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E. coli Outbreaks Affect Demand for Salad Vegetables

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Fresh salad vegetables are generally considered safe-to-eat by consumers. However, the Centers for Disease Control and Prevention (CDC) found that vegetables contributed to 5% of the food borne illnesses in the world during the period 1973 to 1987 (Bean and Griffin, 1990). Outbreaks of food borne diseases caused by *E. coli (Escherichia coli)* bacteria are a serious concern in the United States. The CDC estimates 73,000 cases of infection with *E. coli* 0157:H7 and 61 deaths on average occur in the United States every year (Seto, Soller, and Colford, 2007).

2006 E. coli Outbreaks in Spinach and Lettuce

On Sept. 14, 2006, the U.S. Food and Drug Administration (FDA) issued an alert to consumers about an *E. coli* O157:H7 outbreak associated with the consumption of bagged fresh spinach in multiple states. The FDA called for bagged fresh spinach to be removed from grocery store shelves and warned people not to eat fresh spinach or products containing fresh spinach. On Sept. 29, the FDA downgraded the warning to be only against specific brands packaged on specific dates, instead of all fresh spinach. By Oct. 6, the outbreak of *E. coli* O157:H7 in spinach caused at least 199 consumer illnesses and three deaths from 26 states (*CDC Update,* 2006). In California, where three-quarters of all domestic spinach is grown, the trade association Western Growers estimated that the 2006 spinach outbreak could cost farmers up to $74 million (AP, 2006).

On Oct. 8, less than a week after the downgraded warning on fresh spinach, the FDA issued a recall on lettuce grown in the Salinas Valley in California over concerns about *E. coli* contamination. The recall covered green leaf lettuce sold from Oct. 3 to Oct. 6 under a popular brand in grocery stores in Arizona, California, Idaho, Montana, Nevada, Oregon and Washington. In November and December, a subsequent *E. coli* outbreak linked to Taco Bell and Taco John's restaurants involving five eastern states was found to be caused by prepackaged iceberg lettuce, which resulted in 71 infections, 53 hospitalized cases, and eight cases of kidney failure.

In contrast to the previous outbreaks, this outbreak was due to exposure to *E. coli* in restaurants. Initially the source of the contamination was thought to be green onions. Only after the outbreak had been contained was lettuce considered to be the culprit. Unlike the September outbreak, there was no recall of lettuce and no FDA warning to consumers not to eat lettuce.

In this article, we discuss effects of the 2006 E. coli outbreaks on retail demand for salad vegetables in grocery stores located on the West Coast of the United States. Interesting issues include how consumers responded to the outbreak in terms of buying substitutes, how demand recovered, how the response to the first outbreak was different from the response to the second outbreak, and whether the response was different across demographic groups.

Retail Scanner Data Analyzed

The discussion in this article is based on analysis of a retail scanner dataset containing information about the transaction dates, quantities sold, and markdowns of salad vegetables. The stores included in the analysis are located in Washington, California and Oregon, with ten stores from each state. The stores were selected to ensure both geographical dispersion throughout each state and representation of both rural and urban areas. The daily observations represent purchases of salad vegetables for calendar year 2006, as well as household expenditures, quantities purchased, and demographic variables that are expected to influence consumer behavior. The data includes observations on the purchases of tomatoes, onions, cabbage, lettuce, and spinach. These vegetable categories were chosen based on

the categories that experienced outbreaks (spinach and lettuce), a substitute (cabbage), and two major salad complements (tomatoes and onions), and considering the preferences of the retail chain for the analysis. The sample contains 377,149 observations. The data were aggregated by the week of sale, and variables were created to indicate specific months.

Results of Analysis

A Quadratic Almost Ideal Demand System (QUAIDS) model in budget-share form was estimated using a generalized method of moments (GMM) approach. The details of the theory and estimation are presented in Fahs, Mittelhammer, and McCluskey (2009). In order to account for the seasonal nature of the demand for salad vegetables explicitly in the model, a polynomial in time (months) was included in the model specification.

Findings include that the parameters associated with the expenditure terms are statistically significant for all five types of salad vegetables. The coefficients associated with the prices are also significant. As expected, households with different demographic profiles have different consumption preferences and exhibit different consumption patterns.

Of importance for this study, the indicator variables for specific months are statistically significant. In October, households preferred more tomatoes, cabbage and lettuce, and less spinach and onions. In November, during the subsequent outbreak, households preferred even less spinach and more of other vegetables compared to the initial outbreak in September. It is possible that households during the later outbreaks were more alert and educated about the *E. coli* warnings, as the result of the first outbreak. This suggests that damage from a series of outbreaks can be cumulative. In December, households preferred more tomatoes, cabbage and lettuce, and less spinach and onions. It is likely that households adjusted their preferences for vegetables after the second outbreak. The estimated time trends also suggest that households consumed more salad vegetables in the summer months, which is typical of U.S. consumption patterns.

