Effects of Meat Recalls on Futures Market Prices

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Practitioner's Abstract

The number of meat recalls has increased markedly in recent years. Meat recalls have the potential to adversely affect short run demand for meat because of the associated decline in consumer confidence. This research examines the impact of beef and pork recalls on nearby daily live cattle and lean hog futures market prices, respectively. Results indicate that medium sized beef and large pork recalls that are a serious health concern have a marginally negative impact on short-term live cattle and lean hog futures prices, respectively. However, results are not robust across recall size and severity. This research suggests that if there is any systematic significant change in beef and pork demand due to meat recalls, it likely occurs over an extended period of time and only in certain cases does it noticeably affect daily futures prices.

Keywords: meat recalls, event study, meat demand

Introduction

Recently, much attention has been directed at quantifying the effects of non-price factors in meat demand studies. In an attempt to identify the causes of structural change in the beef industry (as identified by Moschini; Moschini and Meilke; Eales and Unnevehr, 1988), numerous studies have examined factors such as food safety, health and nutrition, media, and advertising on meat demand. For example, Kinnucan et al. found that adverse health information had a strong negative influence on beef demand and a slightly negative influence on the demand for pork. Capps and Schmitz also found that cholesterol information was negatively associated with meat demand. Brester and Schroeder found that brand advertising had a significant effect on beef, pork, and poultry demand. They also found that poultry advertising negatively influenced beef and pork demand. These types of studies often use aggregate consumption and retail data over extended periods of time (e.g. Kinnucan et al. used quarterly data from 1976 to 1993). Examining effects of advertising in demand analysis using scanner data is one exception to these studies (Capps). Because of the nature of the data and the construct of the analyses, the data may not reflect short run changes in meat demand because they may be masked when performing aggregate time series analysis. Short run changes in meat demand are extremely important, especially to those involved in futures markets.

To determine short run shifts in meat demand, Robenstein and Thurman examined the effect of health related information on futures market prices. They examined the immediate impact of articles published in the Wall Street Journal on live cattle, feeder cattle, pork belly, and live hog futures prices. They concluded that futures markets had no discernable reaction to these public releases of information. Although Robenstein and Thurman found no significant short run impacts of health related articles, other health related information may influence short run changes in futures markets.

Recently food safety concerns regarding meat products have escalated. Numerous food products have transmitted food borne illnesses to consumers via a myriad of known and unknown food borne pathogens (Centers for Disease Control and Prevention). Common meat food borne bacteria include *Listeria monocytogenes*, *Escherichia coli* (*E coli* O157:H7), and *Salmonella*. Recent research by Flake and Patterson (1999) examined the impact of health information and food safety on beef demand. A food safety information index was constructed by counting the number of Associated Press articles published on BSE, and *E. coli* and salmonellosis contamination in beef. Their findings suggested food safety concerns had a modest negative impact on meat demand. In addition, Schroeder, Marsh, and Mintert estimated a demand system incorporating Food Safety Inspection Service (FSIS) meat recall events. The impact of a beef recall event on beef demand was relatively small (elasticity of –0.0065) although statistically significant. However, in certain years when recall events increased markedly, demand for beef declined by more than 5% as a result of beef recalls.

Beef and pork recalls have the potential to adversely affect meat demand in the short run (i.e., day-to-day), in addition to the longer run impacts found in previous studies. An information shock such as a meat recall, if the event is an important short-run demand determinant, would be expected to cause downward futures price movement. Further, the magnitude of the daily price movement would be expected to depend upon the severity of the recall (e.g., volume of meat recalled and likely health hazard consequence of consuming the product). Despite the potential importance of beef and pork recall events on daily cattle and hog futures market prices, no previous study has estimated their impacts.

