates of the recurring costs of complying with the FSMA as they vary by commodity, developed by Bovay, Ferrier, and Zhen (2018) based on the FDA's estimates by farm size. Using detailed data from the 2012 Census of Agriculture (US Department of Agriculture, 2012), they first calculated the share of each regulated farm's acreage used for growing each produce commodity. Then, assuming that each commodity's distribution of acreage is equal to the distribution of production across farm sizes, the authors estimated average costs of implementing the Produce Safety Rule, by commodity, based on the distribution of farm size (sales) for each commodity. the authors further note that compliance costs will differ based on each commodity's current state of food-safety practices—which depends on local idiosyncrasies, state laws, and agreements already in place between producer groups or producers and retailers—and that the FDA's cost estimates may therefore be overestimates.

Table 2 shows estimates of the cost of implementation for the 18 fruits and 20 vegetables considered in this study, which enter our model as h_i (see equation 4). Among vegetables, romaine and head lettuce have the lowest implementation costs at 0.3%–0.4% of revenue, while snap beans have the highest at 3.0%. Among fruits, honeydew has the lowest cost of implementation at 0.3%, while mangos have the highest at 3.6%. Table 2 also indicates whether the commodity is covered or exempted from the final Produce Safety Rule and the shares of domestically consumed wholesale-level goods that are imported, which we assume have the same supply elasticities and cost increases as domestically supply goods.

Cost Shares

To estimate the share of the retail commodity's costs that is derived from the cost of wholesale agricultural costs, we divide the wholesale price by the retail price index following the method described in Stewart (2006). We obtain wholesale prices for 2010 from the USDA Economic Research Service's Fruit and Vegetable Yearbooks. Retail prices are calculated as a weighted average of observed prices within our IRI InfoScan retail scanner dataset covering 2008–2012. Table 2 provides estimates of these cost shares. By construction, the share of the retail price attributable to marketing inputs is the residual share $(1 - \omega_i)$ in our two-input production function.

Elasticities of Supply

To parameterize the elasticity of supply and the elasticity of input substitution, we reviewed the available literature. While supply elasticities have been estimated for many of the goods we consider, the estimation methods and the data used within the analyses vary considerably across goods. For instance, a common method for estimating supply response is to regress current production of the commodity on an estimate of the expected price, which is itself based on lagged prices. These specifications are typically specific to the region or country and can be sensitive to modeling choices on how price expectations are formed.

Then, this relationship can be used to determine the amount that supply changes in response to a change in the expected average price both in the short run and the long run. Estimated values of supply

Table 2. Estimates of FSMA Produce Safety Rule Cost Shifts by Commodity

Fruit	Cost Shift	Import Share	Wholesale Cost Share	Exempt?	Vegetables	Cost Shift	Import Share	Wholesale Cost Share	Exempt?
1. Apples	2.2%	7.5%	24.32%	No	1. Artichokes	0.4%	80.5%	31.29%	No
2. Apricots	2.2%	3.5%	32.34%	No	2. Asparagus	0.0%	n/a	29.47%	Yes
3. Avocados	3.5%	81.4%	70.96%	No	3. Broccoli	0.4%	19.5%	18.95%	No
4. Bananas	3.5%	99.9%	33.00%	No	4. Cabbage	1.6%	8.2%	24.22%	No
5. Cantaloupes	1.4%	43.6%	20.46%	No	5. Carrots	1.0%	15.1%	18.23%	No
6. Cherries	2.7%	7.9%	29.47%	No	6. Caulifl.	0.4%	14.1%	27.20%	No
7. Grapefruit	1.7%	2.9%	17.90%	No	7. Celery	0.4%	6.1%	11.24%	No
8. Grapes	2.1%	46.1%	36.55%	No	8. Cucumbers	2.1%	73.5%	13.96%	No
9. Honeydew	0.7%	42.0%	19.89%	No	9. Kale	0.0%	n/a	18.00%	Yes
10. Mangos	3.6%	99.9%	33.00%	No	10. Head Let.	0.3%	6.9%	18.00%	No
11. Nectarines	1.2%	8.7%	19.45%	No	11. Leaf Let.	0.4%	5.4%	10.60%	No
12. Oranges	2.2%	12.5%	16.02%	No	12. Rom. Let.	0.3%	5.4%	11.26%	No
13. Peaches	2.3%	8.7%	31.28%	No	13. Onions	1.7%	18.3%	53.33%	No
14. Pears	3.0%	19.8%	22.04%	No	14. Peppers, bell	1.3%	59.3%	23.56%	No
15. Plums	2.3%	26.9%	28.60%	No	15. Peppers, chile	2.6%	n/a	14.33%	No
16. Strawberries	1.3%	12.6%	37.15%	No	16. Snap Beans	3.0%	31.4%	14.70%	No
17. Tangerines	1.3%	28.0%	13.28%	No	17. Spinach	0.8%	4.8%	15.82%	No
18. Watermelons	2.7%	32.9%	57.94%	No	18. Squash	2.5%	n/a	21.88%	No
					19. Sweet corn	0.0%	n/a	23.33%	Yes
					20. Tomatoes	1.1%	52.5%	29.01%	No
Average	2.33%				Average	1.15%			
Max	3.57%				Max	4.55%			
Min	0.70%				Min	0.31%			

Sources: Bovay, Ferrier, and Zhen (2018); Stewart (2006).

elasticities vary considerably, as seen in Table S1 of the online supplement. For example, supply elasticity estimates for carrots range from 0.02 to 6.67. Because of the tremendous variation in estimated supply elasticities and concerns about the reliability of these estimates, we conducted our simulations with high, medium, and low values for the elasticity of supply and used the same values for multiple commodities rather than applying the commodity-level estimates from the literature. Orchard and certain perennial vegetables (asparagus and artichokes) often require several years before they begin bearing. For these crops, we used 0.8, 0.5, and 0.2 as the high, medium, and low values of the supply elasticity. Annual crops can potentially show quicker adjustment to the price changes. For annual crops, we used 1.0, 0.7, and 0.4 as the high, medium, and low values of the supply elasticity. Table S1 also details our specifications for these different scenarios.[7]

Elasticities of Substitution in Supply

To our knowledge, only Wohlgenant (1989) has systematically estimated the elasticity of substitution between agricultural commodity production and marketing inputs for vegetables, and only for vegetables as a broad aggregate category. Instead, analysts using EDMs often assume that marketing inputs and wholesale commodities are used in fixed proportions, which implies that the elasticity of substitution is 0 (see, e.g., Okrent and Alston, 2012). Besides making the models tractable, the fixed proportions assumption is intuitively appealing: Selling one retail apple require one wholesale apple as an input. However, fixed proportions in production is a limiting case, and any departure from it ($\sigma > 0$) will tend to make the wholesale demand for the commodity more elastic and dampen the retail-level price increase of an FSMA cost shift. We assume the elasticity of substitution (σ) is 0.54 for all vegetables (based on Wohlgenant, 1989) and 0 for all fruits in our baseline case but also discuss the effects under the assumption of fixed proportions (i.e., $\sigma = 0$) for all fruits and vegetables.

Demand Model

When estimating a demand system as large as ours, the standard approach has been to assume weakly separable preferences and resort to multistage budgeting to reduce the dimension of the parameter space in each estimation stage (Edgerton, 1997). In the first stage, the consumer allocates total expenditures to fruit and vegetables as two groups and to a numeraire good representing all goods and services. In the second stage, the consumer decides how much to spend on individual fruits (vegetables) conditional on the group expenditure allocated to fruit (vegetables) in the first stage. We seek to relax this theoretical constraint on budgeting by separately estimating two incomplete demand systems (LaFrance and Hanemann, 1989) for the 18 fruits and 20 vegetables. The incomplete quadratic almost ideal demand (QUAID) (Banks, Blundell, and Lewbel, 1997) for fruits or vegetables is specified as

$$(26) \qquad w_{mit} = \alpha_{mit} + \sum_{j=1}^{n} \gamma_{ij} \ln P_{mjt} + \beta_i \ln \left[\frac{x_{mt}}{\alpha(p_{mt})} \right] + \frac{\lambda_i}{b(p_{mt})} \left[\left[\ln \frac{x_{mt}}{\alpha(p_{mt})} \right] \right]^2,$$

where w_{mit} is the expenditure share of the ith fruit or vegetable subgroup sold in market m at time t; P_{mjt} is the aggregate price index of good j; x_{mt} is income; and α, γ, β, and λ are parameters. The $a(p_t)$ and $b(p_t)$ terms are defined, respectively, as

$$(27) \qquad \ln a(p_{mt}) = \alpha_0 + \sum_{i=1}^{n} \alpha_{i0} \ln p_{mit} + 0.5 \sum_{i=1}^{n} \sum_{i=1}^{n} \gamma_{ij} \ln p_{mit} \ln p_{mjt} \text{ and}$$

$$(28) \qquad b(p_{mt}) = \prod_{i=1}^{n} p_{mit}^{\beta_i}.$$

[7] We assume that all cross-price elasticities of supply are 0 so that all the off-diagonal elements of ε are 0.

When equation (26) is for fruit (vegetable) product demand, the first $n - 2$ goods are the 18 fruits (20 vegetables), the $(n - 1)$th good is a composite good for the 20 vegetables (18 fruits), and the nth good is the numeraire. The Stone price index is used for the $(n - 1)$th composite good. Equation (26) is "incomplete" in the sense that the all other goods and services are lumped into a composite good. We assume the intercept α_{mit} to be a linear function of market and seasonal fixed effects:

$$\alpha_{mit} = a_{i0} + \sum_{i=2}^{72} a_{it} mkt_{ml} + \sum_{r=2}^{13} a_{it} sea_{tr}, \tag{29}$$

where mkt_{ml} and sea_{tr} are dummy variables for market l and the rth time period within a year.

Assuming the mild conditions of Lewbel's generalized composite commodity theorem are met, cross-price elasticities derived from the share equation (w_{mit}) are the best unbiased estimates of the effects on individual fruit (vegetable) products of a change in the vegetable (fruit) group price that would be obtained from estimating a disaggregate system of 38 fruits and vegetables (Lewbel, 1996, p. 528). Let $e_{i(n-1)} (i = 1,...,n - 2)$ be the uncompensated elasticity of demand for fruit (vegetable) i with respect to vegetable (fruit) group price. Then the uncompensated elasticity of fruit (vegetable) i demand with respect to the jth vegetable (fruit) is equal to $e_{i(n-1)} \times \overline{w}_j$, where $\overline{w}_j$ is the mean budget share of vegetable (fruit) j within its group.[8]

Data

Fruit and vegetable sales data come from the IRI InfoScan retail scanner data that the USDA Economic Research Service acquired to support its food market and policy research. Our sample covers 65 quadweeks (i.e., 4-weekly periods) between January 6, 2008, and December 29, 2012. In InfoScan, there are 65 markets and 8 standard whitespaces (i.e., remaining areas). We dropped the Green Bay, Wisconsin, market from the sample due to insufficient retail data for the study period. This gives a balanced panel dataset with 4,680 market-quadweek observations.[9]

We have sales data on 18 fruits and 20 vegetables. To reduce unit value bias, we created a Fisher Ideal price index for each fruit and vegetable. The Fisher Ideal price index is a superlative index that approximates the true cost of living index for a class of expenditure function (Diewert, 1976). This allows us to account for item substitution without estimating an item-level demand model for each fruit and vegetable (Zhen et al., 2011). We constructed the Fisher Ideal price index for fruit or vegetable j as

$$p_{mjt} = \sqrt{\left(\frac{\sum (p_{mkt} q_{k0})}{\sum (p_{k0} q_{k0})}\right)\left(\frac{\sum (p_{mkt} q_{kmt})}{\sum (p_{k0} q_{kmt})}\right)}, \tag{30}$$

where p_{kmt} and q_{kmt} are the price and volume sales, respectively, of item k in market m and quadweek t and p_{k0} and q_{k0} are the base price and volume of item k set at their sample means. Within each fruit and vegetable, we defined items at the brand (name brand, no brand, private label), organic (organic, nonorganic), and type (fresh, frozen) level, yielding a maximum of 12 unique items for each food.

[8] Under two-stage budgeting, the cross-price elasticity between fruit i and vegetable j would be $e_{ij} = e_i e_{FV} \overline{w}_j$, where e_i is the expenditure elasticity for fruit i in the second stage and e_{FV} is the cross-price elasticity between the fruit and vegetable groups in the first stage. The effect of a change in price j on i of a different group is channeled through the expenditure effect by design.

[9] The InfoScan dataset contains barcode-level point-of-sale data. Some retailers provided sales data at the store level but others only at the Retail Market Area (RMA) level. The exact RMA definition varies from one retailer to another but a typical RMA contain a cluster of counties. We aggregate store-level data to the IRI market level. For RMA-only retailers, IRI reports the number of stores and addresses under each RMA. To impute IRI market-level sales for these retailers, we divided RMA-level sales by store number to get average sales per store and allocate RMA sales to each IRI market based on the number of stores the retailer has in each IRI market. The number of InfoScan retailers in each market changes over time. For market m, we multiplied total sales by the ratio of average store count to store count at t to compensate secular variation in total sales due to store entry and exit from the InfoScan program. We then divided total sales by market population to produce per capita estimates.

We multiplied annual Regional Price Parities from the Bureau of Economic Analysis with monthly Consumer Price Index from the Bureau of Labor Statistics to obtain a panel of cost-of-living index values at the Metropolitan Statistical Area (MSA) level. These index values were then weighted by county population to construct P_{mNt}, price of the numeraire, in equation (26).

To correct for price endogeneity due to unobserved demand shocks, we created an instrumental variable for each P_{mjt} in equation (26) and p_{mjt} in equation (29) by taking the weighted average price of all other markets where the weight is the inverse squared distance (in 100 miles) between market m and other markets. Identification of the price coefficients in demand equations (26) and (29) relies on common supply shocks across markets and the assumption that remaining demand shocks are uncorrelated across markets once the intercept terms A_{mit} and α_{mit} include enough demand shifters.

Empirical Specification

In our first stage, we estimate the expenditures on fruits and vegetables as groups, along with that of a numeraire food. In the second stage, we estimate the demands for 18 fruits and 20 vegetables subgroups. Table S2 of the online supplement provides descriptive statistics on the quantities and expenditures for each of the subgroups.

We have two alternative specifications of demand shifters that go into the intercept terms A_{mit} and α_{mit}. The first specification includes a constant, 71 market-specific fixed effects (base = Los Angeles), 4 yearly fixed effects (base = 2008), and 12 time-of-year dummies (base = first quadweek of a year). The second specification includes, besides the constant and market fixed effects, 64 quadweek fixed effects (base = first quadweek of the 65-quadweek sample). Compared to the second specification, the first specification has the advantage of parsimony while presumably accounting for much of demand shocks through the market, year and seasonal fixed effects. The second specification further controls for possible quadweek-specific demand shocks. However, it may over-parameterize the nonlinear QUAID model and inadvertently remove national supply shocks that would have helped identify the price coefficients. Therefore, we use the first specification as the baseline and only resort to the second specification when necessary.

We estimate equations (26) and (27) by full information maximum likelihood (FIML). We employ the parametric specification of (Moschini and Moro, 1994) for singular equation systems to account for autocorrelation in the conditional QUAID model. We also correct for autocorrelation in equation (26) using Moschini and Moro's n-parameter approach, but without the parametric restrictions implied by singular equation systems. In addition to instrumenting all prices by the Hausman-type instruments, we instrument subgroup expenditure x_{Gmt} by total expenditures on fruit and vegetables (fresh and frozen). We also include market, year, and seasonal fixed effects in equation (27) for goods.

