# Consumer Meat Safety Concerns: Impacts of Beef *E. coli* O157: H7 Recalls on Meat Consumption

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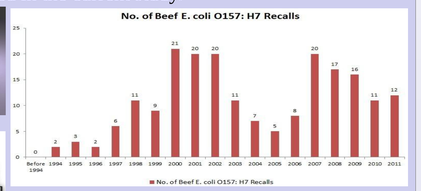
STEC Managing the Risk of Shiga Toxin-Producing *Escherichia coli* in Beef

## Introduction and Background

- Several studies have indicated that meat demand is driven by a number of factors, including traditional economic determinants such as consumer income and relative prices, as well as nontraditional determinants such as nutrition and food safety information (Tonsor *et al.*, 2010).
- In addition to food safety information, meat safety issues have dramatically concerned livestock producers, consumers, and governments in recent years. Foodborne contaminants directly impact producers and may also influence consumer food demand adversely. Unsafe contaminants on food lead to human illness which causes the loss of billions of US dollars to the society annually (Marsh *et al.*, 2004).
- Within meat safety issues, *E. coli* O157: H7 is a deadly toxin which can cause severe public health threat. As a result, the outbreaks of *E. coli* O157: H7 is an obvious risk factor for the consumption of meat. The USDA Food Safety Inspection Service (FSIS) is responsible for inspecting meat safety and releasing safety recall information to the public.
- The previous researches examined the impacts of FSIS recall on aggregated quarterly demand for meat products by different methods. However, they did not answer a specific question: what is the magnitude of own- and cross-effects to the meat demand due to *E. coli* O157: H7 based recalls of beef? Thus, the effects of beef *E. coli* O157: H7 is analyzed in the current study.



| USDA Recall Classifications | |
|---|---|
| Class I | This is a health hazard situation where there is a reasonable probability that the use of the product will cause serious, adverse health consequences or death. |
| Class II | This is a health hazard situation where there is a remote probability of adverse health consequences from the use of the product. |
| Class III | This is a situation where the use of the product will not cause adverse health consequences. |

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## Research Objectives

- Provide an updated answer to the question: how do FSIS recalls impact consumer's meat consumption?
- Investigate the effects of FSIS beef E. coli O157: H7 recalls on U.S. meat consumption by applying quarterly meat consumption data.
- Estimate meat consumption using both Rotterdam model and 1st difference LA/AIDS model. Compare the results from the two models under the same condition and discuss the model selection.

## Methodology

For the empirical model of previous studies, two common approaches have been widely used: the Rotterdam model and the Almost Ideal Demand System (AIDS).

➢ Rotterdam model

$$w_i \Delta \ln(x_i) = \alpha_{i0} + \sum_{j=1}^{3} d_{ij} D_j + \sum_{j=1}^{n} c_{ij} \Delta \ln\left(p_j\right) + \beta_i \Delta \ln(\bar{q}) + \sum_{k=1}^{K} \sum_{l=0}^{2} \lambda_{ikl} \Delta \ln(R_{kl}) + v_i$$

where $w_i$ is budge share; $\Delta$ is the first-difference operator; $x_i$ is per capita consumption; $D_j$ is a quarterly dummy variable accounting for seasonality; $p_j$ is the price of $j$th good; $\Delta \ln(\bar{q})$ is the Divisia volume index; $R_{kl}$ indicates $k$th FSIS recalls with lag length $l$ including beef *E. coli* recall, beef *non-E. coli* recall, poultry recall, and pork recall.

➢ 1st difference LA/AIDS model

$$\Delta w_i = \alpha_{i0} + \sum_{j=1}^{3} d_{ij} D_j + \sum_{j=1}^{n} \gamma_{ij} \Delta \ln\left(p_j\right) + \beta_i [\Delta \ln(x) - \Delta \ln(P)] + \sum_{k=1}^{K} \sum_{l=0}^{2} \lambda_{ikl} \Delta \ln(R_{kl})$$

where P is the Stone price index.

