The Impact of the E.coli Spinach Outbreak on Acreage Decisions Under Uncertainty

Belinda Acuña Mohr
FDA Center for Food Safety and Applied Nutrition

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Introduction

- In September 2006, fresh spinach contaminated with *E.coli* 0157:H7 caused hundreds of consumer illnesses and a few deaths across the U.S.
- Consumers decreased expenditures on bagged spinach by 20% and on bulk spinach by 1% over the 17 months following the outbreak (Arnade et al., 2009).
- Spinach growers were prohibited from harvesting spinach until more was known about the contamination.

Objective

- To examine the effect of the 2006 food-borne illness outbreak from contaminated spinach on farm acreage decisions given price uncertainty due to the outbreak.

Theoretical Background

- Model examines optimal farm acreage decisions for a perfectly competitive farmer with multiple commodities and with price uncertainty for one product.
- Price uncertainty is caused by the potential of a future outbreak associated with that product.
- Prior to the 2006 outbreak, it is expected that farmers chose the optimal amount of acres to plant based on a zero subjective probability of a future outbreak from contaminated spinach.
- After 2006, farmers potentially chose their new optimal acreage based on having spinach revenue uncertainty.
- A farm household, *i*, grows a total of *J* commodities where *aj* denotes the number of acres planted in commodity *j*.
- The household chooses a production plan, A≥0, to maximize their expected utility of constrained profit shown in (1):

$$(1)\quad \max_{A=a_1 \ldots a_J \geq 0} E\left[U_i\left(\varpi + \sum_{j=1}^{J}(p_j y_j - c_j)a_j - F + \lambda f(A)\right)\right]$$

- The farm household is only uncertain about a future outbreak that will implicate commodity *j*, therefore the expectations operator only applies to *pj*.
- Solving the F.O.C.s, we obtain the marginal rate of transformation between the implicated commodity *j* and a non-implicated commodity *k*.

$$(2)\quad \frac{\left[E(p_j) + \frac{\operatorname{cov}(\partial U_i/\partial a_j, p_j)}{E(\partial U_i/\partial a_j)}\right] y_j - c_j}{(p_k y_k - c_k)} = -\frac{\partial a_k}{\partial a_j}$$

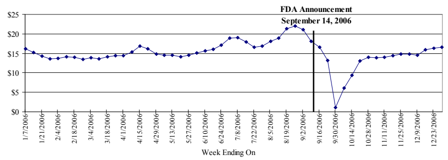
- Price uncertainty decreases optimal planted acreage compared to the certainty case (Sandmo, 1971).
- A risk-averse farm will reduce the amount of *aj*, the implicated commodity acreage, by more than the amount of a risk-neutral or a risk-loving farm in exchange for the same level of *ak*, the non-implicated commodity acreage.

Data

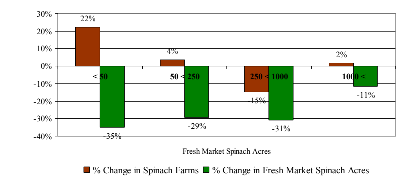
- Farm-level data from the 2002 and 2007 Census of Agriculture to measure harvested fresh spinach acreage before and after the outbreak.
- Terminal market fresh spinach price variances to measure uncertainty (USDA, AMS).
- Summary Statistics

Variable	2002	2007
Fresh spinach acres	36.4	26.9
Fresh spinach price variance	12.82	18.21
Total value of production (in thousands)	$1,936	$1,585
Variable costs	$858,421	$818,709
Fixed costs	$325,488	$312,750
Other acres operated	398	348
N	*986*	*1,109*

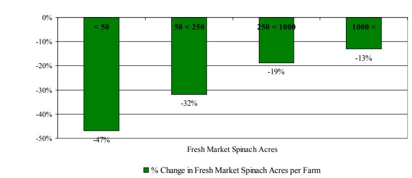
- Figure 1: Fresh spinach wholesale weekly prices