Demand Estimates

Tables S3–S6 of the online supplement provide the own- and cross-price elasticities of our demand model for fruits, vegetables, and the commodity aggregates along with the expenditure elasticities.[10] In these tables, the diagonal terms are the own-price elasticities of demand and are all of the expected sign (negative) for normal goods.

For all fruits and vegetables considered in our analysis, income elasticities that are positive but less than 1 indicate necessities. Fruits and vegetables are substitutes where their cross-price elasticities are positive and complements where their cross-price elasticities are negative. While there is no *a priori* theoretical reason why fruits or vegetables would necessarily be complements or substitutes, the finding that many of these goods are complements has strong implications for our analysis regarding the value of FSMA exemptions. An FSMA rule that raises the cost (and price) of substitutes for

[10] The standard deviations of the elasticity estimates are shown in Tables S7–S10. Tables with the parameter estimates of the demand system are available from the authors on request.

an exempted fruit or vegetable commodity would necessarily benefit producers of the exempted commodity by increasing demand for the exempted commodity. On the other hand, if fruit and vegetable commodities were often complements, then FSMA-induced cost shifts might potentially reduce the welfare of producers of exempted goods.

Simulation Results

To simulate the market-equilibrium effects of FSMA implementation, we use the EDM framework, with assumptions about commodity-level farm and price shifts based on Bovay, Ferrier, and Zhen (2018), demand parameter estimates from the QUAIDS model, and our calculated farm cost shares. Confidence intervals for key findings are found using Monte Carlo simulation.[11] We draw conclusions about the effects on producers, retail prices, and consumer welfare, and discuss the counterfactual welfare effects of (i) unilateral adoption of FSMA-like practices and (ii) exemptions for individual commodities.

FSMA Cost Pass-Through

To calculate the pass-through of costs of FSMA compliance to consumers, we first use the EDM to calculate the effects on the variables $\partial \ln P$, $\partial \ln Q$, $\partial \ln W$, $\partial \ln X$, and $\partial \ln M$ from the cost shift embedded in the β term in equation (10) and then use equations (22) and (23) to calculate specific cost pass-through (CPT) and farm pass-through (FPT) values. These values are given for fruits and vegetables in Tables 3 and 4. For example, in the case of apples, the 2.2% increase in production costs related to the Produce Safety Rule shown in Table 3 causes retail and wholesale price increases of 0.3% and 1.249% or 0.454 cents and 0.452 cents, respectively.[12]

The estimated CPT varies across commodities. For the fruits in our study, farm prices rise by 76.59% of the farm cost of implementing the regulations while consumer prices rise by 23.97% of the farm cost of compliance, or by 0.2% of total farm costs. For the vegetables in our study, farm prices rise by 50.27% of the farm cost of implementing the regulation while consumer prices rise by 11.61% of the farm cost of compliance.

Across all commodities, the retail price effects of the farm costs associated with implementing the FSMA Produce Safety Rule are tiny. The largest simulated retail price increase is a 1.00% increase in the price of grapes. Given an average retail price of $1.96/lb of grapes, a 1% increase in retail price would be $1.98/lb. We conclude that the FSMA will not substantially impact the affordability of retail food and will not drive substantial demand shifts.

Welfare Effects of FSMA Regulation Costs

Equations (20) and (21)—along with the market-equilibrium shifts in Tables 3 and 4—are used to calculate the producer and consumer welfare effects under the assumption that improved food-safety outcomes as a result of the FSMA regulations do not affect the demand for regulated commodities.[13] These tables indicate that farm producer welfare is simulated to fall by 0.63% (of farm revenue) for

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[11] Specifically, we draw 100 values based on our estimated covariance matrix for the demand elasticities. We then recalculate all our simulated effects with each of those new sets of parameters. In our tables, we report only the standard deviations.

[12] Specifically, the retail price increase is 0.454 cents ($\$1.49 \times 0.00304$) and the wholesale price increase is 0.452 cents ($\$1.49 \times 0.2432 \times 0.0129$).

[13] Improved food safety may also plausibly increase demand for a good. However, this (hypothesized) effect is subtle and difficult to identify. Bovay (2017) estimated wholesale demand for fresh-market tomatoes before and after members of that industry adopted Good Agricultural Practices (GAPs), standards for on-farm food-safety practices that closely resemble the effect of the Produce Safety Rule, and found no evidence of increased demand for tomatoes from regions that had collectively adopted GAPs, after the date of required GAPs adoption. We know of no existing estimates of positive demand for foods grown under better food-safety practices.

Table 3. Shifts in Equilibrium Prices, Quantities, and Welfare and Cost Pass-Through (Fruit)

Commodity	Expend. Shares	$d \ln Q$	$d \ln P$	CPT (Cons.)	$d \ln X$	$d \ln W$	$d \ln MI$	CPT (Farm)	ΔCS	ΔPS	ΔCS ($ m)	Δ PS ($ m)
1. Apples	19.7%	−0.478%	0.304%	13.9%	−0.478%	1.249%	−0.478%	57.3%	−0.231%	−0.929%	−$19.23	−$18.80
2. Apricots	0.2%	−0.586%	0.281%	13.9%	−0.586%	0.869%	−0.586%	43.0%	−0.280%	−1.148%	−$0.24	−$0.31
3. Avocados	4.6%	−1.760%	0.766%	21.7%	−1.760%	1.080%	−1.760%	30.6%	−0.759%	−2.428%	−$14.75	−$33.48
4. Bananas	15.2%	−0.933%	0.726%	20.9%	−0.933%	2.199%	−0.933%	63.4%	−0.723%	−1.265%	−$46.43	−$26.81
5. Cantaloupes	3.0%	−0.059%	0.275%	19.4%	−0.059%	1.345%	−0.059%	94.7%	−0.275%	−0.075%	−$3.49	−$0.19
6. Cherries	4.1%	−0.378%	0.584%	21.6%	−0.378%	1.981%	−0.378%	73.4%	−0.583%	−0.718%	−$10.10	−$3.67
7. Grapefruit	1.1%	0.087%	0.342%	19.9%	0.087%	1.910%	0.087%	111.0%	−0.342%	0.190%	−$1.59	$0.16
8. Grapes	14.4%	0.324%	0.997%	48.4%	0.324%	2.729%	0.324%	132.5%	−0.999%	0.670%	−$60.77	$14.90
9. Honeydew	0.5%	0.116%	0.173%	24.7%	0.116%	0.869%	0.116%	124.1%	−0.173%	0.169%	−$0.37	$0.07
10. Mangos	1.1%	−1.173%	0.647%	18.1%	−1.173%	1.960%	−1.173%	54.9%	−0.643%	−1.601%	−$2.99	−$2.46
11. Nectarines	1.5%	−0.277%	0.133%	10.8%	−0.277%	0.684%	−0.277%	55.6%	−0.133%	−0.545%	−$0.84	−$0.67
12. Oranges	5.0%	−0.217%	0.280%	13.0%	−0.217%	1.750%	−0.217%	81.0%	−0.280%	−0.410%	−$5.91	−$1.39
13. Peaches	4.7%	−0.272%	0.568%	24.7%	−0.272%	1.782%	−0.272%	77.5%	−0.567%	−0.517%	−$11.26	−$3.21
14. Pears	2.9%	−0.476%	0.455%	15.3%	−0.476%	2.064%	−0.476%	69.5%	−0.454%	−0.904%	−$5.56	−$2.44
15. Plums	1.2%	−0.276%	0.508%	22.1%	−0.276%	1.775%	−0.276%	77.2%	−0.507%	−0.524%	−$2.57	−$0.76
16. Strawberries	11.7%	−0.231%	0.367%	28.0%	−0.231%	0.989%	−0.231%	75.5%	−0.367%	−0.321%	−$18.84	−$5.89
17. Tangerines	3.5%	0.034%	0.188%	14.1%	0.034%	1.418%	0.034%	105.8%	−0.188%	0.078%	−$2.78	$0.15
18. Watermelons	5.5%	−0.965%	0.757%	28.6%	−0.965%	1.307%	−0.965%	49.3%	−0.753%	−1.337%	−$17.50	−$18.00
Average	100%	−0.424%	0.55%	23.97%	−0.42%	1.69%	−0.42%	76.59%	−0.53%	−0.63%		
Standard deviation		0.001082	0.00065		0.00108	0.002	0.00108		0.00066	0.00200		

Table 4. Shifts in Equilibrium Prices, Quantities, and Welfare and Cost Pass-Through (Vegetables)

Commodity	Expend. Shares	$d \ln Q$	$d \ln P$	CPT (Cons.)	$d \ln X$	$d \ln W$	$d \ln MI$	CPT (Farm)	ΔCS	ΔPS	ΔCS ($ m)	Δ PS ($ m)
1. Artichokes	0.73%	−0.09%	0.03%	8.76%	−0.13%	0.10%	−0.06%	28.00%	−0.03%	−0.26%	−$0.08	−$0.22
2. Asparagus	3.29%	0.18%	0.06%	0.00%	0.10%	0.20%	0.25%	0.00%	−0.06%	0.20%	−$0.73	$0.71
3. Broccoli	6.23%	−0.09%	0.04%	8.32%	−0.17%	0.19%	0.00%	43.89%	−0.04%	−0.25%	−$0.92	−$1.09
4. Cabbage	2.31%	−0.19%	0.20%	12.77%	−0.54%	0.84%	0.15%	52.71%	−0.20%	−0.75%	−$1.70	−$1.54
5. Carrots	7.38%	−0.06%	0.10%	10.20%	−0.30%	0.54%	0.18%	55.96%	−0.10%	−0.43%	−$2.71	−$2.13
6. Cauliflower	1.60%	−0.13%	0.04%	10.02%	−0.19%	0.16%	−0.07%	36.83%	−0.04%	−0.27%	−$0.24	−$0.43
7. Celery	3.68%	0.01%	0.03%	6.97%	−0.11%	0.26%	0.14%	62.02%	−0.03%	−0.16%	−$0.41	−$0.24
8. Cucumumbers	4.28%	−0.50%	0.12%	5.65%	−0.90%	0.86%	−0.10%	40.44%	−0.12%	−1.26%	−$1.89	−$2.77
9. Kale	0.25%	0.19%	0.03%	0.00%	0.11%	0.16%	0.26%	0.00%	−0.03%	0.16%	−$0.03	$0.03
10. Lettuce, head	4.21%	−0.20%	0.00%	1.50%	−0.21%	0.03%	−0.19%	8.28%	0.00%	−0.30%	$0.00	−$0.84
11. Lettuce, leaf	1.38%	0.15%	0.04%	9.84%	−0.02%	0.36%	0.33%	92.87%	−0.04%	−0.03%	−$0.20	−$0.02
12. Lettuce, romaine	3.02%	0.68%	0.09%	27.58%	0.31%	0.76%	1.04%	244.90%	−0.09%	0.45%	−$1.00	$0.56
13. Onions	9.43%	−0.44%	0.43%	25.08%	−0.65%	0.81%	−0.24%	47.04%	−0.43%	−0.91%	−$14.91	−$16.83
14. Peppers, bell	7.63%	−0.09%	0.17%	13.52%	−0.39%	0.74%	0.22%	57.37%	−0.17%	−0.55%	−$4.77	−$3.64
15. Peppers, chile	0.82%	−0.43%	0.18%	6.75%	−1.00%	1.24%	0.15%	47.09%	−0.18%	−1.38%	−$0.54	−$0.60
16. Snap beans	5.65%	−0.04%	0.26%	8.82%	−0.87%	1.79%	0.78%	59.99%	−0.26%	−1.19%	−$5.40	−$3.63
17. Spinach	1.77%	−0.19%	0.06%	6.60%	−0.35%	0.35%	−0.03%	41.71%	−0.06%	−0.49%	−$0.39	−$0.50
18. Squash	3.94%	−0.32%	0.28%	11.32%	−0.87%	1.29%	0.22%	51.74%	−0.28%	−1.20%	−$4.06	−$3.80
19. Sweet corn	7.88%	−0.05%	−0.01%	0.00%	−0.03%	−0.04%	−0.06%	0.00%	0.01%	−0.04%	$0.29	−$0.27
20. Tomatoes	24.54%	−0.14%	0.16%	15.39%	−0.36%	0.57%	0.08%	53.04%	−0.16%	−0.50%	−$14.44	−$13.09
Average (Veg.)		−0.13%	0.15%	11.61%	−0.37%	0.59%	0.11%	50.29%	−0.15%	−0.51%		
Standard deviation		−0.00317	0.00201		0.10181	−0.00724	0.00954		0.00020	0.00087		
Average (Fruits and Veg.)	100.0%	−0.16%	0.44%	20.37%	−0.26%	1.40%	−0.06%	69.50%	−0.15%	−0.51%		
Standard deviation		0.00103	0.00044		0.00086	0.00147	0.00119		0.00044	0.00147		

Notes: $d \ln Z = \frac{dZ}{Z}$ for $Z = Q, P, X, W, MI$. Q and P represent output quantity and price, respectively. X is the quantity of farm inputs, W is the price of farm inputs, and MI is the quantity of marketing (nonfarm) inputs. CPT = cost pass-through.

fruit and 0.51% for vegetables. Among fruits, producer surplus losses were highest proportionately for avocados, bananas, mangos, and watermelons. This is unsurprising as these four goods saw larger relative costs shifts as a result of the rule. The last two columns of Tables 4 and 5 provide the dollar value (in millions) of consumer and producers welfare changes as a result of the rule.[14]

Producer losses are greatest for avocados, bananas, and watermelons—goods that had relatively high compliance costs—and apples—a commodity that has a larger consumer expenditure share than most other fruits. Producer welfare actually improves for grapefruit, grapes, honeydew, and tangerines. We attribute this shift to these goods having relatively small costs, relatively small input cost shares, and strong positive substitution effects that cause their demand to increase as the prices of other fruits and vegetables increase. Among vegetables, producer surplus losses were highest for snap beans, chile peppers, and squash and lowest for celery, broccoli, and the three lettuce varieties (excluding the three vegetables—sweet corn, kale, and asparagus—that were exempted from the regulation). As with fruits, we attribute this pattern to the underlying differences in cost shifts. In dollar levels, producer welfare losses were largest for onions and tomatoes, a pattern we attribute to their high shares of consumer expenditure. In general, the relatively small effect on the producer surplus from an increase in Produce Rule costs, in terms of a comparison of percentage changes, stems mainly from the small share of farm input cost in retail food products. This makes retailer demand for farm products inelastic and allows farms to shift a large share of the cost increase downstream to retailers.

Our analysis does not disaggregate welfare effects for foreign and domestic producers and does not consider additional costs to foreign producers under the Foreign Supplier Verification Program, assuming instead that foreign producers' costs are identical to US producers' costs for the same commodity. The disaggregated data on distribution of farm acreage and sales is only available for the United States, and accurate simulation of the costs of implementing the FSMA in other countries, using the same methods, would have required farm- or wholesale-level data or gross simplifying assumptions, as in Bovay and Sumner (2018). When import shares are large, as in the cases of avocados, mangos, bananas, artichokes, cucumbers, peppers, and tomatoes (see Table 2), the producer surplus loss will fall more significantly on foreign suppliers.