Over the past 15 years, the number of meat recalls has risen. In 1982 there were only six FSIS beef and five pork product recalls. This increased to 18 beef and 19 pork product recalls in 1999 (FSIS). Figure 1 shows the number of FSIS recalls from 1982 to 1999. Some of the increased incidence of recalls is likely attributable to heightened public concern over food borne illnesses prompting closer regulatory scrutiny of meat product safety. For example, the first *E. coli* O157:H7 FSIS recall (beef's most common bacterial contamination problem) recorded since 1982 did not occur until 1988. However, since 1988 *E. coli* contaminant beef recalls have averaged over three per year. Understanding how futures markets behave when meat recalls occur is becoming increasingly important because of the rising number of product recalls.

The goal of this research is to quantify the effects of beef and pork recalls on the daily live cattle and lean hog futures market prices, respectively. The magnitude of change in the futures market price as well as the length of time required for the price to return its "normal" path following a product recall are examined. Factors hypothesized to be important in affecting magnitude and degree of persistence associated with a meat recall are the size to the meat recall and the severity of the recall (i.e. amount of health concern associated with recall). Results of the study indicate that beef recalls may place downward pressure on live cattle futures prices. In general, large quantity beef recalls that are of a serious health concern have a marginally statistically significant affect on nearby live cattle futures prices. A serious beef recall between 2,400 and 37,500 lbs. is associated with a $0.38/cwt. drop in the nearby live cattle futures price the day after the recall. Lean hog futures prices may decline $0.31/cwt one day after a serious pork recall greater than 15,211lbs. However, results are not consistent across recall size and severity. In general, pork recall information does not appear to appreciably impact the lean hogs futures market.

Data and Procedures

The recall data for this study were obtained from the United States Department of Agriculture (USDA) – FSIS. The data set contains over 500 observations resulting from all reported meat recalls from 1982 through 1999. The recall data set contains meat recalls for pork, beef, chicken, turkey, and other miscellaneous meat products. Reasons for recalls range from bacterial contamination and foreign material to mislabeling of the product. The recalls are identified as being in one of three classes: Class 1 - Involves a health hazard situation where there is a reasonable probability that consumption of the product will cause serious, adverse health consequences or death (Serious); Class 2 - Involves a potential health hazard situation where there is a remote probability of adverse health consequences from the use of the product (Not Serious); or Class 3 - Involves a situation where the use of the product is not likely to cause adverse health consequences (Not Serious). From 1982 to 1999, there were 168 beef recalls and 155 pork recalls. Out of the total number of recalls, 100 beef and 93 pork recalls were a serious health concern. Additionally, the number of pounds recalled is identified for each case. The size of the recalls ranged from 0 pounds to 35,000,000 pounds. With such a large range in the recall volumes, rather than using this variable as continuous, it was converted to three categorical variables that divided each meat type into one of three equal (by number of occurrences) recall size categories: small, medium, or large. For beef, size categories were segregated as follows: small – less than 2,400 lbs.; medium – between 2,400 lbs. and 37,500 lbs.; and large – greater than 37,500 lbs. For pork, size categories were segregated as follows: small – less than 1,725 lbs.; medium – between 1,725 lbs. and 15,211 lbs.; and large – greater than 15,211 lbs. Table 1 provides summary statistics of the meat recalls.

Daily futures market prices for the live cattle and lean hog futures contracts were obtained from the Chicago Mercantile Exchange. To construct a continuous series, closing prices for each trading day in the nearby contract were used for the analysis. Since prices in the nearby contract month often become volatile, the price series is rolled over to the next futures contract on the first of each month in which a contract closes. The meat recall events individually consider futures prices for the same contract month (i.e., no recall event switched contracts in the analysis).

Meat recalls are expected to adversely affect beef and pork demand. If consumers become uncertain of the safety of their food at the retail level when a meat recall occurs, demand is likely to fall. Futures traders, realizing the impact of product recalls on consumer demand and knowing that derived demand for meat will decline are assumed to act on upon this change. Assuming a positively sloped industry supply curve, one would expect prices of meat to fall in the face of a meat recall because of the decline in consumer confidence.