❑ Elasticities

- Rotterdam model

  Compensated price: $\varepsilon_{ij} = \frac{c_{ij}}{w_i}$ ; Income: $\eta_i = \frac{\beta_i}{w_i}$ ; Shift: $\kappa_{ikl} = \frac{\sum_{l=0}^{L} \lambda_{ikl}}{w_i}$

- 1st difference LA/AIDS model

  Compensated own-price: $\varepsilon_{ii} = -1 + \frac{\gamma_{ii}}{w_i} + w_i$ ; Cross-price: $\varepsilon_{ij} = \frac{\gamma_{ij}}{w_i} + w_j$

  Income: $\eta_i = 1 + \frac{\beta_i}{w_i}$ ; Shift: $\kappa_{ikl} = \frac{\sum_{l=0}^{L} \lambda_{ikl}}{w_i}$

## Estimated Results

Following the suggestion of Tonsor *et al.* (2010 ), we assume that the right-hand-side variables are endogenous, and the models are estimated using IT3SLS (iterative three-stage least squares). The IT3SLS has the same results as ITSUR (iterative seemingly unrelated regression) in this case.

## Estimated Results (Cont.)

1. Rotterdam model (Coefficients);

| | Demand Equation | | | |
|---|---|---|---|---|
| | Beef | Pork | Poultry | Other food |
| Beef Price | -0.00113* | 0.000152 | -0.00012 | 0.001018 |
| | (0.000296) | (0.000155) | (0.000138) | (0.00114) |
| Pork Price | | -0.00093* | -4.3E-06 | -0.00006 |
| | | (0.000183) | (0.000119) | (0.000779) |
| Poultry Price | | | -0.00011 | -0.00167* |
| | | | (0.000143) | (0.000677) |
| Other food Price | | | | -0.04475* |
| | | | | (0.0131) |
| Beef E.coli Lag=0 | -0.00001 | -0.00002 | -0.00002* | -0.00003 |
| | (0.000016) | (0.000011) | (9.31E-06) | (0.00018) |
| Beef E.coli Lag=1 | -0.00001 | -1.3E-06 | -0.00002* | -0.00013 |
| | (0.000019) | (0.000012) | (0.000011) | (0.000216) |
| Beef E.coli Lag=2 | 0.000022 | -0.00001 | -0.00002* | 0.000169 |
| | (1.7E-05) | (1.1E-05) | (9.53E-06) | (0.000188) |
| Beef Non-E.coli Lag=0 | 7.46E-06 | -9.3E-06 | 7E-06 | -0.00021 |
| | (0.000011) | (6.99E-06) | (6.15E-06) | (0.000123) |
| Beef Non-E.coli Lag=1 | 2.67E-06 | -3.3E-06 | 0.000014* | -0.00034* |
| | (0.000012) | (7.62E-06) | (6.68E-06) | (0.000131) |
| Beef Non-E.coli Lag=2 | -0.00002* | -1.7E-06 | 7.78E-06 | -0.00009 |
| | (0.00001) | (6.62E-06) | (5.82E-06) | (0.000116) |
| Pork Recall Lag=0 | -0.00002 | 2.88E-06 | 1.31E-06 | 0.000238* |
| | (0.000012) | (8.11E-06) | (7.16E-06) | (0.000141) |
| Pork Recall Lag=1 | -0.00002 | -1.2E-06 | -8.1E-06 | 0.000174 |
| | (0.000014) | (9.21E-06) | (8.13E-06) | (0.000159) |
| Pork Recall Lag=2 | -8.1E-06 | -2.9E-06 | -9.3E-06 | 0.000059 |
| | (0.000013) | (8.61E-06) | (7.63E-06) | (0.000149) |
| Poultry Recall Lag=0 | -8.7E-07 | 0.00001 | 3.85E-06 | -0.00008 |
| | (0.000013) | (8.72E-06) | (7.69E-06) | (0.000153) |
| Poultry Recall Lag=1 | -2.9E-06 | 4.46E-06 | 5.6E-06 | 0.000058 |
| | (0.000014) | (9.41E-06) | (8.31E-06) | (0.000165) |
| Poultry Recall Lag=2 | -0.00001 | -6.2E-06 | -2.3E-06 | -0.00006 |
| | (0.000013) | (8.64E-06) | (7.6E-06) | (0.000151) |
| Intercept | -0.00019* | 0.000154* | 0.000069* | -0.00006 |
| | (0.000017) | (0.000011) | (9.74E-06) | (0.000193) |
| Quarter Dummy 1 | 0.000147* | -0.0003* | -0.00018* | -0.00031 |
| | (0.000023) | (0.000015) | (0.000013) | (0.000259) |
| Quarter Dummy 2 | 0.000324* | -0.0002* | -0.00002 | -0.00006 |
| | (0.00003) | (0.000019) | (0.000017) | (0.000337) |
| Quarter Dummy 3 | 0.000228* | -0.00011* | -0.00004* | -0.00008 |
| | (0.000024) | (0.000017) | (0.000015) | (0.00026) |
| Expenditure | 0.002226* | 0.000505 | -0.00028 | 0.074265* |
| | (0.00107) | (0.000698) | (0.000614) | (0.0122) |