Table S11 of the online supplement provides the estimates of the change in consumer welfare and estimates of the both consumer and producer surplus values under our alternative low and high specifications for the elasticity of supply.[15] In general, the effects on producer surplus are small and similar across commodities. As discussed, some of the fruit commodities with the highest estimated producer losses are tropical fruits with small-scale US production. But even in the most extreme case, these producers lose only 2.4% of revenue (aggregated to the commodity level), and producers of more than 75% of commodities lose less than 1% of revenue. Fruit producer groups that gain from the implementation of the FSMA as the result of substitution include grapes, grapefruit, and tangerines. Producers of most vegetable commodities see welfare losses from FSMA costs, with losses of up to 1.4% of revenue at the commodity level. Producers of exempt commodities (kale and asparagus) and of romaine lettuce are expected to gain up to 0.5% of revenue at the commodity level. Many other factors, including changes in trade policy and disruptions attributable to the pandemic, have likely had greater effects on producer surplus since FSMA implementation began in 2018.

[14] Consumer expenditures for a specific fruit (or vegetable) are obtained as the product of annual per capita fruit (or vegetable) expenditure (from the Bureau of Labor Statistics' 2019 Consumer Expenditure Survey; \$128.80 for fruit and \$112.10 for vegetables), the US population size in 2020 (327 million), and the specific fruit's (or vegetable's) expenditure share. The consumer welfare effect for a specific fruit or vegetable is the product of the commodity's consumer expenditure and the percentage change in consumer surplus as a share of expenditure; the producer welfare effect is the product of the commodity's consumer expenditure, the commodity input's share of costs, and the percentage change in consumer surplus as a share of expenditure.

[15] In the case of vegetables, the distribution of the welfare loss was sensitive to the specification of the elasticity of substitution. When fixed proportions was alternatively specified (i.e., $\sigma = 0$); the values $d\ln Q$, $d\ln X$, and $d\ln LMI$ all equal -0.17%; $d\ln P = 0.21\%$; and $d\ln X = 0.88\%$. These numbers imply the consumer welfare falls 0.21% and producer welfare falls 0.23%. Since demand for farm products is less elastic under the fixed proportion specification, farm prices rise more and farm producer welfare falls less compared with those under the base specification.

We stress that our analysis does not imply that growers of certain commodities are unconditionally disadvantaged by the costs imposed by the FSMA. Our results characterize the average effects by commodity and are driven entirely by the size distribution of farms growing the various commodities, the relationship between farm size and the cost of compliance as outlined by Bovay, Ferrier, and Zhen (2018), and the demand elasticities. Our estimates should not be taken to imply that, for example, avocado growers should switch to growing apricots because of the smaller producer surplus losses simulated for apricot growers. Again, our estimates merely reflect average welfare effects, with the size distribution of farms growing each commodity being the main driver of these effects. At the same time, we anticipate that farms growing multiple commodities, some of which have higher profit margins than others, may pursue additional acreage of the higher-margin commodities as a result of the cost pressures created by the FSMA.

Value of Comprehensive Enactment and Exemptions

Producers of commodities that are exempt from the FSMA Produce Safety Rule may benefit when producers of substitute commodities face a cost increase. Under this same logic, the comprehensive enactment of the Produce Safety Rule offsets some of the producer surplus loss faced by producers of individual commodities since it causes the price of substitute goods to rise. Appendix B of the online supplement shows that the effect of the regulation on the new equilibrium can be decomposed into two effects. The total effect of the regulation is equal to the sum of the direct effects of the cost increase and the indirect effect from raising costs facing producers of other commodities (the comprehensive enactment effect). Appendix D of the online supplement shows that the value of an exemption is the total effect minus the direct effect. As with all our analysis of producer welfare, we assume that enactment of the Produce Safety Rule does not affect consumer demand.

Tables S12 and S13 of the online supplement provide estimates of the new equilibrium in the counter-factual case in which each commodity group unilaterally undertook collective standards for food safety with the same costs as the FSMA Produce Safety Rule. Tables S14 and S15 provide estimated welfare effects in terms of the producer surplus change for specific commodities along with their (share-weighted) averages across fruits and vegetables. For fruits, average producer welfare falls by 0.63% under comprehensive enactment but 0.93% under unilateral enactment. This large difference suggests that coordinating the timing of cost-raising food-safety investments across fruit producers mitigates much of the harm to specific commodity producer through higher costs. For vegetables, producer welfare falls by 0.51% under comprehensive enactment but 0.31% under unilateral enactment.[16] The value of an exemption from FSMA rules (as a share of industry revenue) is the difference between the producer surplus effects of comprehensive and unilateral enactment, and this is largest for tropical fruits (avocados, mangos, and bananas) and bulb onions among fruits and vegetables, respectively.

Conclusion

While its public health benefits may be large and tangible, the requirements for on-farm food-safety practices under the Food Safety Modernization Act are expected to impose substantial costs on producers. Using new findings on the size and distribution of regulatory costs across producers and new estimates of own- and cross-price elasticities for 38 fruit and vegetable commodities, we estimate that, absent any offsetting effect on consumer demand, the implementation costs of the Produce Safety Rule will reduce producer welfare by 0.63% for fruit and 0.51% for vegetables. Commodity producers are unable to fully pass along the increased cost of production to buyers. Specifically, for fruits as an aggregate, farm prices are estimated to rise by 76.6% of the farm cost of implementing the regulation

[16] Because kale, asparagus, and sweet corn are excluded from coverage under the final Produce Safety Rule and face no direct cost increase, these commodities were excluded from the welfare calculation.

while consumer prices are estimated to rise by 24.0% of the farm cost. For vegetables as an aggregate, farm prices are estimated to rise by 50.3% of the farm cost of implementing the regulation while consumer prices are estimated to rise by 11.6% of the farm cost. We estimate that the effects of increased farm costs from implementation of the FSMA on consumer prices will be no greater than 1% of retail prices for all 38 commodities; effects on consumption will also be minimal.

The comprehensive enactment of a cost-raising regulation across producers of similar goods has the potential to cause less producer welfare loss than the unilateral enactment of the same regulation by individual producers. We find this effect to be substantial for the fruits but not the vegetables covered by the Produce Safety Rule and attribute this to the difference in substitution patterns between the groups. For similar reasons, we show that producers of fruit and vegetable commodities that see bigger losses from unilateral enactment would also see a greater value to an exemption from the regulations requirements, with the caveat that this analysis assumes that improved food safety does not impart to commodities a direct demand-enhancing effect.

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References

Adalja, A., and E. Lichtenberg. "Foodborne Illness Outbreaks, Collective Reputation, and Voluntary Adoption of Industry-Wide Food Safety Protocols by Fruit and Vegetable Growers." 2016. Paper presented at the annual meeting of the Agricultural and Applied Economics Association, July 31–August 2, Boston, Massachusetts. doi: 10.22004/ag.econ.235865.

Alston, J. M., J. M. Crespi, H. M. Kaiser, and R. J. Sexton. "An Evaluation of California's Mandated Commodity Promotion Programs." *Applied Economic Perspectives and Policy* 29(2007):40–63. doi: 10.1111/j.1467-9353.2006.00329.x.

Arnade, C., L. Calvin, and F. Kuchler. "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(2009):734–750. doi: 10.1111/j.1467-9353.2009.01464.x.

Arnade, C., F. Kuchler, and L. Calvin. "Consumers' Response When Regulators Are Uncertain about the Source of Foodborne Illness." *Journal of Consumer Policy* 36(2013):17–36. doi: 10.1007/s10603-012-9217-6.

Banks, J., R. Blundell, and A. Lewbel. "Quadratic Engel Curves and Consumer Demand." *Review of Economics and Statistics* 79(1997):527–539. doi: 10.1162/003465397557015.

Bovay, J. "Demand for Collective Food-Safety Standards." *Agricultural Economics* 48(2017):793–803. doi: 10.1111/agec.12375.

Bovay, J., P. Ferrier, and C. Zhen. "Estimated Costs for Fruit and Vegetable Producers to Comply with the Food Safety Modernization Act's Produce Rule." Economic Information Bulletin 195, US Department of Agriculture, Economic Research Service, Washington, DC, 2018.

Bovay, J., and D. A. Sumner. "Economic Effects of the US Food Safety Modernization Act." *Applied Economic Perspectives and Policy* 40(2018):402–420. doi: 10.1093/aepp/ppx039.

Calvin, L. "Response to U.S. Foodborne Illness Outbreaks Associated with Imported Produce." Agriculture Information Bulletin 789-5, US Department of Agriculture, Economic Research Service, Washington, DC, 2004.

Calvin, L., H. Jensen, K. Klonsky, and R. Cook. "Food Safety Practices and Costs Under the California Leafy Greens Marketing Agreement." Economic Information Bulletin EIB-173, US Department of Agriculture, Economic Research Service, Washington, DC, 2017.

Davis, G. C., and M. C. Espinoza. "A Unified Approach to Sensitivity Analysis in Equilibrium Displacement Models." *American Journal of Agricultural Economics* 80(1998):868–879. doi: 10.2307/1244070.

Diewert, W. E. "Exact and Superlative Index Numbers." *Journal of Econometrics* 4(1976): 115–145. doi: 10.1016/0304-4076(76)90009-9.

Durham, C., and J. Eales. "Demand Elasticities for Fresh Fruit at the Retail Level." *Applied Economics* 42(2010):1345–1354. doi: 10.1080/00036840701721356.

Edgerton, D. L. "Weak Separability and the Estimation of Elasticities in Multistage Demand Systems." *American Journal of Agricultural Economics* 79(1997):62–79. 10.2307/1243943.

Hölmstrom, B. "Moral Hazard and Observability." *Bell Journal of Economics* 10(1979):74–91.

Johnson, R. "The FDA Food Safety Modernization Act (P.L. 111-353)." Report R40443, Congressional Research Service, Washington, DC, 2011.

LaFrance, J. T., and W. M. Hanemann. "The Dual Structure of Incomplete Demand Systems." *American Journal of Agricultural Economics* 71(1989):262–274. doi: 10.2307/1241583.

Lewbel, A. "Aggregation without Separability: A Generalized Composite Commodity Theorem." *American Economic Review* (1996):524–543. doi: JSTOR.

Miljkovic, D., W. Nganje, and B. Onyango. "Offsetting Behavior and the Benefits of Food Safety Regulation." *Journal of Food Safety* 29(2009):49–58. doi: 10.1111/j.1745-4565.2008.00138.x.

Moschini, G., and D. Moro. "Autocorrelation Specification in Singular Equation Systems." *Economics Letters* 46(1994):303–309. doi: 10.1016/0165-1765(94)90150-3.

Okrent, A. M., and J. M. Alston. "Demand for Food in the United States: A Review of Literature, Evaluation of Previous Estimates, and Presentation of New Estimates of Demand." Monograph 48, Giannini Foundation, Berkeley, CA, 2011.

———. "The Effects of Farm Commodity and Retail Food Policies on Obesity and Economic Welfare in the United States." *American Journal of Agricultural Economics* 94(2012):611–646. doi: 10.1093/ajae/aar138.

Peltzman, S. "Toward a More General Theory of Regulation." *Journal of Law and Economics* 19(1976):211–240. doi: 10.1086/466865.

Produce Marketing Association. "Letter of Support for FSMA Funding." 2015. Available online at https://www.pma.com/content/articles/fda-food-safety-budget.

———. "RE: 21 CFR Part 1: Requirements for Additional Traceability Records for Certain Foods; FDA-2014-N-0053-0184." 2021. Available online at https://web.archive.org/web/20210624170415/https://www.pma.com/-/media/pma-files/final-pma-statement-onthe-fsma-traceability-rule-feb2021.pdf.

Reuters. "EU Raises Farmers' *E. coli* Aid Offer to 210 Mln Euro." 2011. Available online at http://news.trust.org//item/20110608164100-nr138/.

Sexton, R. J. "Market Power, Misconceptions, and Modern Agricultural Markets." *American Journal of Agricultural Economics* 95(2013):209–219. doi: 10.1093/ajae/aas102.

Starbird, S. A. "Moral Hazard, Inspection Policy, and Food Safety." *American Journal of Agricultural Economics* 87(2005a):15–27. doi: 10.1111/j.0002-9092.2005.00698.x.

———. "Supply Chain Contracts and Food Safety." *Choices* 20(2005b):123–128. doi: 10.22004/ag.econ.93487.

Stewart, H. "How Low Has the Farm Share of Retail Food Prices Really Fallen?" Economic Research Report 24, US Department of Agriculture, Economic Research Service, Washington, DC, 2006.

Thomassen, Ø., H. Smith, S. Seiler, and P. Schiraldi. "Multi-Category Competition and Market Power: A Model of Supermarket Pricing." *American Economic Review* 107(2017):2308–5231. doi: 10.1257/aer.20160055.

US Department of Agriculture. *2012 Census of Agriculture*. Washington, DC: USDA National Agricultural Statistics Service, 2012. Available online at www.nass.usda.gov/AgCensus.

US Food and Drug Administration. "Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption." *21 CFR Parts 11, 16, and 112* (2015a).

———. "Standards for the Growing, Harvesting, Packing and Holding of Produce for Human Consumption - Final Regulatory Analysis - Unfunded Mandates Reform Act Analysis." *Federal Register* 87(2015b):42,973–42,979.

Villas-Boas, J. M., and Y. Zhao. "Retailer, Manufacturers, and Individual Consumers: Modeling the Supply Side in the Ketchup Marketplace." *Journal of Marketing Research* 42(2005):83–95. doi: 10.1509/jmkr.42.1.83.56959.

Villas-Boas, S. B. "Vertical Relationships between Manufacturers and Retailers: Inference with Limited Data." *Review of Economic Studies* 74(2007):625–652. doi: 10.1111/j.1467-937X.2007.00433.x.

Wohlgenant, M. K. "Demand for Farm Output in a Complete System of Demand Functions." *American Journal of Agricultural Economics* 71(1989):241–252. doi: 10.2307/1241581.

Zhang, W. "California's Climate Policy and the Dairy Manufacturing Industry: How Does a Federal Milk Marketing Order Matter?" *Journal of Agricultural and Resource Economics* 46(2021):401–424. doi: 10.22004/ag.econ.305224.

Zhen, C., M. K. Wohlgenant, S. Karns, and P. Kaufman. "Habit Formation and Demand for Sugar-Sweetened Beverages." *American Journal of Agricultural Economics* 93(2011):175–193. doi: 10.1093/ajae/aaq155.

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Online Supplement:
Price and Welfare Effects of the Food Safety Modernization Act Produce Safety Rule

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Appendix A. Derivation of Equilibrium Displacement Model

To derive the equilibrium displacement model, we take the total derivative for each of equations (1) through (6) and then rearrange terms to organize the equations in terms of elasticities (η,ε,σ), budget shares (ω) and log changes in variables (noting that $\frac{\partial X}{X} = \partial \ln X$, $\frac{\partial P}{P} = d \ln P$, and so on).

Assuming $\boldsymbol{A}$ is constant, Equation (1) becomes:

$$\partial Q_i^D = \sum_{j=1}^{N} \frac{\partial Q_i^D}{\partial P_j} \partial P_n + \frac{\partial Q_i^D}{\partial A_i} \partial A_i$$

$$\partial \ln Q_i^D = \sum_{j=1}^{N} \frac{\partial Q_i^D}{\partial Pj} \frac{P_j}{Q_i^D} \partial \ln P_j$$

$$\partial \ln Q_i^D = \sum_{j=1}^{N} \eta_{ij} \partial \ln P_j$$

$$\partial \ln Q = \eta \partial \ln P.$$

Note that by assuming competitive markets $c_i = P_i$ and, by Shepherd's Lemma, $\frac{\partial c_i}{\partial W_i}$ and $\frac{\partial c_i}{\partial W_M} = X_i$ and M_i. Equation (2) becomes:

$$\partial P_i = \frac{\partial c_i}{\partial W_j} \partial W_j + \frac{\partial c_i}{\partial W_M} \partial W_M$$

$$\partial \ln P_i = \frac{X_i W_j}{Q_i P_i} \partial \ln W_j + \frac{M_i W_M}{Q_i P_i} \partial \ln W_M$$

$$\partial \ln P_i = \omega_i \times \partial \ln W + (1 - \omega_i) \times \partial \ln W_M.$$

where ω_i is the wholesale product's share of retail costs.