Two different methods are used to examine the effects of a meat recall on the futures market price. In this study, we follow methods commonly employed in event study literature. In this type of analysis, an event is identified and prices during and after the event are compared to the previous equilibrium price. This type of analysis has been frequently used to examine the impact of market reports on futures prices (see Carter and Galopin; Colling, Irwin, and Zulaf; or Schroeder, Blair, and Mintert for examples). In this case, the meat recall instead of a market report marks the "event." Here, the meat recall is treated as unexpected information introduced into the market at random points in time.

Fist, to determine whether meat recall events adversely affect daily futures prices, daily price changes over the entire time period from 1982 to 1999 are examined. The daily price changes in which a meat recall occurred are compared against all other daily price changes as shown in equation 1.

$$P_{t+1} - P_t = \beta_0 + \beta_1 RECALL + \beta_2 Med + \beta_3 Lrg + \beta_4 MedSer + \beta_5 LrgSer + \beta_6 \Delta Mkt + \varepsilon \qquad (1)$$

Where, P is the nearby futures price, t is day, and *RECALL* is a dummy variable that takes the value of 1 for the first change after the recall announcement and 0 otherwise[1]. *Med* and *Lrg* are dummy variables that take the value of 1 if there was a medium or large recall (as previously defined) in period t and 0 otherwise, respectively. *MedSer* and *LrgSer* are dummy variables that represent medium and large sized recalls, respectively that were of a serious health concern[2]. If any meat recalls places downward pressure on nearby futures prices the day after the recall, then β_1 will be less than zero. Since many of the recalls are small and involve inconsequential health concerns, β_1 may not be statistically less than zero, but the signs of β_2 through β_5 should give an indication of the effect of sizeable recalls of serious health concern on daily changes in futures prices. Lastly, because changes in other commodity markets influence the daily changes in the live cattle or lean hog futures markets, ΔMkt was added to the model. For this analysis, the foodstuff component of the CRB futures trading index was used where ΔMkt is the daily change in the index of the foodstuff component ($\Delta Mkt = Mkt_{t+1} - Mkt_t$). If the live cattle or lean hog nearby futures prices tend to move in the same direction as other "foodstuff" futures prices, β_6 will be positive.

Second, to determine the effects of size and seriousness on meat recalls, the futures price prior to the recall is compared to the price found any number of days after the recall. A model is formulated where the price difference is dependent upon several other independent factors. This model only examines daily prices changes *after* a recall occurs. Various forms of the following conceptual model are examined for both live cattle and lean hog futures markets.

$$P_{t+k} - P_t = \alpha_0 + \alpha_1 Med + \alpha_2 Lrg + \alpha_3 MedSer + \alpha_4 LrgSer + \alpha_5 \Delta Mkt + \varepsilon \qquad (2)$$

where P is the nearby futures price, k represents time in days after the recall, and t refers to the day prior to the recall. *Med* is a dummy variable indicating that the recall was a medium recall, and *Lrg* is a dummy variable indicating that the recall was large. As previously indicated, the recall size was placed into categorical variables because explanatory power may be lost with one continuous variable that ranges from 0 to 35,000,000. *MedSer* and *LrgSer* are dummy variables identifying those recalls that were classified as Medium or Large and were a serious health concern. ΔMkt represents the change in other foodstuff futures market contracts from time period t to period k that may influence changes in the nearby live cattle or lean hog nearby futures contracts over the same time period ($\Delta Mkt = Mkt_{t+k} - Mkt_t$).

To minimize the effects of market movements associated with *Cattle on Feed* or *Hogs and Pigs* reports, any recall that occurred one day before, during, or one day after the report was removed from the data set. Thus, 16 beef and 6 pork recalls were dropped from the data set. If the futures price is unaffected by the size or seriousness of the meat recall, then we fail to reject the hypothesis that "$_1$ = "$_2$ = "$_3$ = "$_4$ = 0. At k = 1, the first day after the recall, effects are expected to be most pronounced. However, as time progresses, it is expected that the impacts of the recall will decay. To determine when the effects cease to exist, the aforementioned hypothesis will be tested at various times, k. The time, k, at which we fail to reject the hypothesis, is amount of time necessary for prices to return to their "normal" path. It is hypothesized that a meat recall will have a negative effect on prices following the event. That is, futures market participants will become bearish because of the perceived negative reaction of consumers to the meat recall. Thus, it is expected that more sizable recalls will cause larger price declines than small recalls and that serious recalls will cause larger price declines than non-serious recalls (i.e. "$_1$, "$_2$, and "$_3$ are expected to be negative).