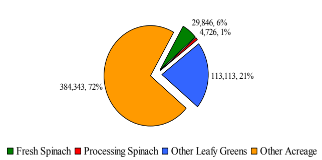
- Figure 2: % change in spinach farms and fresh spinach acres by acres harvested, 2002 to 2007



- Figure 3: % change in the average fresh spinach acres per farm by acres harvested, 2002 to 2007



- Figure 4: Proportion of fresh spinach acreage out of total acreage for spinach farms, 2007



Methodology

- Observe farmer's harvesting decisions before the September 2006 outbreak and after, starting in January 2007.
- Examine the effect of weekly fresh spinach price variance on two variables:
  - Fresh market spinach acres
  - Other commodity acres
- Measure of price uncertainty = Fresh spinach price variance, σ^2_{it}
- Coefficients of interest are α_1 and β_1:

  (3) $\ln(\text{Fresh spinach acres})_{it} = \alpha_0 + \alpha_1 {*} \sigma^2_{it} + \mathbf{X'}\boldsymbol{\gamma} + \varepsilon_{it}$

  (4) $\ln(\text{Other acres})_{it} = \beta_0 + \beta_1 {*} \sigma^2_{it} + \mathbf{X'}\boldsymbol{\delta} + \varepsilon_{it}$

  - **X** = Revenue, costs, indicator variables for CA & AZ LGMA, size, year, and location
  - ε_{it} = error term
- It is expected that as the weekly price variance for fresh spinach increases, indicating the price moves farther away from the average, fresh spinach acreage decreases.
- Other market forces could have also caused a change in producer behavior that are independent of the spinach outbreak**.**
- Control for CA*2007 & AZ*2007 indicators to capture the differences between CA & AZ due to LGMA.

Results

- Regression results:

	Dependent Variable			
	Fresh spinach acres		Other acres	
Explanatory variables	(1)	(2)	(1)	(2)
Fresh spinach price variance	-.059***	-.013*	-.041***	-.011**
	(.008)	(.008)	(.008)	(.006)
Controls	No	Yes	No	Yes
Constant	.655	-1.55	3.58	2.52
	(.147)	(.173)	(.142)	(.198)
R^2	.03	.72	0.01	0.83
N	*2,095*	*2,095*	*2,095*	*2,095*

Note: Coefficients marked with ***, **, and * are statistically significant at the 1%, 5%, and 10% levels, respectively. Robust standard errors are denoted in parentheses.

- Without controlling for market forces and farm characteristics, if the fresh spinach weekly price varies by $1 from the mean, then:
  - Fresh spinach acreage will decrease by 5.9% on average all else equal.
  - Other commodity acreage will decrease by 4.1% on average all else equal.
- With controls, fresh spinach acreage will decrease by 1.3% on average, and other commodity acreage will decrease by 1.1% on average all else equal.
- LGMA indicators were not statistically significant.

Conclusion

- The outbreak caused an average decrease of 1.3% of harvested fresh spinach acres.
- Following the outbreak, growers of fresh market spinach had to make their new planting decisions based on price uncertainty.
- Farms decreased their acreage of fresh spinach to reduce profit uncertainty caused by the probability of a future outbreak.
- This outbreak also caused changes in producer behavior that included greater producer efforts and investments into food safety (Horsfall, 2008).

Policy Implications

- Policy makers are interested in the costly effects to producers as well as consumers of food-borne illness outbreaks.
- The Food Safety Modernization Act (FSMA) that passed in January of 2011 requires farms to implement food safety practices that reduce the probability of outbreaks.
- Examining the changes in producer behavior due to food-borne illness outbreaks provides insight into the costs and structural industry changes that potentially could be prevented by the requirements in FSMA and future regulations.

References

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Contact Information

- Belinda Acuña Mohr, Ph.D.
  FDA CFSAN HFS-020
  5100 Paint Branch Parkway
  College Park, MD 20740
  (301) 436-1800
  Belinda.Acuna@fda.hhs.gov

- The views presented here do not necessarily reflect official FDA policy.
- Summaries were derived using data collected from the 2002 and 2007 Census of Agriculture by the National Agricultural Statistics Service (NASS), USDA and do not necessarily represent the views of NASS.