Because the supply of marketing inputs (M) is perfectly elastic, $\partial lnW_M = 0$. Also, since average costs are constant, $\frac{\partial X_i^D}{\partial Q_j} \frac{Q_j}{X_i^D} = 1$. Equation (3) becomes:

$$\partial X_i^D = \frac{\partial X_i^d}{\partial W_j} \partial W_j + \frac{\partial X_i^d}{\partial W_M} \partial W_M + \frac{\partial X_i^D}{\partial Q_j} \partial Q_j$$

$$\partial \ln X_i^D = \frac{\partial X_i^D}{\partial W_j} \frac{W_j}{X_i^D} \partial lnW_j + \frac{\partial X_i^D}{\partial W_M} \frac{W_M}{X_i^D} \partial lnW_M + \frac{\partial X_i^D}{\partial Q_j} \frac{Q_j}{X_i^D} \partial lnQ_j$$

$$\partial \ln X = \boldsymbol{\gamma_X} \times \partial \ln W + 0 + \partial \ln Q$$

Noting that $\beta_i = 1 - h_i$, Equation (4) becomes:

$$\partial X_i^S = \frac{\partial X_i^S}{\partial(\beta \times W_i)} \partial(\beta \times W_i)$$

$$\partial \ln X_i^S = \frac{\partial X_i^S}{\partial(\beta \times W_i)} \frac{(\beta \times W_i)}{X_i^S} \frac{\partial(\beta \times W_i)}{\beta \times W_i} = \varepsilon_{ij} \frac{\partial(\beta \times W_i)}{\beta \times W_i}$$

$$\partial \ln X_i^S = \varepsilon_{ij}(\partial \ln W_i + \partial \ln \beta)$$

$$\partial \ln X = \boldsymbol{\varepsilon} \partial \ln W + \boldsymbol{\varepsilon} \ln \beta.$$

Equation (5) becomes:

$$\partial M_i^D = \frac{\partial M_i^D}{\partial W_j} \partial W_j + \frac{\partial M_i^D}{\partial W_M} \partial W_M + \frac{\partial M_i^D}{\partial Q_i} \partial Q_i$$

$$\partial \ln M_i^D = \frac{\partial M_i^D}{\partial W_j} \frac{W_j}{M_i} \partial \ln M_i + \frac{\partial M_i^D}{\partial W_M} \frac{W_M}{M_i} \partial \ln W_M + \frac{Q_i}{M_i} \partial \ln Q_i$$

$$\partial \ln M = \boldsymbol{\gamma_M} \partial \ln W_j + 0 + \partial \ln Q.$$

Equation (6) becomes:

$$\partial M_i^S = \frac{\partial M_i^S}{\partial W_M} \partial W_M$$

$$\partial \ln M_i^S = \frac{\partial M_i^S}{\partial W_M} \frac{W_M}{M_i^S} \partial \ln W_M$$

$$\partial \ln M_i^S = \boldsymbol{\varepsilon_M} \partial \ln W_M.$$

Impose market equilibrium so that $Q_i^D = Q_i^S, X_i^D = X_i^S$, etc. If the supply of marketing inputs is perfectly elastic, then $\varepsilon_M = \infty$ and $\frac{1}{\varepsilon_M} = 0$. These substitutions allow the last equation to be dropped as $\partial \ln W_M = 0$ and the other equations to be simplified to:

$$\partial \ln Q - \boldsymbol{\eta} \partial \ln P = 0$$

$$\partial \ln P - \boldsymbol{\omega} \partial \ln W = 0$$

$$\partial \ln X - \boldsymbol{\gamma_X} \partial \ln W - \partial \ln Q = 0$$

$$\partial \ln X - \boldsymbol{\varepsilon} \partial \ln W = \varepsilon \ln \beta$$

$$-\partial \ln Q - \boldsymbol{\gamma_M} \partial \ln W + \partial \ln M = 0$$

Appendix B. Relationship of Substitution and Input Demand Elasticities

The variables γ_{X_i} and γ_M can be shown to equal $(1-\omega_{X_i})\sigma_{X_i,M}$ and $-(1-\omega_{X_i})\sigma_{X_i,M}$, respectively. Note that q_i is produced with two inputs X_i and M. Following equation (2), let the per unit cost of $q_i = c(W_i, W_m)$ where W_i and W_m are input prices. Following Sato and Koizumi (1973), we define the elasticity of substitution as:

$$\sigma_{X_i,M} = \frac{c_{W_i,W_M}}{c_{W_i}} \frac{c}{c_{W_M}}$$

where $c_{X_i} = \frac{\partial c}{\partial w_i}$, $c_{W_M} = \frac{\partial c}{\partial W_M}$, and $c_{x,W_M} = \frac{\partial c^2}{\partial W_i \partial W_M}$.

Note that the Hicksian cross-price elasticities of demand for input X_i are:

$$\begin{aligned}\boldsymbol{\gamma_M} &= \frac{\partial c_{W_i}}{\partial W_M} \frac{W_M}{c_{W_i}} \\ &= \frac{\partial c^2}{\partial W_i \partial W_M} \frac{W_M}{c_{W_i}} \\ &= \frac{c_{W_i,W_M}}{c_{W_i}} W_M .\end{aligned}$$

Therefore,

$$\begin{aligned}\sigma_{X,M} &= \frac{c_{W_i,W_M}}{c_w} \frac{c}{c_{W_M} \times W_M} \\ &= \gamma_{W_M} \frac{c}{c_{W_M}} \\ &= \gamma_{W_M} \frac{1}{1-\omega} \\ \gamma_M &= (1-\omega)\sigma_{X_i,M} .\end{aligned}$$

To solve for γ_X, note that:

$$c = W_i \times c_{W_i} + W_M \times c_{W_M}$$

and that:

$$\partial c = W_i \frac{\partial c_{W_i}}{\partial W_i} + W_M \frac{\partial c_{W_M}}{\partial W_i} = 0.$$

Since $\frac{\partial c_{W_M}}{\partial W_i} = \frac{\partial c^2}{\partial W_i \partial W_M} = \frac{\partial c_{W_i}}{\partial W_M}$, multiply by $\frac{1}{W_i}$ and simplify to get:

$$\gamma_X + \gamma_M = 0$$

so that:

$$\gamma_X = -(1-\omega_i)\sigma_{X_i,M} .$$

Appendix C. Proof that A is Invertible

$\boldsymbol{A}$ is invertible because its determinant is non-zero. To show this, suppress the subscripts on the identity (I_N) and zero (0_N) matrices and denote the elements of $\boldsymbol{A}$ as a_{ii} so that:

$$\text{(S1)} \qquad \boldsymbol{A} = \begin{bmatrix} I & a_{12} & 0 & 0 & 0 \\ 0 & I & 0 & a_{24} & 0 \\ -I & 0 & I & a_{34} & 0 \\ 0 & 0 & I & a_{44} & 0 \\ -I & 0 & 0 & a_{54} & I \end{bmatrix}$$

where $a_{12} = -\eta^N$, $a_{24} = -\omega_N$,$a_{34} = (I_N - \omega_N)\sigma_{X,M}$,$a_{44} = -\varepsilon_N$, and $a_{54} = -(I_N - \omega_N)\sigma_{X,I}$.

Note that the determinants of an identity matrix is 1 and a zero matrix is 0 and $det(\boldsymbol{AB}) = det(\boldsymbol{A}) * det(\boldsymbol{B})$. Swap columns of matrix A three times and rows of B four times (an odd number) to obtain matrix $\boldsymbol{B}$ where $-det(\boldsymbol{B}) = det(\boldsymbol{A})$ so that :

$$\text{(S2)} \qquad \boldsymbol{B} = \begin{bmatrix} I & -I & 0 & 0 & a_{54} \\ 0 & I & a_{12} & 0 & 0 \\ 0 & -I & 0 & I & a_{34} \\ 0 & 0 & I & 0 & a_{24} \\ 0 & 0 & 0 & I & a_{44} \end{bmatrix}$$

$$\text{(S3)} \qquad det(\boldsymbol{B}) = det \begin{bmatrix} 0 & I & a_{34} \\ I & 0 & a_{24} \\ 0 & I & a_{44} \end{bmatrix} + det \begin{bmatrix} a_{12} & 0 & 0 \\ I & 0 & a_{24} \\ 0 & I & a_{44} \end{bmatrix}$$

$$\text{(S4)} \qquad -det(\boldsymbol{B}) = det(a_{34}) - det(a_{44}) - det(a_{24}) \times det(a_{12})$$

$$\text{(S5)} \qquad det(\boldsymbol{A}) = det((I_N - \omega_N)\sigma_{X,M}) + det(\varepsilon_N) - det(\omega_N)det(\eta^N)$$

Each term in $det(\boldsymbol{A})$ is non-zero so $\boldsymbol{A}$ is invertible.

Appendix D. Relationship between Market Effects under Comprehensive and Unilateral Enactment

This section shows that the total effect on market equilibrium of the comprehensive enactment of the produce rule (without exemptions) is the sum of two distinct effects—a direct effect, the market effect on good i when it unilaterally enacts the rules, and an indirect effect, the market effect on good i when good i has an exemption from the Rules while other goods enact them. Let D be the set of cost shifts and Z be the set of effects on P, Q, W, X, and M when all non-exempted commodities must incur the costs of rule (i.e. comprehensive enactment). Reorder the rows of A, Z, and D so that:

$$\boldsymbol{A} = \begin{bmatrix} I_N & -\eta^N & 0_N & 0_N & 0_N \\ 0_N & I_N & 0_N & -\omega_N & 0_N \\ -I_N & 0_N & I_N & (I_N - \omega_N)\sigma_{X,M} & 0_N \\ -I_N & 0_N & 0_N & -(I_N - \omega_N)\sigma_{X,M} & I_N \\ 0_N & 0_N & I_N & -\varepsilon_N & 0_N \end{bmatrix},$$

$$\boldsymbol{Z} = \begin{bmatrix} \partial \ln Q & \partial \ln P & \partial \ln X & \partial \ln M & \partial \ln W \end{bmatrix}', \text{ and}$$

$$\boldsymbol{D} = \begin{bmatrix} 0 & 0 & 0 & 0 & \varepsilon\beta \end{bmatrix}'.$$

Importantly, let only the nth good receive an exemption $h_n = 0$ noting that the rows of $\boldsymbol{A}$, $\boldsymbol{Z}$, and $\boldsymbol{D}$ can be arbitrarily reordered to have any of the n goods to be ordered last. The value of an exemption for good n is the effect of the last entry in β being changed to 0. To isolate this effect, partitioning $\boldsymbol{D}$ so that $\boldsymbol{D}_{11}$ includes the first $5 \times (N-1)$ entries and $\boldsymbol{D}_{12}$ includes the last entry of $\boldsymbol{\beta}$ only. The effect of exemption is the effect of $\boldsymbol{D}_{12}$ being equal to zero. To examine this effect, similarly partition A so that the dimensions of $\boldsymbol{A}_{11}$ are $((5 \times (N-1)) \times (5 \times (N-1)))$, $\boldsymbol{A}_{12}'$ and A_{21} are $((5 \times (N-1)) \times 1)$, and $\boldsymbol{A}_{22}$ is (1×1) as follows:

$$\boldsymbol{A} = \begin{bmatrix} \boldsymbol{A}_{11} & \boldsymbol{A}_{12} \\ \boldsymbol{A}_{21} & \boldsymbol{A}_{22} \end{bmatrix} \text{ and } \boldsymbol{D} = \begin{bmatrix} \boldsymbol{D}_{11} \\ \boldsymbol{D}_{21} \end{bmatrix}$$

Note that inverse of A^{-1} is:

$$\boldsymbol{A}^{-1} = \begin{bmatrix} \boldsymbol{B}_{11} & \boldsymbol{B}_{12} \\ \boldsymbol{B}_{21} & \boldsymbol{B}_{22} \end{bmatrix}$$

where

$$\boldsymbol{B}_{11} = \left(\boldsymbol{A}_{11} - \boldsymbol{A}_{12}\boldsymbol{A}_{22}^{-1}\boldsymbol{A}_{21}\right)^{-1},$$

$$\boldsymbol{B}_{12} = -\left(\boldsymbol{A}_{11} - \boldsymbol{A}_{12}\boldsymbol{A}_{22}^{-1}\boldsymbol{A}_{21}\right)^{-1}\boldsymbol{A}_{12}\boldsymbol{A}_{22}^{-1},$$

$$\boldsymbol{B}_{21} = -\left(\boldsymbol{A}_{22} - \boldsymbol{A}_{21}\boldsymbol{A}_{11}^{-1}\boldsymbol{A}_{12}\right)^{-1}\boldsymbol{A}_{21}\boldsymbol{A}_{11}^{-1}, \text{ and}$$

$$\boldsymbol{B}_{22} = \left(\boldsymbol{A}_{22} - \boldsymbol{A}_{21}\boldsymbol{A}_{11}^{-1}\boldsymbol{A}_{12}\right)^{-1}$$

so that:

$$\boldsymbol{Z} = \begin{bmatrix} \boldsymbol{B}_{11}\boldsymbol{D}_{11} - \boldsymbol{B}_{12}\boldsymbol{D}_{12} \\ -\boldsymbol{B}_{21}\boldsymbol{D}_{11} + \boldsymbol{B}_{22}\boldsymbol{D}_{12} \end{bmatrix}.$$

Compared to the case of comprehensive enactment where all producers incur a cost reflect in β, when producers of the Nth good unilaterally undertake the producer safety rules the market effects are instead reflect in the outcome where $\boldsymbol{D}_{11} = 0$. If instead producers of the nth good receive an exemption to the rules while the rules are still comprehensively enacted by all other producers then $\boldsymbol{D}_{12} = 0$.

The market equilibrium under an exemption of the Nth good is described by the $\boldsymbol{Z}$ values where $\boldsymbol{D}_{12} = 0$ so that:

$$\text{(S6)} \qquad \boldsymbol{Z}(\boldsymbol{D}_{12} = 0) = \begin{bmatrix} \boldsymbol{B}_{11}\boldsymbol{D}_{11} \\ -\boldsymbol{B}_{21}\boldsymbol{D}_{11} \end{bmatrix}$$

while the equilibrium under unilateral enactment of the rules for Nth good is:

$$\text{(S7)} \qquad \boldsymbol{Z}(\boldsymbol{D}_{11} = 0) = \begin{bmatrix} -\boldsymbol{B}_{12}\boldsymbol{D}_{12} \\ \boldsymbol{B}_{22}\boldsymbol{D}_{12} \end{bmatrix}.$$

In reference to the nth good, D_{12} is responsible for the direct effect, the effect of the added costs to the nth producer. Similarly, D_{11} is responsible for the indirect effect, the market effect on good n when good n has an exemption while other goods face increased costs from the rules. Since the nth good is assigned by re-arranging rows for any of the N goods, this finding applies to all of the N goods. Since the sum of $\boldsymbol{Z}(\boldsymbol{D}_{11} = 0)$ and $\boldsymbol{Z}(\boldsymbol{D}_{12} = 0)$ is equal to $\boldsymbol{Z}$, the effect under comprehensive enactment across all goods is equal to the sum of the direct effect under unilateral enactment and the indirect effect under an exemption to comprehensively enacted rules.