Because the dependent variable in equations 1 and 2 are bounded by "limit-moves", estimation using ordinary least squares is inappropriate because it may lead to biased estimates. Because the live cattle futures price cannot move by more than \$1.50/cwt in one day and the lean hog futures price cannot move by more than \$2.00/cwt in one day, equation 1 is estimated using a double limit tobit. The double limit tobit model accounts for probability that a "limit-move" may occur and the conditional mean of the dependent variable, given that a limit move does not occur (Greene). Since equation 2 only includes a subset of the data, only recall events from 1982 to 1999, a double limit tobit will be used only if a limit move occurred in dependent variable, otherwise ordinary least squares is appropriate.

Results

Figures 2 and 3 compare the total sample (1982 to 1999) of daily price changes in the nearby live cattle and lean hog futures contracts to the daily price change when a medium or large serious meat recall occurred. Figure 2 indicates that the percentage of trading days in the two largest negative price change categories is higher for the beef recall distribution than for the total sample. Further, there is a lower percentage of trading days in all positive price change categories for the beef recalls distribution than for the total sample. These two findings together indicate that medium and large beef recalls of serious health concern have the tendency to cause a downward shift in nearby live cattle prices. As shown in Figure 3, daily price changes for large serious pork recalls are not noticeably different than daily price changes for the total sample.

Figures 4 and 5 show the effects of beef and pork recall severity on daily changes in live cattle and lean hog futures prices, respectively. Figures 4 and 5 only include price changes after a meat recall occurred. For the live cattle futures contract, downward price movements occurred more frequently for serious beef recalls than for non-serious recalls. In addition, positive price movements occur less frequently for the serious recall distribution than for the non-serious recall distribution. In the case of the lean hog futures contract, the distribution of daily price changes for serious and non-serious pork recalls is virtually indistinguishable.

Figures 6 and 7 show the effects of beef and pork recall size on daily changes in live cattle and lean hog futures prices, respectively. For both beef and pork, the recalls were divided into three categories of equal number or recalls. Figure 6 indicates that in general large and medium size beef recalls are more likely to cause a downward shift in live cattle prices than small beef recalls. The effect of size on pork recalls is varied. No clear inferences can be drawn about the effect of pork recalls on lean hog futures prices.

To test whether size and severity of meat recalls statistically affect the live cattle and lean hog futures prices, equations 1 and 2 are estimated for beef and pork recalls. Estimation of equation 1 for beef recalls suggests medium beef recalls that are serious cause a downward shift in live cattle prices (table 2). The dependent variable in table 2 is the daily price change in the nearby live cattle futures contract from 1982 to 1999. The estimated coefficient on *MedSer* indicates that the daily price change is 0.37/cwt lower when there is a medium serious recall than when there is no medium serious recall. Large recalls also place downward pressure on nearby live cattle futures prices. It is unclear why medium recalls of serious health concern affect nearby live cattle futures prices, but large serious recalls do not. One would expect that market participants would be more concerned with larger recalls. However, results do not support this hypothesis. Estimates for the *DMkt* variable indicate that nearby live cattle futures prices are positively affected by price changes in other foodstuff futures contracts.