2. 1st difference LA/AIDS (Coefficients)

| | Demand Equation | | | |
|---|---|---|---|---|
| | Beef | Pork | Poultry | Other food |
| Beef Price | -0.00118* | 0.000165 | -0.00017 | 0.000543 |
| | (0.000324) | (0.000164) | (0.000145) | (0.00122) |
| Pork Price | | -0.00093* | -0.00003 | -0.0003 |
| | | (0.000178) | (0.000115) | (0.000771) |
| Poultry Price | | | -0.00008 | -0.0019* |
| | | | (0.000139) | (0.000671) |
| Other food Price | | | | -0.062* |
| | | | | (0.0141) |
| Beef E.coli Lag=0 | -1.9E-06 | -4.6E-06 | -4.9E-06* | -0.00002 |
| | (4.62E-06) | (2.82E-06) | (2.48E-06) | (0.000054) |
| Beef E.coli Lag=1 | -6.5E-07 | -3.8E-07 | -5.6E-06* | -0.00006 |
| | (5.68E-06) | (3.44E-06) | (3E-06) | (0.000066) |
| Beef E.coli Lag=2 | 6.85E-06 | -2.6E-06 | -5.4E-06* | 0.000023 |
| | (4.8E-06) | (2.88E-06) | (2.52E-06) | (0.000055) |
| Beef Non-Ecoli Lag=0 | 7.15E-07 | -3.9E-06* | 5.66E-07 | -0.00005 |
| | (3.54E-06) | (2.14E-06) | (1.87E-06) | (0.000042) |
| Beef Non-Ecoli Lag=1 | 2.18E-06 | -1.4E-06 | 3.58E-06* | -0.00008* |
| | (3.68E-06) | (2.22E-06) | (1.94E-06) | (0.000043) |
| Beef Non-Ecoli Lag=2 | -6E-06* | 7.75E-08 | 2.98E-06 | -1E-05 |
| | (3.47E-06) | (2.1E-06) | (1.84E-06) | (0.000041) |
| Pork Recall Lag=0 | -1.2E-06 | 1.51E-07 | -7.4E-07 | 0.000035 |
| | (3.64E-06) | (2.2E-06) | (1.94E-06) | (0.000043) |
| Pork Recall Lag=1 | -4.8E-06 | 2.78E-07 | -1.4E-06 | -4.5E-06 |
| | (4.13E-06) | (2.49E-06) | (2.19E-06) | (0.000048) |
| Pork Recall Lag=2 | -1.2E-06 | -3.1E-07 | -3.2E-06 | -0.00002 |
| | (3.78E-06) | (2.27E-06) | (2E-06) | (0.000044) |
| Poultry Recall Lag=0 | 8.1E-07 | 3.09E-06 | 2.7E-06 | -6.8E-06 |
| | (3.75E-06) | (2.26E-06) | (1.99E-06) | (0.000044) |
| Poultry Recall Lag=1 | 5.19E-07 | 8.15E-07 | 2.2E-06 | 0.000049 |
| | (4.37E-06) | (2.63E-06) | (2.32E-06) | (0.000051) |
| Poultry Recall Lag=2 | -2.8E-06 | -2E-06 | 1.91E-07 | -9.8E-08 |
| | (3.92E-06) | (2.37E-06) | (2.08E-06) | (0.000046) |
| Intercept | -0.00019* | 0.000146* | 0.00007* | -0.00004* |
| | (0.000017) | (0.000011) | (9.25E-06) | (0.000205) |
| Quarter Dummy 1 | 0.000145* | -0.0003* | -0.00018* | -0.00035 |
| | (0.000023) | (0.000014) | (0.000012) | (0.000272) |
| Quarter Dummy 2 | 0.000315* | -0.00019* | -0.00003* | 0.000043 |
| | (0.00003) | (0.000018) | (0.000016) | (0.000351) |
| Quarter Dummy 3 | 0.00023* | -0.0001* | -0.00004* | -0.00009 |
| | (0.000025) | (0.000016) | (0.000015) | (0.000279) |
| Expenditure | -0.00152* | -0.00139* | -0.00165* | -0.08085* |
| | (0.00115) | (0.000691) | (0.000606) | (0.0135) |