Table S1. Supply Elasticities for Fruits and Vegetables

	Supply Elast. in Simulations			Range of Empirical			Supply Elast. in Simulations			Range of Empirical	
Fruits	Low	Med.	High	Estimates	Source	Vegetables	Low	Med.	High	Estimates	Source
1. Strawberries	0.4	0.7	1	[0.68, 1.40]	F	1. Broccoli	0.4	0.7	1	[0.12, 3.77]	J
2. Cantaloupe	0.4	0.7	1	[0.03, 0.17]	A,G	2. Kale	0.4	0.7	1	[0.56, 0.77]	
3. Honeydew	0.4	0.7	1	[0.20, 1.16]	J	3. Lettuce, leaf	0.4	0.7	1	[1.19, 1.19]	J,D,E,F
4. Watermelon	0.4	0.7	1	[0.14, 0.60]	G,J	4. Lettuce, romaine	0.4	0.7	1	n/a	J,D,E,F
5. Grapefruit	0.2	0.5	0.8	n/a		5. Spinach	0.4	0.7	1	[0.28, 2.80]	A,F
6. Oranges	0.2	0.5	0.8	n/a		6. Carrots	0.4	0.7	1	[0.02, 6.67]	G,J
7. Tangerines	0.2	0.5	0.8	n/a		7. Peppers, bell	0.4	0.7	1	[0.12, 3.50]	F,H
8. Apricots	0.2	0.5	0.8	n/a		8. Peppers, chile	0.4	0.7	1	n/a	
9. Cherries	0.2	0.5	0.8	n/a		9. Squash	0.4	0.7	1	[0.12, 0.12]	H
10. Nectarines	0.2	0.5	0.8	n/a		10. Tomatoes	0.4	0.7	1	[0.04, 0.72]	
11. Peaches	0.2	0.5	0.8	[0.80, 1.20]	F	11. Sweet corn	0.4	0.7	1	[0.00, 1.06]	F,J,C
12. Plums	0.2	0.5	0.8	n/a		12. Artichokes	0.2	0.5	0.8	n/a	
13. Apples	0.2	0.5	0.8	[0.76, 1.31]	F	13. Asparagus	0.2	0.5	0.8	[0.17, 1.11]	F,J
14. Avocados	0.4	0.7	1	0.05	K	14. Cabbage	0.4	0.7	1	[0.39, 0.93]	F,G
15. Bananas	0.4	0.7	1	n/a		15. Cauliflower	0.4	0.7	1	[0.22, 4.35]	J
16. Grapes	0.2	0.5	0.8	n/a		16. Celery	0.4	0.7	1	[0.10, 0.23]	J
17. Mangos	0.4	0.7	1	n/a		17. Cucumbers	0.4	0.7	1	[0.14, 1.11]	F,J,H
18. Pears	0.2	0.5	0.8	0.29	L	18. Lettuce, head	0.4	0.7	1	[0.32, 0.39]	J,D,E,F
						19. Onions (Bulb)	0.4	0.7	1	[0.10, 1.13]	A,G,H
						20. Snap beans	0.4	0.7	1	[0.12, 0.75]	

Sources: Seale, Zhang, and Traboulsi (2013); Russo, Green, and Howitt (2008); Mérel, Simon, and Yi (2011); Clevenger and Shelley (1974); Hammig and Mittelhammer (1982); Onyango and Bhuyan (2000); Ornelas and Shumway (1993); Málaga, Williams, and Fuller (2001); Hammig and Mittelhammer (1980); Buxton (1992); Peterson and Orden (2008); Wann and Sexton (1992)

Table S2. Descriptive Statistics of IRI Storescan Data Used in Demand Estimation

	Budget Share		Per Capita Expend. ($ /4 weeks)		Per Capita Quantity (lb/4 weeks)		Unit Value ($ /lb)			Budget Share		Per Capita Expend. ($ /4 weeks)		Per Capita Quantity (lb/4 weeks)		Unit Value ($ /lb)	
Fruits	**Avg.**	**Std.**	**Avg.**	**Std.**	**Avg.**	**Std.**	**Avg.**	**Std.**	**Vegetables**	**Avg.**	**Std.**	**Avg.**	**Std.**	**Avg.**	**Std.**	**Avg.**	**Std.**
1. Apples	0.10	0.03	0.56	0.24	0.38	0.17	1.49	0.21	1. Artichokes	0.00	0.00	0.01	0.01	0.01	0.01	2.33	0.55
2. Apricots	0.00	0.00	0.00	0.01	0.00	0.00	3.28	0.63	2. Asparagus	0.02	0.01	0.09	0.05	0.03	0.02	3.10	0.59
3. Avocados	0.03	0.01	0.15	0.10	0.06	0.05	2.67	0.61	3. Broccoli	0.03	0.01	0.18	0.09	0.10	0.05	1.78	0.17
4. Bananas	0.09	0.02	0.50	0.20	0.87	0.32	0.58	0.10	4. Cabbage	0.01	0.00	0.06	0.03	0.08	0.05	0.71	0.15
5. Cantaloupe	0.02	0.01	0.10	0.07	0.17	0.14	0.66	0.20	5. Carrots	0.04	0.01	0.21	0.10	0.16	0.08	1.32	0.13
6. Cherries	0.02	0.03	0.13	0.21	0.04	0.07	3.91	0.86	6. Cauliflower	0.01	0.00	0.05	0.02	0.04	0.02	1.26	0.25
7. Grapefruit	0.01	0.00	0.04	0.02	0.04	0.03	0.92	0.20	7. Celery	0.02	0.01	0.10	0.06	0.08	0.04	1.34	0.42
8. Grapes	0.08	0.02	0.46	0.21	0.25	0.12	1.96	0.45	8. Cucumbers	0.02	0.01	0.12	0.08	0.08	0.05	1.55	0.34
9. Honeydew	0.00	0.00	0.02	0.01	0.02	0.02	0.96	0.20	9. Kale	0.00	0.00	0.01	0.01	0.00	0.00	1.46	0.35
10. Mangos	0.01	0.00	0.03	0.02	0.02	0.02	1.76	0.45	10. Lettuce, head	0.02	0.00	0.12	0.05	0.10	0.04	1.20	0.22
11. Nectarines	0.01	0.01	0.05	0.07	0.03	0.04	1.92	0.43	11. Lettuce, leaf.	0.01	0.00	0.04	0.02	0.02	0.01	1.90	0.39
12. Oranges	0.03	0.01	0.17	0.09	0.17	0.11	1.07	0.27	12. Lettuce, romaine	0.02	0.00	0.09	0.05	0.04	0.02	2.34	0.37
13. Peaches	0.01	0.02	0.09	0.11	0.06	0.07	1.88	0.51	13. Peppers, bell	0.04	0.01	0.22	0.11	0.10	0.05	2.13	0.36
14. Pears	0.01	0.01	0.07	0.04	0.05	0.03	1.48	0.20	14. Peppers, chile	0.00	0.00	0.02	0.02	0.01	0.02	1.99	0.64
15. Plums	0.01	0.01	0.04	0.04	0.02	0.03	1.94	0.44	15. Onions	0.05	0.01	0.27	0.12	0.25	0.11	1.07	0.20
16. Strawberries	0.07	0.03	0.38	0.23	0.17	0.12	2.56	0.61	16. Snap beans	0.01	0.01	0.07	0.05	0.04	0.03	1.98	0.30
17. Tangerines	0.02	0.02	0.12	0.11	0.09	0.09	1.43	0.26	17. Spinach	0.01	0.00	0.05	0.03	0.02	0.01	2.33	0.28
18. Watermelon	0.03	0.03	0.18	0.19	0.41	0.52	0.71	0.32	18. Squash	0.02	0.01	0.09	0.07	0.07	0.08	1.46	0.35
									19. Sweet corn	0.03	0.01	0.15	0.09	0.13	0.12	1.52	0.54
									20. Tomatoes	0.09	0.02	0.51	0.24	0.24	0.11	2.20	0.40

Table S3. Unconditional Own- and Cross-Price Elasticities

	Apples	Apricots	Avocados	Bananas	Cantaloupe	Cherries	Grapefruit	Grapes	Honeydew	Mangos	Nectarines	Oranges	Peaches	Pears	Plums	Strawberries	Tangerines	Watermelon
1. Apples	−1.623	−0.033	0.287	0.123	0.030	−0.081	−0.166	−0.028	0.475	−0.315	−0.084	0.024	−0.073	−0.013	0.018	0.065	0.329	−0.037
2. Apricots	−0.008	−1.680	0.512	−0.127	0.014	0.018	0.086	−0.903	0.146	−0.439	0.281	0.064	0.020	−0.026	−0.004	0.027	0.075	0.022
3. Avocados	0.012	0.088	−2.369	0.010	0.071	−0.060	0.082	0.001	−0.008	0.010	−0.014	−0.116	−0.002	0.033	−0.002	−0.001	−0.023	−0.071
4. Bananas	0.056	−0.234	0.106	−1.506	−0.133	−0.008	0.021	1.632	0.184	0.565	−0.31	0.144	0.004	−0.010	−0.039	0.079	−0.220	−0.030
5. Cantaloupe	0.003	0.005	0.159	−0.0280	−1.255	0.061	0.051	−0.871	−0.015	−0.221	−0.029	−0.091	0.002	0.034	0.017	0.011	0.068	0.090
6. Cherries	−0.035	0.030	−0.605	−0.008	0.276	−1.012	0.563	−0.232	0.103	0.154	−0.044	−0.195	0.051	−0.181	−0.021	0.059	0.212	−0.014
7. Grapefruit	−0.051	0.107	0.593	0.015	0.165	0.404	−1.888	0.805	0.057	−0.321	0.146	−0.006	0.030	0.071	0.061	−0.013	0.496	0.161
8. Grapes	0.000	−0.045	0.000	0.044	−0.112	−0.007	0.032	−1.178	−0.035	−0.069	0.055	0.070	−0.002	0.018	0.001	0.002	−0.152	0.095
9. Honeydew	0.157	0.197	−0.064	0.134	−0.050	0.080	0.062	−0.958	−2.662	−0.171	0.003	0.010	0.002	−0.026	0.029	0.125	0.085	0.073
10. Mangos	−0.041	−0.235	0.030	0.163	−0.304	0.047	−0.137	−0.743	−0.068	−1.928	0.385	−0.094	0.000	0.026	0.025	−0.033	0.242	0.016
11. Nectarines	−0.018	0.246	−0.071	−0.147	−0.066	−0.022	0.102	0.974	0.002	0.633	−1.549	−0.123	0.007	−0.055	−0.037	−0.031	−0.273	0.000
12. Oranges	0.002	0.025	−0.265	0.031	−0.093	−0.044	−0.002	0.550	0.003	−0.069	−0.055	−1.514	0.020	−0.014	0.011	−0.008	0.191	0.050
13. Peaches	−0.107	0.121	−0.083	0.011	0.024	0.175	0.143	−0.226	0.005	−0.003	0.049	0.310	−0.393	−0.113	−0.117	0.012	−0.443	0.149
14. Pears	−0.005	−0.041	0.296	−0.009	0.138	−0.163	0.088	0.566	−0.031	0.076	−0.098	−0.057	−0.030	−0.960	0.002	0.006	0.201	0.097
15. Plums	0.023	−0.023	−0.064	−0.113	0.227	−0.064	0.256	0.054	0.114	0.248	−0.223	0.148	−0.104	0.008	−0.369	0.013	0.047	−0.117
16. Strawberries	0.079	0.136	−0.033	0.215	0.140	0.171	−0.051	0.167	0.466	−0.308	−0.177	−0.097	0.011	0.019	0.013	−1.010	0.375	0.081
17. Tangerines	0.028	0.026	−0.047	−0.042	0.061	0.042	0.138	−1.064	0.022	0.158	−0.109	0.170	−0.026	0.045	0.003	0.026	−2.105	0.014
18. Watermelon	−0.007	0.017	−0.318	−0.013	0.178	−0.006	0.099	1.466	0.042	0.024	0.000	0.097	0.019	0.048	−0.017	0.012	0.030	−1.583

Notes: Cell values refer to the change in log quantity for goods in each row in responses to the change in log price of goods in each column.

Table S4. Unconditional Own- and Cross-Price Elasticities

	Artichokes	Asparagus	Broccoli	Cabbage	Carrots	Cauliflower	Celery	Cucumbers	Kale	Lettuce, Head	Lettuce, Leaf	Lettuce, Romaine	Onions	Peppers, Bell	Peppers, Chile	Snap Beans	Spinach	Squash	Sweet Corn	Tomatoes
1. Apples	−0.018	0.051	−0.028	−0.011	−0.007	−0.024	−0.006	−0.139	0.046	−0.057	0.030	0.291	0.092	0.044	−0.065	0.027	−0.032	−0.058	−0.019	0.012
2. Apricots	−0.004	0.013	−0.007	−0.003	−0.002	−0.006	−0.002	−0.034	0.011	−0.014	0.007	0.071	0.023	0.011	−0.016	0.007	−0.008	−0.014	−0.005	0.003
3. Avocados	−0.001	0.002	−0.001	0.000	0.000	−0.001	0.000	−0.006	0.002	−0.002	0.001	0.012	0.004	0.002	−0.003	0.001	−0.001	−0.002	−0.001	0.001
4. Bananas	−0.008	0.023	−0.013	−0.005	−0.003	−0.011	−0.003	−0.063	0.021	−0.026	0.014	0.132	0.042	0.020	−0.029	0.012	−0.015	−0.026	−0.009	0.005
5. Cantaloupe	−0.002	0.005	−0.003	−0.001	−0.001	−0.002	−0.001	−0.013	0.004	−0.005	0.003	0.028	0.009	0.004	−0.006	0.003	−0.003	−0.006	−0.002	0.001
6. Cherries	−0.008	0.022	−0.012	−0.005	−0.003	−0.010	−0.003	−0.059	0.019	−0.024	0.013	0.124	0.039	0.019	−0.028	0.011	−0.014	−0.025	−0.008	0.005
7. Grapefruit	−0.006	0.016	−0.009	−0.003	−0.002	−0.007	−0.002	−0.043	0.014	−0.017	0.009	0.089	0.028	0.013	−0.020	0.008	−0.010	−0.018	−0.006	0.004
8. Grapes	0.000	0.001	0.000	0.000	0.000	0.000	0.000	−0.002	0.001	−0.001	0.000	0.004	0.001	0.001	−0.001	0.000	0.000	−0.001	0.000	0.000
9. Honeydew	−0.006	0.017	−0.009	−0.003	−0.002	−0.008	−0.002	−0.046	0.015	−0.019	0.010	0.096	0.030	0.014	−0.021	0.009	−0.011	−0.019	−0.006	0.004
10. Mangos	−0.002	0.007	−0.004	−0.001	−0.001	−0.003	−0.001	−0.018	0.006	−0.007	0.004	0.038	0.012	0.006	−0.008	0.003	−0.004	−0.008	−0.003	0.002
11. Nectarines	−0.004	0.011	−0.006	−0.002	−0.001	−0.005	−0.001	−0.030	0.010	−0.012	0.006	0.062	0.020	0.009	−0.014	0.006	−0.007	−0.013	−0.004	0.003
12. Oranges	−0.002	0.005	−0.003	−0.001	−0.001	−0.002	−0.001	−0.013	0.004	−0.005	0.003	0.028	0.009	0.004	−0.006	0.003	−0.003	−0.006	−0.002	0.001
13. Peaches	−0.026	0.075	−0.041	−0.015	−0.010	−0.035	−0.009	−0.202	0.066	−0.082	0.044	0.424	0.135	0.064	−0.095	0.039	−0.047	−0.085	−0.028	0.018
14. Pears	−0.007	0.020	−0.011	−0.004	−0.003	−0.009	−0.002	−0.053	0.017	−0.022	0.011	0.112	0.035	0.017	−0.025	0.010	−0.012	−0.022	−0.007	0.005
15. Plums	−0.024	0.066	−0.037	−0.014	−0.009	−0.031	−0.008	−0.18	0.059	−0.073	0.039	0.378	0.120	0.057	−0.084	0.035	−0.042	−0.076	−0.025	0.016
16. Strawberries	−0.022	0.063	−0.035	−0.013	−0.008	−0.030	−0.008	−0.171	0.056	−0.07	0.037	0.358	0.114	0.054	−0.08	0.033	−0.04	−0.072	−0.024	0.015
17. Tangerines	−0.002	0.004	−0.002	−0.001	−0.001	−0.002	−0.001	−0.012	0.004	−0.005	0.003	0.025	0.008	0.004	−0.006	0.002	−0.003	−0.005	−0.002	0.001
18. Watermelon	−0.003	0.010	−0.005	−0.002	−0.001	−0.005	−0.001	−0.026	0.009	−0.011	0.006	0.055	0.017	0.008	−0.012	0.005	−0.006	−0.011	−0.004	0.002

Notes: Cell values refer to the change in log quantity for goods in each row in responses to the change in log price of goods in each column.