Estimates of equation 2 at k = 1 (1 day after the recall) through k = 4 (4 days after the recall) for beef recalls are shown in table 3. Expected signs were obtained for most variables through k = 4 (the one exception being the sign on *LrgSer*). At k = 1, *Lrg* and *MedSer* were significant at the 80 percent and 95 percent confidence level, respectively. The interpretation of the *MedSer* variables indicates that a beef recall between 2,400 and 37,500 lbs. that is a serious health concern causes a $0.28/cwt. drop in the nearby live cattle futures prices. A joint F-test of the hypothesis that the coefficients on *Med*, *Lrg*, and *MedSer* and *LrgSer* are equal to zero is rejected at the 85 percent confidence level. Once again, the results indicate that beef recalls *may* put downward pressure on nearby live cattle futures prices. Equation 2 is re-estimated for k = 2 through k = 4 to examine the persistence of the recall effects. Effects of a medium sized beef recall of serious health concern seem to be pronounced even three to four days after the recall. At k = 4, a medium beef recall causes a $0.53/cwt. drop in the nearby live cattle prices from the time the recall occurs until four trading days later. Surprisingly, the effects of the beef recall are more pronounced as the time since the event increases. The F-statistics increases from 1.7 at k = 1 to 2.03 at k = 4. At k = 5 and other time periods thereafter (not shown in table 3), the F-statistic begins to fall and all dummy variables associated with the beef recall cease to be statistically different from zero. Once again, it is unclear why medium serious recalls have a negative influence on nearby live cattle prices whereas large serious recalls do not.

Estimations of equation 1 and equation 2 at k = 1 and k = 2 for pork recalls are shown in tables 4 and 5, respectively. Large serious recalls seem to place some downward pressure on nearby lean hog futures prices. However, this result is not persistent. When equation 2 is estimated and k is increased to 2 days, the recall effect becomes zero. This is also true several days into the future (not shown in table 5). Estimates indicate that large serious pork recalls have a slightly negative affect on nearby lean hog futures prices at k = 1.

Implications and Conclusions

Identifying the impacts of structural change in meat demand has been a heavily discussed topic in recent years. Much of the research in this area has focused on long-run changes in meat demand due to health-related information, media reports, or advertisement. Product recalls by meat processors are important factors that have the potential to influence meat demand. The number of meat recalls has increased over the past 15 years. With the publicity of recent meat contamination events, the public is becoming more concerned with the safety of beef and pork. Public awareness of the number of recalls and the risk associated with the occurrence likely reduces consumer confidence when a recall occurs.

This research examines the short-run impact of beef and pork recalls on nearby live cattle and lean hog futures market prices, respectively. Beef recalls marginally influence nearby live cattle futures prices if the recalls are sizeable and would cause a serious health hazard. In general, this research indicates that live cattle prices may decline $0.38/cwt. the day a serious beef recall between 2,400 and 37,500 lbs. occurs. In practical terms, the value of 1 live cattle futures contract changes by $144 depending upon the position one takes in the market in the face on a medium serious beef recall. Medium sized recalls seem to have the most persistent affect on live cattle futures prices. By the fifth day after the beef recall event cattle futures typically recovered to roughly pre-recall levels. Large serious pork recalls may have an immediate impact on nearby lean hog futures prices, but in general they do not appear to systematically influence the nearby lean hog futures market. Graphical analysis lends support to the argument that sizable beef recalls of serious health concern have a marginally negative impact on live cattle futures prices whereas, nearby lean hog futures prices do not appear to be appreciably affected by pork recalls. However, with both beef and pork recalls, results are not robust across weight classifications or severity.

In general, both beef and pork recalls have marginal impacts on futures market prices at best. It is possible that changes in meat demand occur at a slow rate and are thus not reflected in one- or two-day changes in futures market prices. Regardless, meat recall information is apparently not a large concern to futures market participants. Either traders are oblivious to the information, our models cannot detect the market reaction, or there is no perceived relationship between consumer demand and meat recalls in the short run. However, futures traders are not likely to be ignorant of important market forces. If consumer demand for beef and pork is adversely affected by meat recalls, it is likely that this change is gradual.

Footnotes

[1]Ideally, if one knew the exact time the recall was made public information, intra-day futures prices could be compared. However, this information was not available from the USDA FSIS.