Figure 1 presents the predicted expenditure shares during the nonoutbreak period (January to August) and the two outbreak periods (September and November). Consumption of tomatoes, cabbage, lettuce and onions increased by 8.6%, 32.6%, 31.8% and 0.7%, respectively, in September; while the consumption of spinach decreased by 50.6%. Similarly, tomatoes, cabbage, lettuce and onions increased by 13.5%, 34.4%, 33.4% and 1.3%, respectively, in November; while spinach decreased by 54.2%. The results suggest that other salad vegetables were substituted for spinach during both outbreaks and that the second outbreak had an even greater impact on demand.

An "elasticity" is a measure of the responsiveness of one factor to a change in another factor. For example, "expenditure elasticity" is a measure of the responsiveness of demand to changes in expenditure on a bundle of similar goods. It shows how the quantity purchased changes in response to a change in the consumer's expenditure, which is a proxy for income (Economic Research Service, 2009). In order to gain insight into the effect of the *E. coli* outbreak on the consumer demand for salad vegetables, we compare the elasticities before the outbreak (i.e. Jan. to Aug.) to the elasticities during the first outbreak (September) and during the second outbreak period (November) Then we calculate the percentage change in marginal effects due to the demographic variables on the consumption of salad vegetables before and during the outbreaks.

Figure 2 presents the expenditure elasticities during the nonoutbreak and the outbreak periods. The results indicate that during the nonoutbreak period, tomatoes (1.22), lettuce (1.13) and spinach (1.73) were expenditure elastic, while cabbage (0.87) and onions (0.72) were expenditure inelastic. During the first outbreak, the expenditure elasticities of tomatoes (1.35), cabbage (1.06) and lettuce (1.31) were elastic, while onions (0.83) and spinach (0.81) were inelastic. The results for the subsequent outbreak period indicate that the expenditure elasticities for tomatoes (1.37), cabbage (1.06) and lettuce (1.51) were more elastic compared to the first outbreak, while spinach (0.73) became even more inelastic than during the first outbreak.

Figure 1. Predicted Expenditure Shares during the Nonoutbreak and Outbreak Periods

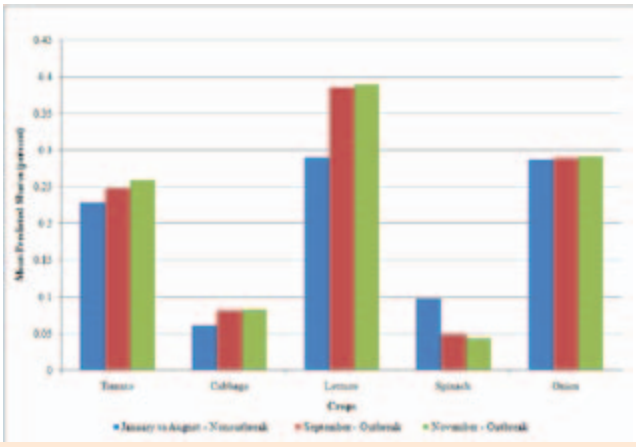


Figure 2. Expenditure Elasticities during the Nonoutbreak and Outbreak Periods

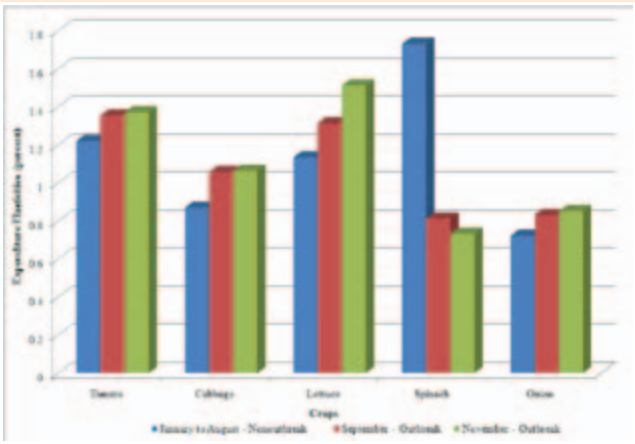
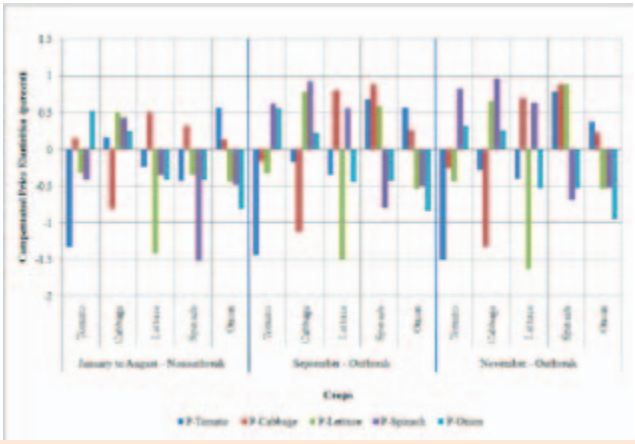