Table S5. Unconditional Own- and Cross-Price Elasticities

	Apples	Apricots	Avocados	Bananas	Cantaloupe	Cherries	Grapefruit	Grapes	Honeydew	Mangos	Nectarines	Oranges	Peaches	Pears	Plums	Strawberries	Tangerines	Watermelon
1. Artichokes	0.017	−0.028	0.089	−0.030	0.060	0.035	0.054	−0.181	−0.003	−0.062	0.026	0.028	−0.022	0.002	−0.021	−0.005	0.095	−0.008
2. Asparagus	0.001	−0.001	0.003	−0.001	0.002	0.001	0.002	−0.007	0.000	−0.002	0.001	0.001	−0.001	0.000	−0.001	0.000	0.004	0.000
3. Broccoli	0.004	−0.006	0.018	−0.006	0.012	0.007	0.011	−0.037	−0.001	−0.013	0.005	0.006	−0.004	0.000	−0.004	−0.001	0.020	−0.002
4. Cabbage	0.008	−0.014	0.043	−0.015	0.029	0.017	0.026	−0.088	−0.001	−0.030	0.013	0.014	−0.011	0.001	−0.010	−0.002	0.046	−0.004
5. Carrots	0.004	−0.007	0.022	−0.008	0.015	0.009	0.014	−0.045	−0.001	−0.016	0.007	0.007	−0.005	0.000	−0.005	−0.001	0.024	−0.002
6. Cauliflower	0.020	−0.033	0.103	−0.035	0.070	0.041	0.062	−0.208	−0.004	−0.072	0.030	0.033	−0.025	0.002	−0.024	−0.006	0.109	−0.009
7. Celery	0.021	−0.034	0.109	−0.037	0.073	0.043	0.066	−0.220	−0.004	−0.076	0.032	0.034	−0.026	0.002	−0.026	−0.006	0.116	−0.010
8. Cucumbers	0.002	−0.003	0.011	−0.004	0.007	0.004	0.006	−0.021	0.000	−0.007	0.003	0.003	−0.003	0.000	−0.002	−0.001	0.011	−0.001
9. Kale	0.009	−0.014	0.045	−0.015	0.030	0.018	0.027	−0.090	−0.002	−0.031	0.013	0.014	−0.011	0.001	−0.010	−0.003	0.047	−0.004
10. Lettuce, head	0.049	−0.081	0.255	−0.086	0.172	0.101	0.154	−0.516	−0.009	−0.178	0.075	0.081	−0.062	0.005	−0.06	−0.014	0.271	−0.022
11. Lettuce, leaf	0.014	−0.023	0.072	−0.024	0.049	0.029	0.044	−0.147	−0.002	−0.051	0.021	0.023	−0.018	0.001	−0.017	−0.004	0.077	−0.006
12. Lettuce, romaine	0.001	−0.002	0.005	−0.002	0.003	0.002	0.003	−0.010	0.000	−0.003	0.001	0.002	−0.001	0.000	−0.001	0.000	0.005	0.000
13. Onions (Bulb)	0.008	−0.013	0.042	−0.014	0.029	0.017	0.026	−0.086	−0.001	−0.030	0.013	0.013	−0.010	0.001	−0.010	−0.002	0.045	−0.004
14. Onions (Gr.)	0.005	−0.009	0.028	−0.009	0.019	0.011	0.017	−0.057	−0.001	−0.020	0.008	0.009	−0.007	0.001	−0.007	−0.002	0.030	−0.002
15. Peppers, bell	0.004	−0.007	0.023	−0.008	0.015	0.009	0.014	−0.046	−0.001	−0.016	0.007	0.007	−0.006	0.000	−0.005	−0.001	0.024	−0.002
16. Peppers, chile	0.010	−0.016	0.051	−0.017	0.035	0.020	0.031	−0.104	−0.002	−0.036	0.015	0.016	−0.012	0.001	−0.012	−0.003	0.055	−0.005
17. Snap beans	0.012	−0.019	0.061	−0.021	0.041	0.024	0.037	−0.123	−0.002	−0.043	0.018	0.019	−0.015	0.001	−0.014	−0.003	0.065	−0.005
18. Spinach	0.012	−0.020	0.062	−0.021	0.042	0.024	0.037	−0.125	−0.002	−0.043	0.018	0.020	−0.015	0.001	−0.014	−0.004	0.066	−0.005
19. Squash	0.026	−0.043	0.134	−0.045	0.091	0.053	0.081	−0.273	−0.005	−0.094	0.040	0.043	−0.033	0.003	−0.032	−0.008	0.143	−0.012
20. Sweet corn	0.007	−0.012	0.037	−0.012	0.025	0.014	0.022	−0.074	−0.001	−0.026	0.011	0.012	−0.009	0.001	−0.009	−0.002	0.039	−0.003

Notes: Cell values refer to the change in log quantity for goods in each row in responses to the change in log price of goods in each column.

Table S6. Unconditional Own- and Cross-Price Elasticities

	Artichokes	Asparagus	Broccoli	Cabbage	Carrots	Cauliflower	Celery	Cucumbers	Kale	Lettuce, Head	Lettuce, Leaf	Lettuce, Romaine	Onions	Peppers, Bell	Peppers, Chile	Snap Beans	Spinach	Squash	Sweet Corn	Tomatoes
1. Artichokes	−0.709	−0.526	0.010	−0.019	−0.234	0.007	−0.002	−0.147	0.109	0.043	0.121	−1.588	0.091	−0.355	−0.549	−0.021	0.014	0.185	0.024	−0.033
2. Asparagus	−0.019	−1.408	0.033	−0.037	−0.160	0.046	−0.001	0.019	−0.008	−0.001	0.003	0.436	0.012	0.050	−0.017	0.005	0.015	0.001	0.002	0.017
3. Broccoli	0.002	0.181	−0.327	0.098	−0.230	−0.157	−0.007	0.262	0.010	−0.007	0.004	−0.189	0.012	0.117	−0.055	0.003	−0.001	0.014	−0.010	−0.073
4. Cabbage	−0.009	−0.490	0.231	−1.271	0.334	0.111	−0.017	0.405	−0.003	0.018	0.016	0.461	−0.004	−0.075	0.200	−0.019	0.010	0.082	0.000	0.105
5. Carrots	−0.059	−1.086	−0.281	0.173	−0.325	0.023	0.009	0.332	0.023	0.019	0.042	0.127	−0.053	−0.052	0.076	−0.007	0.047	−0.052	0.012	0.023
6. Cauliflower	0.008	1.444	−0.879	0.263	0.107	−1.097	0.042	0.478	0.182	−0.069	0.120	0.170	0.011	−0.333	0.016	0.099	0.210	−0.315	−0.094	0.193
7. Celery	−0.002	−0.027	−0.043	−0.043	0.042	0.044	−0.938	0.037	0.105	0.035	−0.162	0.284	0.140	0.220	0.199	−0.055	−0.015	0.110	0.042	0.281
8. Cucumbers	−0.018	0.062	0.151	0.099	0.157	0.049	0.004	−1.245	0.048	−0.012	−0.020	−0.212	0.016	−0.026	0.082	−0.011	0.005	−0.005	−0.003	−0.001
9. Kale	0.054	−0.102	0.024	−0.003	0.046	0.079	0.043	0.201	−1.763	0.058	−0.034	−0.128	−0.018	0.163	0.015	0.121	0.019	−0.023	0.069	0.063
10. Lettuce, head	0.122	−0.068	−0.092	0.105	0.216	−0.17	0.081	−0.292	0.331	−0.443	−0.013	−0.270	0.048	−0.17	−0.123	0.013	0.089	−0.156	−0.352	−0.005
11. Lettuce, leaf	0.098	0.064	0.017	0.027	0.136	0.085	−0.108	−0.139	−0.055	−0.004	−1.513	0.689	0.146	0.196	0.068	0.044	0.047	0.043	−0.022	0.115
12. Lettuce, romaine	−0.087	0.645	−0.050	0.052	0.028	0.008	0.013	−0.098	−0.014	−0.005	0.046	−3.483	−0.038	0.024	−0.065	0.016	−0.062	−0.024	0.034	0.080
13. Onions (Bulb)	0.043	0.150	0.027	−0.004	−0.101	0.004	0.055	0.063	−0.017	0.008	0.086	−0.332	−1.677	−0.026	−0.044	−0.078	−0.050	−0.036	0.059	−0.044
14. Onions (Gr.)	−0.111	0.425	0.179	−0.048	−0.065	−0.091	0.057	−0.068	0.102	−0.019	0.076	0.136	−0.017	−1.363	0.006	−0.041	0.017	0.103	0.045	−0.071
15. Peppers, bell	−0.141	−0.116	−0.069	0.106	0.077	0.004	0.042	0.177	0.008	−0.011	0.021	−0.305	−0.024	0.005	−1.265	0.016	0.075	−0.029	0.004	0.050
16. Peppers, chile	−0.012	0.082	0.009	−0.023	−0.015	0.050	−0.026	−0.052	0.140	0.003	0.031	0.173	−0.095	−0.075	0.036	−0.482	−0.153	0.065	−0.011	0.081
17. Snap beans	0.009	0.269	−0.002	0.014	0.127	0.124	−0.008	0.030	0.026	0.021	0.040	−0.776	−0.071	0.038	0.199	−0.181	−0.624	0.014	−0.031	−0.119
18. Spinach	0.128	0.027	0.047	0.116	−0.142	−0.189	0.062	−0.026	−0.032	−0.038	0.036	−0.303	−0.052	0.227	−0.079	0.078	0.014	−0.503	−0.071	−0.014
19. Squash	0.037	0.066	−0.077	−0.002	0.069	−0.123	0.052	−0.039	0.207	−0.186	−0.041	0.937	0.188	0.216	0.022	−0.029	−0.068	−0.155	−0.346	−0.005
20. Sweet corn	−0.013	0.188	−0.145	0.089	0.037	0.068	0.094	−0.004	0.052	−0.001	0.058	0.600	−0.038	−0.092	0.080	0.058	−0.072	−0.008	−0.001	−1.331

Notes: Cell values refer to the change in log quantity for goods in each row in responses to the change in log price of goods in each column.

Table S7. Unconditional Own- and Cross-Price Elasticities

	Apples	Apricots	Avocados	Bananas	Cantaloupe	Cherries	Grapefruit	Grapes	Honeydew	Mangos	Nectarines	Oranges	Peaches	Pears	Plums	Strawberries	Tangerines	Watermelon
1. Apples	0.062	0.021	0.007	0.029	0.007	0.031	0.039	0.004	0.043	0.020	0.033	0.014	0.062	0.016	0.045	0.046	0.008	0.010
2. Apricots	0.089	0.069	0.020	0.068	0.020	0.067	0.070	0.012	0.054	0.044	0.058	0.033	0.113	0.038	0.092	0.082	0.024	0.029
3. Avocados	0.177	0.120	0.133	0.110	0.113	0.156	0.184	0.074	0.114	0.156	0.163	0.138	0.256	0.132	0.303	0.151	0.099	0.153
4. Bananas	0.065	0.036	0.010	0.080	0.011	0.040	0.054	0.006	0.073	0.030	0.050	0.021	0.095	0.030	0.070	0.078	0.013	0.015
5. Cantaloupe	0.073	0.050	0.051	0.053	0.077	0.087	0.090	0.032	0.059	0.067	0.076	0.050	0.108	0.063	0.112	0.076	0.046	0.069
6. Cherries	0.072	0.038	0.015	0.042	0.019	0.077	0.060	0.010	0.052	0.035	0.046	0.027	0.082	0.035	0.076	0.059	0.020	0.017
7. Grapefruit	0.126	0.055	0.024	0.079	0.028	0.079	0.181	0.013	0.114	0.048	0.076	0.044	0.160	0.062	0.117	0.130	0.027	0.029
8. Grapes	0.300	0.258	0.252	0.200	0.253	0.342	0.319	0.329	0.198	0.328	0.321	0.253	0.417	0.274	0.542	0.299	0.206	0.367
9. Honeydew	0.138	0.041	0.015	0.099	0.017	0.070	0.107	0.007	0.211	0.048	0.073	0.031	0.115	0.042	0.097	0.143	0.018	0.023
10. Mangos	0.154	0.081	0.050	0.100	0.050	0.119	0.115	0.031	0.120	0.115	0.138	0.070	0.164	0.097	0.176	0.144	0.053	0.064
11. Nectarines	0.158	0.065	0.032	0.107	0.034	0.091	0.111	0.018	0.112	0.086	0.148	0.059	0.151	0.057	0.175	0.149	0.030	0.037
12. Oranges	0.149	0.082	0.060	0.099	0.050	0.122	0.142	0.032	0.104	0.095	0.129	0.101	0.193	0.095	0.220	0.147	0.057	0.075
13. Peaches	0.042	0.019	0.007	0.029	0.007	0.024	0.034	0.003	0.026	0.015	0.022	0.013	0.034	0.016	0.044	0.045	0.009	0.009
14. Pears	0.040	0.024	0.015	0.035	0.016	0.038	0.051	0.009	0.035	0.033	0.031	0.024	0.060	0.044	0.058	0.042	0.017	0.019
15. Plums	0.034	0.017	0.010	0.024	0.008	0.025	0.028	0.005	0.024	0.018	0.028	0.016	0.050	0.017	0.052	0.035	0.013	0.010
16. Strawberries	0.037	0.016	0.005	0.028	0.006	0.021	0.032	0.003	0.036	0.015	0.026	0.011	0.053	0.013	0.037	0.054	0.008	0.009
17. Tangerines	0.093	0.070	0.049	0.071	0.051	0.098	0.097	0.029	0.069	0.080	0.072	0.064	0.156	0.076	0.204	0.114	0.074	0.065
18. Watermelon	0.055	0.037	0.034	0.036	0.034	0.039	0.048	0.023	0.039	0.045	0.041	0.038	0.067	0.038	0.068	0.057	0.029	0.064

Notes: Cell values refer to the standard deviations of the own- and cross-price elasticities.