[2]A dummy variable could be added that took the value of 1 if the recall was a serious health concern and 0 otherwise. In practice, however, this dummy variable was highly correlated with the other independent variables in the model. Thus, it is excluded from the analysis.

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Figure 1 - Number of FSIS meat recalls, 1982-1999

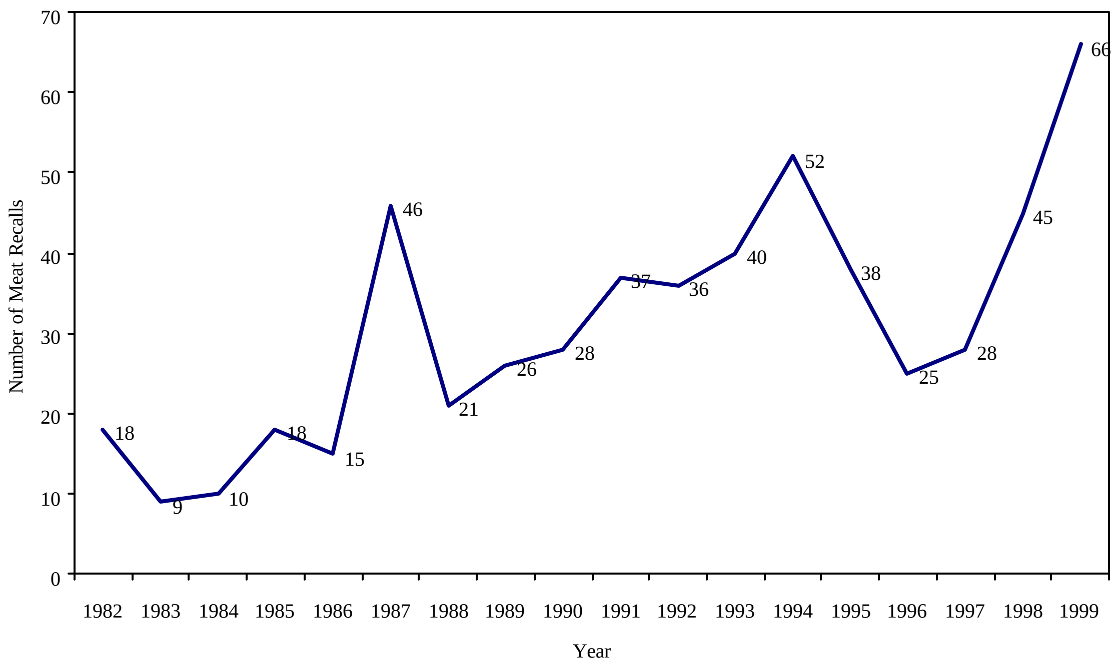

Figure 2 - Percentage Distribution of Daily Changes in Nearby Live Cattle Futures Prices, Typical Days and One Day After a Beef Recall, 1982-1999