Figure 3. Compensated Price Elasticities during the Nonoutbreak and Outbreak Periods



Three main comparative observations can be made. The expenditure elasticity for spinach changes from elastic during the nonoutbreak period to inelastic during both outbreaks, which indicates that spinach demand was less responsive to expenditure changes during the outbreaks. This could be because households have heightened concern for their safety. The expenditure elasticity for cabbage changes from inelastic during the nonoutbreak period to elastic during both outbreaks, which indicates that consumers' demand for cabbage was relatively more responsive to expenditure changes during the outbreak periods. Tomatoes, cabbage and lettuce are more elastic and spinach is more inelastic during the second outbreak compared to the first outbreak period. This indicates that the demands for tomatoes, cabbage and lettuce were more responsive, and the demand for spinach less responsive to expenditure changes in the second outbreak period than the first.

The "compensated" demand function explains the relationship between the price of a good and the quantity purchased of the good purchased under the assumption that other prices and utility (a measure of the satisfaction a consumer derives from a particular market basket) are held constant (Economic Research Service, 2009). Figure 3 presents the "compensated" price elasticities for the nonoutbreak period and for the first and second outbreak periods, respectively. All compensated own-price elasticities are negative and have reasonable magnitudes consistent with economic theory. From these results, we observe that the price elasticity for spinach changes from elastic during the nonoutbreak period to inelastic during both outbreak periods, indicating that consumers were less responsive to price changes during the outbreaks. In contrast, the price elasticity for cabbage changes from inelastic during the nonoutbreak period to elastic during both outbreak periods, indicating a greater responsiveness of demand to price changes during the outbreak periods.

In the subsequent outbreak, the own-price elasticities for tomatoes, cabbage, and lettuce are more elastic, and thus demands are more sensitive to price changes, while spinach is more inelastic and thus demand less price sensitive compared to the first outbreak period. Tomatoes, cabbage, and lettuce were substituted for spinach during both outbreak periods, and this substitution was greater during the second outbreak.

Households with different demographic profiles may have different consumption preferences and exhibit different consumption patterns. In a recent study, only about half of Americans said they regularly ate spinach before the recall, and those with higher levels of education and income were more likely to eat spinach (Cuite, et al, 2007). Demographic factors that increase the substitution away from spinach include the presence of children, the level of income, and residing in California. The effect of children suggests that consumers are more risk averse about food safety when there are children in the household. Also, if food safety is a normal good, then one would expect for income to be significant and negatively related to consumption of a good affected by health concerns. The resi-

dence effect was expected, since the fact that the source of the outbreak was in California and it was heavily covered by the media. Age and marital status did not have statistically significant effects on the demands for any of the salad vegetables.

Conclusions and Implications for Policy

The impacts of the *E. coli* outbreaks that occurred in 2006 on consumer demand for salad vegetables on the West Coast of the United States were major. The results suggest that during and after the initial outbreak lettuce and cabbage were substituted for spinach, indicating consumers' response to health concerns. The expenditure elasticity for spinach changes from elastic during the nonoutbreak period to inelastic during both outbreaks, which indicates that consumers were less responsive to expenditure changes as apprehension about their safety increased. Similarly, the price elasticity for spinach changes from elastic during the nonoutbreak period to inelastic during both outbreaks, indicating that consumers are less responsive to price changes during the outbreaks and suggesting, for instance, that a spinach "*E. coli* sale" in an attempt to increase sales would not fare very well.

Interestingly, the empirical results suggest that subsequent outbreaks had a greater impact on the consumption of salad vegetables than the first. We hypothesize that households during the second outbreak were more alert and educated about the *E. coli* warnings, as the result of the first outbreak, and responded accordingly. This also provides empirical evidence consistent with the hypothesis that negative market effects can be cumulative in magnitude.

This negative impact on spinach demand occurred even though the subsequent outbreaks were ultimately traced to lettuce with the highly publicized outbreaks contained to restaurants. Given the initial confusion regarding the source of the subsequent outbreaks, we conjecture that coming so soon after the initial and severe spinach outbreak, the market reacted to the initial noise by staying away from spinach purchases.

These findings coincide with research in behavioral economics on risk-related behavior. As Thaler and Sunstein, (2008) discuss, "Whether people buy insurance for natural disasters is greatly affected by recent experiences. In the aftermath of an earthquake, purchase of new earthquake insurance policies rise sharply—but purchases decline steadily from that point, as vivid memories recede," (p. 25). As such, the food industry must be extra vigilant in the periods that follow food safety incidences in the food system. Further, it might be welfare enhancing to increase government monitoring or audits beyond what would normally appear to be optimal in the periods following an outbreak.

For More Information

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