Table S8. Unconditional Own- and Cross-Price Elasticities - Standard Deviations

	Artichokes	*Asparagus*	*Broccoli*	*Cabbage*	*Carrots*	*Cauliflower*	*Celery*	*Cucumbers*	*Kale*	*Lettuce, Head*	*Lettuce, Leaf*	*Lettuce, Romaine*	*Onions*	*Peppers, Bell*	*Peppers, Chile*	*Snap Beans*	*Spinach*	*Squash*	*Sweet Corn*	*Tomatoes*
1. Apples	0.011	0.000	0.002	0.005	0.003	0.012	0.013	0.001	0.005	0.030	0.009	0.001	0.005	0.003	0.003	0.006	0.007	0.007	0.016	0.004
2. Apricots	0.020	0.001	0.004	0.010	0.005	0.023	0.024	0.002	0.010	0.056	0.016	0.001	0.009	0.006	0.005	0.011	0.013	0.014	0.030	0.008
3. Avocados	0.040	0.002	0.008	0.020	0.010	0.047	0.049	0.005	0.021	0.115	0.033	0.002	0.019	0.013	0.010	0.023	0.027	0.028	0.060	0.017
4. Bananas	0.015	0.001	0.003	0.007	0.004	0.017	0.018	0.002	0.008	0.043	0.012	0.001	0.007	0.005	0.004	0.009	0.010	0.010	0.023	0.006
5. Cantaloupe	0.017	0.001	0.004	0.008	0.004	0.020	0.021	0.002	0.008	0.049	0.014	0.001	0.008	0.005	0.004	0.010	0.012	0.012	0.026	0.007
6. Cherries	0.014	0.001	0.003	0.007	0.004	0.017	0.018	0.002	0.007	0.041	0.012	0.001	0.007	0.005	0.004	0.008	0.010	0.010	0.022	0.006
7. Grapefruit	0.024	0.001	0.005	0.012	0.006	0.028	0.030	0.003	0.012	0.069	0.020	0.001	0.011	0.008	0.006	0.014	0.016	0.017	0.037	0.010
8. Grapes	0.085	0.003	0.017	0.041	0.021	0.098	0.104	0.010	0.043	0.242	0.069	0.005	0.040	0.027	0.022	0.049	0.058	0.059	0.128	0.035
9. Honeydew	0.021	0.001	0.004	0.010	0.005	0.024	0.026	0.003	0.010	0.060	0.017	0.001	0.010	0.007	0.005	0.012	0.014	0.015	0.032	0.009
10. Mangos	0.033	0.001	0.007	0.016	0.008	0.038	0.041	0.004	0.016	0.094	0.027	0.002	0.016	0.010	0.008	0.019	0.023	0.023	0.050	0.013
11. Nectarines	0.028	0.001	0.006	0.014	0.007	0.033	0.035	0.003	0.014	0.081	0.023	0.002	0.013	0.009	0.007	0.016	0.019	0.020	0.043	0.012
12. Oranges	0.032	0.001	0.007	0.016	0.008	0.037	0.039	0.004	0.016	0.091	0.026	0.002	0.015	0.010	0.008	0.018	0.022	0.022	0.048	0.013
13. Peaches	0.008	0.000	0.002	0.004	0.002	0.010	0.010	0.001	0.004	0.024	0.007	0.000	0.004	0.003	0.002	0.005	0.006	0.006	0.012	0.003
14. Pears	0.012	0.000	0.002	0.006	0.003	0.013	0.014	0.001	0.006	0.033	0.009	0.001	0.006	0.004	0.003	0.007	0.008	0.008	0.018	0.005
15. Plums	0.009	0.000	0.002	0.004	0.002	0.010	0.011	0.001	0.004	0.025	0.007	0.000	0.004	0.003	0.002	0.005	0.006	0.006	0.013	0.004
16. Strawberries	0.008	0.000	0.002	0.004	0.002	0.009	0.010	0.001	0.004	0.023	0.006	0.000	0.004	0.002	0.002	0.005	0.005	0.005	0.012	0.003
17. Tangerines	0.028	0.001	0.006	0.014	0.007	0.032	0.034	0.003	0.014	0.080	0.023	0.002	0.013	0.009	0.007	0.016	0.019	0.019	0.042	0.011
18. Watermelon	0.011	0.000	0.002	0.006	0.003	0.013	0.014	0.001	0.006	0.033	0.009	0.001	0.005	0.004	0.003	0.007	0.008	0.008	0.017	0.005

Notes: Cell values refer to the standard deviations of the own- and cross-price elasticities.

Table S9. Unconditional Own- and Cross-Price Elasticities - Standard Deviations

	Apples	Apricots	Avocados	Bananas	Cantaloupe	Cherries	Grapefruit	Grapes	Honeydew	Mangos	Nectarines	Oranges	Peaches	Pears	Plums	Strawberries	Tangerines	Watermelon
19. Artichokes	0.021	0.005	0.001	0.010	0.002	0.009	0.006	0.000	0.007	0.003	0.005	0.002	0.031	0.008	0.027	0.026	0.002	0.004
20. Asparagus	0.059	0.014	0.002	0.026	0.006	0.025	0.018	0.001	0.019	0.008	0.013	0.006	0.086	0.023	0.076	0.072	0.005	0.011
21. Broccoli	0.023	0.006	0.001	0.010	0.002	0.010	0.007	0.000	0.008	0.003	0.005	0.002	0.033	0.009	0.030	0.028	0.002	0.004
22. Cabbage	0.025	0.006	0.001	0.011	0.002	0.011	0.008	0.000	0.008	0.003	0.005	0.002	0.036	0.010	0.032	0.031	0.002	0.005
23. Carrots	0.022	0.005	0.001	0.010	0.002	0.010	0.007	0.000	0.007	0.003	0.005	0.002	0.033	0.009	0.029	0.027	0.002	0.004
24. Cauliflower	0.022	0.006	0.001	0.010	0.002	0.010	0.007	0.000	0.007	0.003	0.005	0.002	0.033	0.009	0.029	0.028	0.002	0.004
25. Celery	0.030	0.007	0.001	0.014	0.003	0.013	0.009	0.000	0.010	0.004	0.006	0.003	0.044	0.012	0.039	0.037	0.003	0.006
26. Cucumbers	0.058	0.014	0.002	0.026	0.006	0.025	0.018	0.001	0.019	0.007	0.012	0.005	0.085	0.022	0.075	0.072	0.005	0.011
27. Kale	0.051	0.012	0.002	0.023	0.005	0.022	0.015	0.001	0.017	0.007	0.011	0.005	0.074	0.019	0.066	0.062	0.004	0.010
28. Lettuce, head	0.023	0.006	0.001	0.010	0.002	0.010	0.007	0.000	0.008	0.003	0.005	0.002	0.034	0.009	0.030	0.029	0.002	0.004
29. Lettuce, leaf	0.028	0.007	0.001	0.013	0.003	0.012	0.009	0.000	0.009	0.004	0.006	0.003	0.042	0.011	0.037	0.035	0.002	0.005
30. Lettuce, romaine	0.087	0.021	0.004	0.039	0.008	0.037	0.027	0.001	0.028	0.011	0.019	0.008	0.125	0.033	0.113	0.107	0.007	0.016
31. Onions	0.031	0.007	0.001	0.014	0.003	0.013	0.009	0.000	0.010	0.004	0.006	0.003	0.044	0.012	0.039	0.038	0.003	0.006
32. Peppers, bell.	0.029	0.007	0.001	0.013	0.003	0.012	0.009	0.000	0.009	0.004	0.006	0.003	0.042	0.011	0.037	0.035	0.002	0.005
33. Peppers, chile	0.027	0.007	0.001	0.012	0.003	0.012	0.008	0.000	0.009	0.003	0.006	0.003	0.039	0.010	0.035	0.033	0.002	0.005
34. Snap beans	0.036	0.009	0.001	0.016	0.003	0.015	0.011	0.000	0.012	0.005	0.008	0.003	0.052	0.014	0.046	0.044	0.003	0.007
35. Spinach	0.034	0.008	0.001	0.015	0.003	0.015	0.011	0.000	0.011	0.004	0.007	0.003	0.050	0.013	0.044	0.042	0.003	0.006
36. Squash	0.021	0.005	0.001	0.009	0.002	0.009	0.006	0.000	0.007	0.003	0.004	0.002	0.030	0.008	0.027	0.025	0.002	0.004
37. Sweet corn	0.035	0.008	0.001	0.016	0.003	0.015	0.011	0.000	0.011	0.004	0.007	0.003	0.050	0.013	0.045	0.043	0.003	0.007
38. Tomatoes	0.025	0.006	0.001	0.011	0.002	0.011	0.008	0.000	0.008	0.003	0.005	0.002	0.036	0.009	0.032	0.030	0.002	0.005

Notes: Cell values refer to the standard deviations of the own- and cross-price elasticities.

Table S10. Unconditional Own- and Cross-Price Elasticities - Standard Deviations

	Artichokes	*Asparagus*	*Broccoli*	*Cabbage*	*Carrots*	*Cauliflower*	*Celery*	*Cucumbers*	*Kale*	*Lettuce, Head*	*Lettuce, Leaf*	*Lettuce, Romaine*	*Onions*	*Peppers, Bell*	*Peppers, Chile*	*Snap Beans*	*Spinach*	*Squash*	*Sweet Corn*	*Tomatoes*
19. Artichokes	0.101	0.010	0.026	0.062	0.030	0.087	0.079	0.032	0.048	0.072	0.036	0.024	0.046	0.042	0.028	0.050	0.068	0.047	0.064	0.037
20. Asparagus	0.279	0.179	0.212	0.266	0.252	0.400	0.233	0.154	0.097	0.249	0.116	0.113	0.098	0.200	0.189	0.184	0.196	0.203	0.206	0.184
21. Broccoli	0.125	0.038	0.102	0.108	0.086	0.195	0.084	0.056	0.045	0.088	0.050	0.039	0.060	0.078	0.069	0.078	0.092	0.073	0.068	0.072
22. Cabbage	0.128	0.020	0.045	0.121	0.048	0.151	0.106	0.048	0.062	0.105	0.049	0.041	0.054	0.062	0.050	0.086	0.099	0.065	0.095	0.059
23. Carrots	0.119	0.037	0.070	0.093	0.121	0.177	0.100	0.036	0.053	0.099	0.051	0.050	0.046	0.080	0.070	0.073	0.100	0.083	0.069	0.071
24. Cauliflower	0.075	0.013	0.034	0.064	0.039	0.152	0.081	0.033	0.040	0.093	0.045	0.029	0.053	0.047	0.044	0.067	0.076	0.050	0.066	0.045
25. Celery	0.065	0.007	0.014	0.042	0.021	0.077	0.107	0.023	0.054	0.098	0.046	0.012	0.039	0.030	0.025	0.057	0.063	0.045	0.069	0.027
26. Cucumbers	0.269	0.048	0.098	0.196	0.076	0.323	0.236	0.117	0.111	0.190	0.113	0.081	0.103	0.141	0.120	0.158	0.181	0.142	0.190	0.116
27. Kale	0.098	0.007	0.018	0.060	0.026	0.094	0.132	0.027	0.091	0.202	0.080	0.023	0.075	0.044	0.034	0.091	0.093	0.053	0.157	0.042
28. Lettuce, head	0.025	0.003	0.006	0.018	0.009	0.037	0.042	0.008	0.035	0.088	0.030	0.005	0.021	0.012	0.009	0.025	0.031	0.018	0.046	0.014
29. Lettuce, leaf	0.046	0.005	0.013	0.030	0.016	0.065	0.069	0.016	0.049	0.105	0.051	0.013	0.035	0.019	0.018	0.046	0.048	0.029	0.069	0.021
30. Lettuce, romaine	0.430	0.081	0.146	0.365	0.230	0.602	0.267	0.177	0.212	0.260	0.196	0.178	0.157	0.261	0.223	0.250	0.242	0.259	0.211	0.219
31. Onions	0.098	0.008	0.026	0.055	0.024	0.129	0.099	0.026	0.079	0.127	0.060	0.018	0.077	0.039	0.033	0.087	0.082	0.052	0.101	0.037
32. Peppers, bell	0.131	0.023	0.050	0.095	0.064	0.172	0.115	0.054	0.070	0.106	0.050	0.045	0.059	0.089	0.067	0.084	0.103	0.081	0.088	0.062
33. Peppers, chile	0.111	0.027	0.056	0.095	0.068	0.197	0.118	0.055	0.066	0.105	0.057	0.047	0.060	0.082	0.100	0.087	0.099	0.103	0.088	0.068
34. Snap beans	0.086	0.012	0.028	0.072	0.032	0.134	0.120	0.033	0.078	0.124	0.064	0.024	0.072	0.046	0.038	0.106	0.093	0.067	0.093	0.046
35. Spinach	0.100	0.011	0.028	0.071	0.037	0.129	0.113	0.032	0.069	0.130	0.057	0.020	0.057	0.047	0.037	0.080	0.123	0.059	0.098	0.046
36. Squash	0.068	0.011	0.022	0.046	0.030	0.083	0.079	0.024	0.038	0.076	0.034	0.020	0.035	0.037	0.038	0.055	0.058	0.054	0.067	0.036
37. Sweet corn	0.043	0.005	0.009	0.030	0.012	0.051	0.056	0.015	0.052	0.089	0.037	0.007	0.032	0.019	0.015	0.035	0.044	0.031	0.115	0.018
38. Tomatoes	0.091	0.016	0.036	0.070	0.044	0.125	0.081	0.034	0.051	0.098	0.041	0.029	0.043	0.047	0.043	0.064	0.077	0.060	0.067	0.054

Notes: Cell values refer to the standard deviations of the own- and cross-price elasticities.