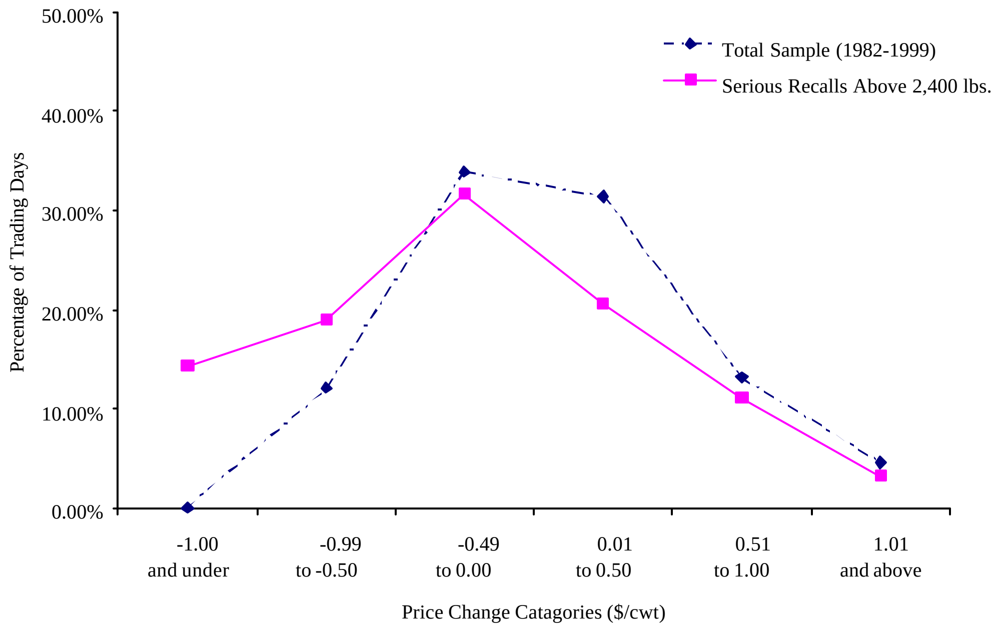

Figure 3 - Percentage Distribution of Daily Changes in Nearby Lean Hog Futures Prices, Typical Days and One Day After a Pork Recall, 1982-1999

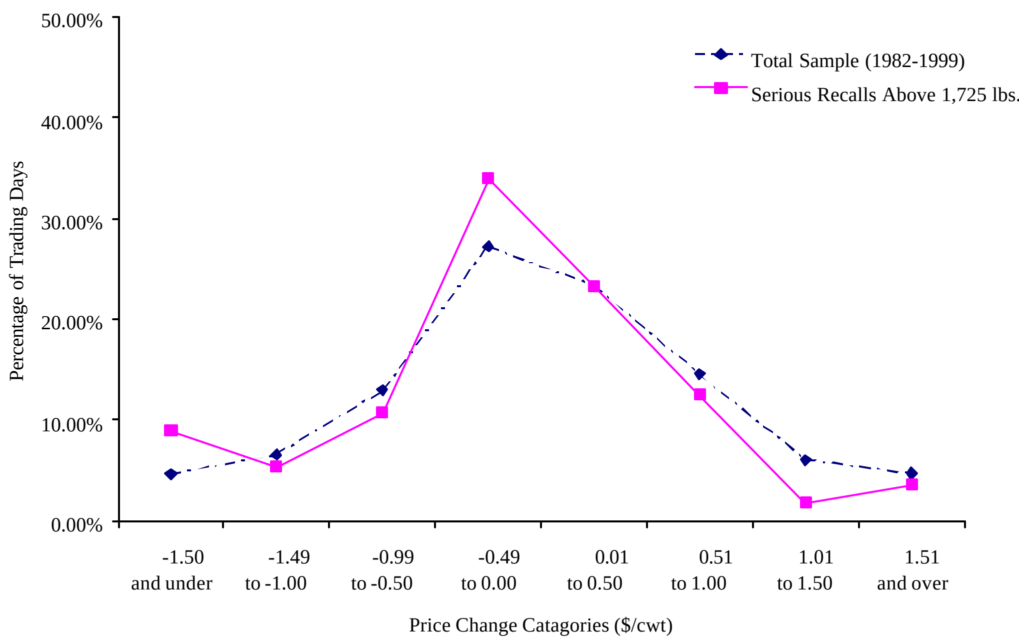

Figure 4 - Percentage Distribution of Changes in Nearby Live Cattle Futures Prices One Day After a Beef Recall by Severity, 1982-1999