- Values in parentheses are standard deviation
- (*) denotes statistical significance at 10% or higher

1.Point Elasticities Rotterdam Model;

| | Beef | Pork | Poultry | Other food |
|---|---|---|---|---|
| Beef Price | -0.3509* | 0.04734 | -0.0385 | 0.31674 |
| | (0.0923) | (0.0498) | (0.355) | (1.1281) |
| Pork Price | 0.08496 | -0.5197* | -0.0024 | -0.0349 |
| | (0.0893) | (0.1022) | (0.0664) | (0.4352) |
| Poultry Price | -0.0936 | -0.0032 | -0.0032 | -1.2684* |
| | (0.1078) | (0.0901) | (0.0901) | (0.5132) |
| Other food Price | 0.00721 | -0.0004 | -0.0119* | -0.3169* |
| | (0.00808) | (0.00552) | (0.0048) | (0.092) |
| Expenditure | 0.69275* | 0.28192 | -0.2148 | 0.52587* |
| | (0.3341) | (0.3898) | (0.4652) | (0.0865) |
| | | | Short Run Recall | |
| Beef E.coli Lag = 0 | -0.0046* | -0.0091* | -0.0124* | -0.0002 |
| | (0.00496) | (0.00589) | (0.00705) | (0.00128) |
| | | | Long Run Recall | |
| Beef E.coli Lag = 1&2 | 0.00341 | -0.0074 | -0.0257* | 0.00025 |
| | (0.00962) | (0.0114) | (0.0135) | (0.00249) |

2.Point Elasticities 1st difference LA/AIDS

| | Beef | Pork | Poultry | Other food |
|---|---|---|---|---|
| Beef Price | -1.36533* | 0.053019 | -0.05266 | 0.310307 |
| | (0.1008) | (0.0511) | (0.0451) | (0.3803) |
| Pork Price | 0.095155 | -1.51628* | -0.01526 | -0.02817 |
| | (0.0917) | (0.0996) | (0.0644) | (0.431) |
| Poultry Price | -0.12817 | -0.0207 | -1.02117* | -1.3012* |
| | (0.1098) | (0.0873) | (0.0873) | (1.6613) |
| Other food Price | 0.007059 | -0.00036 | -0.01216* | -1.29781* |
| | (0.00865) | (0.00546) | (0.00475) | (0.0997) |
| Expenditure | 0.527378* | 0.222744 | -0.25357 | 0.427496* |
| | (0.3582) | (0.3863) | (0.4594) | (0.0953) |
| | | | Short Run Recall | |
| Beef E.coli Lag = 0 | -0.0006 | -0.00255* | -0.00373* | -0.00017 |
| | (0.00144) | (0.00157) | (0.00188) | (0.000383) |
| | | | Long Run Recall | |
| Beef E.coli Lag = 1&2 | 0.001931 | -0.00166 | -0.00833* | -0.00024 |
| | (0.00287) | (0.00311) | (0.00368) | (0.000756) |

## Conclusions and Implications

- Our findings from the Rotterdam model indicate that pork is the most elastic and poultry is the most inelastic demand of the meat goods. These are consistent with Tonsor and Marsh (2007) and Tonsor *et al.* (2010).
- The elasticities of 1st difference LA/AIDS model represent unexpected results. The absolute values of price elasticities are larger than the values of Rotterdam model. We will make further test to compare the two models.
- FSIS Beef *E. coli* O157: H7 recalls have negative and significant effect on the consumption of beef, pork and poultry.
- The meat industry may need to make great effort to reduce risk of foodborne contaminants in production, distribution, and transportation .

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