Table S11. Consumer and Producer Welfare Changes under Alternative Elasticity of Supply Specifications

	Low		High			Low		High	
Fruit	**Δ CS**	**Δ PS**	**Δ CS**	**Δ PS**	**Vegetable**	**Δ CS**	**Δ PS**	**Δ CS**	**Δ PS**
1. Apples	−0.160%	−1.408%	−0.259%	−0.688%	1. Artichokes	−0.010%	−0.340%	−0.050%	−0.210%
2. Apricots	−0.134%	−1.603%	−0.361%	−0.898%	2. Asparagus	−0.060%	0.210%	−0.050%	0.180%
3. Avocados	−0.491%	−2.817%	−0.960%	−2.138%	3. Broccoli	−0.030%	−0.310%	−0.040%	−0.200%
4. Bananas	−0.575%	−1.717%	−0.811%	−0.997%	4. Cabbage	−0.150%	−0.970%	−0.240%	−0.610%
5. Cantaloupe	−0.235%	−0.269%	−0.287%	−0.017%	5. Carrots	−0.070%	−0.560%	−0.110%	−0.340%
6. Cherries	−0.440%	−1.202%	−0.643%	−0.514%	6. Cauliflower	−0.030%	−0.330%	−0.050%	−0.230%
7. Grapefruit	−0.300%	−0.042%	−0.346%	0.215%	7. Celery	−0.020%	−0.220%	−0.030%	−0.120%
8. Grapes	−0.987%	0.637%	−0.987%	0.636%	8. Cucumbers	−0.080%	−1.550%	−0.150%	−1.040%
9. Honeydew	−0.150%	0.054%	−0.176%	0.187%	9. Kale	0.00%	−0.350%	−0.010%	−0.260%
10. Mangos	−0.480%	−2.100%	−0.746%	−1.287%	10. Lettuce, head	0.00%	−0.350%	−0.010%	−0.260%
11. Nectarines	−0.069%	−0.875%	−0.164%	−0.388%	11. Lettuce, leaf	−0.030%	−0.090%	−0.040%	0.00%
12. Oranges	−0.225%	−0.755%	−0.300%	−0.285%	12. Lettuce, romaine	−0.080%	0.400%	−0.080%	0.410%
13. Peaches	−0.426%	−0.963%	−0.621%	−0.350%	13. Onions (Bulb)	−0.310%	−1.130%	−0.510%	−0.760%
14. Pears	−0.313%	−1.547%	−0.515%	−0.627%	14. Peppers, bell	−0.130%	−0.720%	−0.200%	−0.450%
15. Plums	−0.381%	−0.968%	−0.554%	−0.359%	15. Peppers, chile	−0.130%	−1.740%	−0.210%	−1.140%
16. Strawberries	−0.305%	−0.488%	−0.398%	−0.239%	16. Snap beans	−0.200%	−1.610%	−0.300%	−0.940%
17. Tangerines	−0.158%	−0.148%	−0.194%	0.119%	17. Spinach	−0.040%	−0.610%	−0.070%	−0.400%
18. Watermelon	−0.566%	−1.663%	−0.876%	−1.122%	18. Squash	−0.210%	−1.550%	−0.330%	−0.970%
					19. Sweet corn	0.010%	−0.040%	0.010%	−0.040%
Average	−0.011%	0.021%	−0.579%	−0.473%	20. Tomatoes	−0.120%	−0.650%	−0.190%	−0.410%
St Dev	0.00089	0.00274	0.00053	0.00160					
					Average	−0.11%	−0.65%	−0.17%	−0.42%
					St Dev (veg)	0.00020	0.00085	0.00019	0.00079
					Average	−0.11%	−0.65%	−0.17%	−0.42%
					St Dev (all)	0.00057	0.00185	0.00037	0.00122

Table S12. Shifts in Equilibrium Prices, Quantities, and Welfare and Cost Pass-Through Associated with Commodity Groups Unilaterally Implementing FSMA Regulations (Fruit)

Commodity	Expend. Shares	$d \ln Q$	$d \ln P$	CPT (Cons.)	$d \ln X$	$d \ln W$	$d \ln MI$	CPT (Farm)
1. Apples	19.72%	−0.48%	0.30%	13.86%	−0.48%	1.24%	−0.48%	56.97%
2. Apricots	0.19%	−0.52%	0.32%	16.05%	−0.52%	1%	−0.52%	49.64%
3. Avocados	4.63%	−1.78%	0.74%	21.01%	−1.78%	1.05%	−1.78%	29.61%
4. Bananas	15.23%	−1.04%	0.67%	19.42%	−1.04%	2.04%	−1.04%	58.85%
5. Cantaloupe	2.99%	−0.24%	0.22%	15.64%	−0.24%	1.09%	−0.24%	76.45%
6. Cherries	4.11%	−0.46%	0.54%	19.93%	−0.46%	1.83%	−0.46%	67.63%
7. Grapefruit	1.12%	−0.35%	0.18%	10.75%	−0.35%	1.03%	−0.35%	60.04%
8. Grapes	14.44%	−0.39%	0.48%	23.08%	−0.39%	1.30%	−0.39%	63.14%
9. Honeydew	0.50%	−0.21%	0.08%	11.42%	−0.21%	0.40%	−0.21%	57.43%
10. Mangos	1.05%	−1.16%	0.65%	18.29%	−1.16%	1.98%	−1.16%	55.41%
11. Nectarines	1.51%	−0.21%	0.16%	13.04%	−0.21%	0.82%	−0.21%	67.05%
12. Oranges	5.02%	−0.35%	0.24%	11.08%	−0.35%	1.49%	−0.35%	69.14%
13. Peaches	4.66%	−0.22%	0.60%	26.12%	−0.22%	1.88%	−0.22%	81.89%
14. Pears	2.91%	−0.44%	0.47%	15.88%	−0.44%	2.14%	−0.44%	72.06%
15. Plums	1.16%	−0.22%	0.54%	23.56%	−0.22%	1.89%	−0.22%	82.37%
16. Strawberries	11.70%	−0.30%	0.33%	25.18%	−0.30%	0.89%	−0.30%	67.79%
17. Tangerines	3.53%	−0.23%	0.12%	8.79%	−0.23%	0.89%	−0.23%	66.21%
18. Watermelon	5.53%	−1.05%	0.69%	25.93%	−1.05%	1.19%	−1.05%	44.75%
Average	100%	−0.58%	0.45%	19.08%	−0.58%	1.40%	−0.58%	61.48%

Table S13. Shifts in Equilibrium Prices, Quantities, and Welfare and Cost Pass-Through Associated with Commodity Groups Unilaterally Implementing FSMA Regulations (Vegetable)

Commodity	Expend. Shares	$d \ln Q$	$d \ln P$	CPT (Cons.)	$d \ln X$	$d \ln W$	$d \ln MI$	CPT (Farm)
1. Artichokes	0.73%	−0.05%	0.08%	22.65%	−0.05%	0.26%	−0.05%	72.38%
2. Asparagus	3.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3. Broccoli	6.23%	−0.02%	0.08%	17.54%	−0.02%	0.41%	−0.02%	92.56%
4. Cabbage	2.31%	−0.28%	0.29%	18.24%	−0.28%	1.20%	−0.28%	75.32%
5. Carrots	7.38%	−0.05%	0.16%	16.96%	−0.05%	0.90%	−0.05%	93.05%
6. Cauliflower	1.60%	−0.07%	0.09%	20.74%	−0.07%	0.33%	−0.07%	76.24%
7. Celery	3.68%	−0.03%	0.04%	9.97%	−0.03%	0.37%	−0.03%	88.74%
8. Cucumbers	4.28%	−0.29%	0.24%	11.35%	−0.29%	1.72%	−0.29%	81.32%
9. Kale	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10. Lettuce, head	4.21%	−0.02%	0.06%	16.93%	−0.02%	0.31%	−0.02%	93.49%
11. Lettuce, leaf	1.38%	−0.05%	0.03%	8.72%	−0.05%	0.32%	−0.05%	82.23%
12. Lettuce, romaine	3.02%	−0.07%	0.02%	7.48%	−0.07%	0.21%	−0.07%	66.42%
13. Onions (Bulb)	9.43%	−0.68%	0.41%	23.64%	−0.68%	0.76%	−0.68%	44.32%
14. Peppers, bell	7.63%	−0.26%	0.22%	16.93%	−0.26%	0.93%	−0.26%	71.88%
15. Peppers, chile	0.82%	−0.37%	0.31%	11.66%	−0.37%	2.14%	−0.37%	81.42%
16. Snap beans	5.65%	−0.15%	0.41%	13.84%	−0.15%	2.82%	−0.15%	94.18%
17. Spinach	1.77%	−0.09%	0.11%	13.52%	−0.09%	0.72%	−0.09%	85.45%
18. Squash	3.94%	−0.22%	0.49%	19.40%	−0.22%	2.22%	−0.22%	88.67%
19. Sweet corn	7.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
20. Tomatoes	24.54%	−0.26%	0.20%	19.02%	−0.26%	0.70%	−0.26%	65.57%
Average		−0.20%	0.19%	15.24%	−0.20%	0.83%	−0.20%	66.68%
Average (all)	100.0%	−0.31%	0.36%	17.28%	−0.41%	1.15%	-0.21%	59.59%

Notes: $d \ln Z = \frac{dZ}{Z}$ for $Z = Q, P, X, W, MI$. Q and P represent output quantity and price, respectively. X is the quantity of farm inputs, W is the price of farm inputs, and MI is the quantity of marketing (non-farm) inputs. CPT = Cost Pass-Through.

Table S14. Consumer and Producer Welfare Changes under Alternative Elasticity of Supply Specifications for Unilateral Enactment (Fruit)

	Medium		Low		High	
Commodity	**Δ CS**	**Δ PS**	**Δ CS**	**Δ PS**	**Δ CS**	**Δ PS**
1. Apples	−0.30%	−0.94%	−0.19%	−1.59%	−0.40%	−0.94%
2. Apricots	−0.32%	−1.01%	−0.49%	−1.32%	−0.93%	−0.69%
3. Avocados	−0.74%	−2.46%	−0.52%	−1.93%	−0.76%	−1.20%
4. Bananas	−0.67%	−1.42%	−0.19%	−2.53%	−0.24%	−2.30%
5. Cantaloupe	−0.22%	−0.33%	−0.37%	−0.15%	−0.61%	0.65%
6. Cherries	−0.54%	−0.87%	−0.12%	−2.03%	−0.22%	−1.49%
7. Grapefruit	−0.18%	−0.69%	−0.32%	−0.85%	−0.55%	−0.22%
8. Grapes	−0.47%	−0.76%	−0.06%	−1.75%	−0.09%	−1.60%
9. Honeydew	−0.08%	−0.30%	−0.50%	0.81%	−0.74%	1.56%
10. Mangos	−0.65%	−1.58%	−0.11%	−3.00%	−0.18%	−2.63%
11. Nectarines	−0.16%	−0.40%	−0.17%	−0.18%	−0.27%	0.45%
12. Oranges	−0.24%	−0.67%	−0.47%	−0.67%	−0.64%	−0.14%
13. Peaches	−0.60%	−0.42%	−0.33%	−0.79%	−0.53%	0.10%
14. Pears	−0.47%	−0.83%	−0.43%	−1.47%	−0.58%	−0.94%
15. Plums	−0.54%	−0.41%	−0.27%	−1.58%	−0.36%	−1.32%
16. Strawberries	−0.33%	−0.42%	−0.08%	−0.70%	−0.13%	−0.30%
17. Tangerines	−0.12%	−0.45%	−0.49%	−0.49%	−0.82%	0.08%
18. Watermelon	−0.68%	−1.46%	−0.03%	−2.56%	−0.07%	−2.44%
Average	−0.45%	−0.93%	−0.21%	−1.54%	−0.33%	−1.09%

References

Buxton, B. "Supply Response to Price Changes for Selected Vegetables." *Vegetables and Specialties Situation and Outlook* TVS-256(1992):19–22.

Clevenger, T. S., and W. V. Shelley. "Intraseasonal Demand-Supply Relationships for Lettuce." *Proceedings, Annual Meeting (Western Agricultural Economics Association)* 47(1974):18–21.

Hammig, M. D., and R. C. Mittelhammer. "An Imperfectly Competitive Market Model of the U.S. Lettuce Industry." *Western Journal of Agricultural Economics* 5(1980):1–12. doi: 10.22004/ag.econ.32531.

———. "Evaluation of Import Tariffs in the Canada-US Fresh Tomato Market." *Canadian Journal of Agricultural Economics* (1982):133–152. doi: 10.1111/j.1744-7976.1982.tb01974.x.

Málaga, J. E., G. W. Williams, and S. W. Fuller. "US–Mexico Fresh Vegetable Trade: The Effects of Trade Liberalization and Economic Growth." *Agricultural Economics* 26(2001):45–55. doi: 10.1016/S0169-5150(00)00101-8.

Mérel, P., L. K. Simon, and F. Yi. "A Fully Calibrated Generalized Constant-Elasticity-of-Substitution Programming Model of Agricultural Supply." *American Journal of Agricultural Economics* 93(2011):936–948. doi: 10.1093/ajae/aar029.

Onyango, B., and S. Bhuyan. "A Supply Response Analysis of the Fruits and Vegetables Sector in New Jersey." NJAES Report P-02804-2-2000, Rutgers University, New Brunswick, NJ, 2000. Available online at http://aesop.rutgers.edu/~bhuyan/coop/fvreport2.pdf.

Ornelas, F., and C. R. Shumway. "Supply Response and Impact of Government-Supported Crops on the Texas Vegetable Industry." *Agricultural and Resource Economics Review* 22(1993): 27–29. doi: 10.22004/ag.econ.31640.

Table S15. Consumer and Producer Welfare Changes under Alternative Elasticity of Supply Specifications for Unilateral Enactment (Vegetable)

	Medium		Low		High	
Commodity	**Δ CS**	**Δ PS**	**Δ CS**	**Δ PS**	**Δ CS**	**Δ PS**
1. Artichokes	−0.08%	−0.10%	−0.03%	−0.27%	−0.07%	−0.15%
2. Asparagus	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3. Broccoli	−0.08%	−0.03%	−0.04%	−0.24%	−0.06%	−0.15%
4. Cabbage	−0.29%	−0.39%	−0.15%	−0.98%	−0.23%	−0.62%
5. Carrots	−0.16%	−0.07%	−0.08%	−0.54%	−0.12%	−0.32%
6. Cauliflower	−0.09%	−0.10%	−0.05%	−0.26%	−0.07%	−0.17%
7. Celery	−0.04%	−0.05%	−0.02%	−0.25%	−0.03%	−0.15%
8. Cucumbers	−0.24%	−0.40%	−0.12%	−1.29%	−0.18%	−0.81%
9. Kale	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10. Lettuce, head	−0.06%	−0.02%	−0.03%	−0.18%	−0.04%	−0.11%
11. Lettuce, leaf	−0.03%	−0.07%	−0.02%	−0.24%	−0.03%	−0.15%
12. Lettuce, romaine	−0.02%	−0.10%	−0.01%	−0.21%	−0.02%	−0.14%
13. Onions (Bulb)	−0.41%	−0.95%	−0.24%	−1.27%	−0.43%	−0.91%
14. Peppers, bell	−0.22%	−0.36%	−0.11%	−0.81%	−0.18%	−0.53%
15. Peppers, chile	−0.31%	−0.49%	−0.15%	−1.59%	−0.23%	−1.00%
16. Snap beans	−0.41%	−0.17%	−0.19%	−1.66%	−0.29%	−0.99%
17. Spinach	−0.11%	−0.12%	−0.05%	−0.49%	−0.08%	−0.31%
18. Squash	−0.48%	−0.28%	−0.24%	−1.40%	−0.36%	−0.84%
19. Sweet corn	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
20. Tomatoes	−0.20%	−0.37%	−0.11%	−0.70%	−0.18%	−0.46%
Average	−0.19%	−0.31%	−0.10%	−0.69%	−0.16%	−0.44%
Average (all)	−0.36%	−0.62%	−0.27%	−0.90%	−0.41%	−0.48%

Peterson, E. B., and D. Orden. "Avocado Pests and Avocado Trade." *American Journal of Agricultural Economics* 90(2008):321–335. doi: 10.1111/j.1467-8276.2007.01121.x.

Russo, C., R. Green, and R. Howitt. "Estimation of Supply and DemandElasticities of California Commodities." Working paper 08-001, University of California, Davis, Department of Agricultural and Resource Economics, Davis, CA, 2008.

Sato, R., and T. Koizumi. "On the Elasticities of Substitution and Complementarity." *Oxford Economic Papers* 25(1973):44–56.

Seale, J. L., L. Zhang, and M. R. Traboulsi. "U.S. Import Demand and Supply Response for Fresh Tomatoes, Cantaloupes, Onions, Oranges, and Spinach." *Journal of Agricultural and Applied Economics* 45(2013):435–452. doi: 10.1017/S107407080000496X.

Wann, J. J., and R. J. Sexton. "Imperfect Competition in Multiproduct Food Industries with Application to Pear Processing." *American Journal of Agricultural Economics* 74(1992): 980–990. doi: 10.2307/1243196.