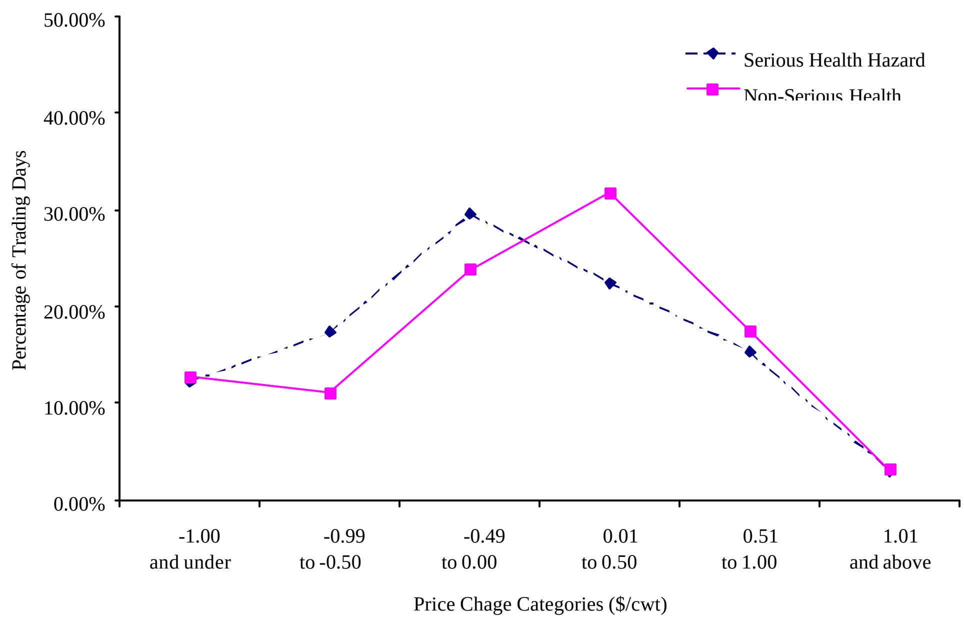

Figure 5 - Percentage Distribution of Changes in Nearby Lean Hog Futures Prices One Day After a Pork Recall by Severity, 1982-1999

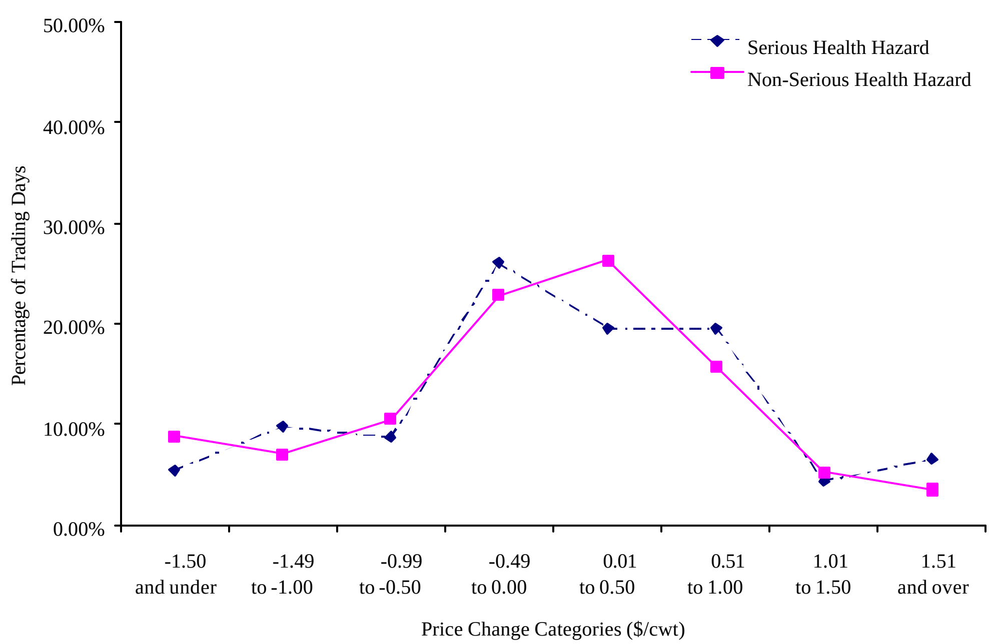

Figure 6 - Percentage Distribution of Changes in Nearby Live Cattle Futures Prices One Day After a Beef Recall by Size, 1982-1999

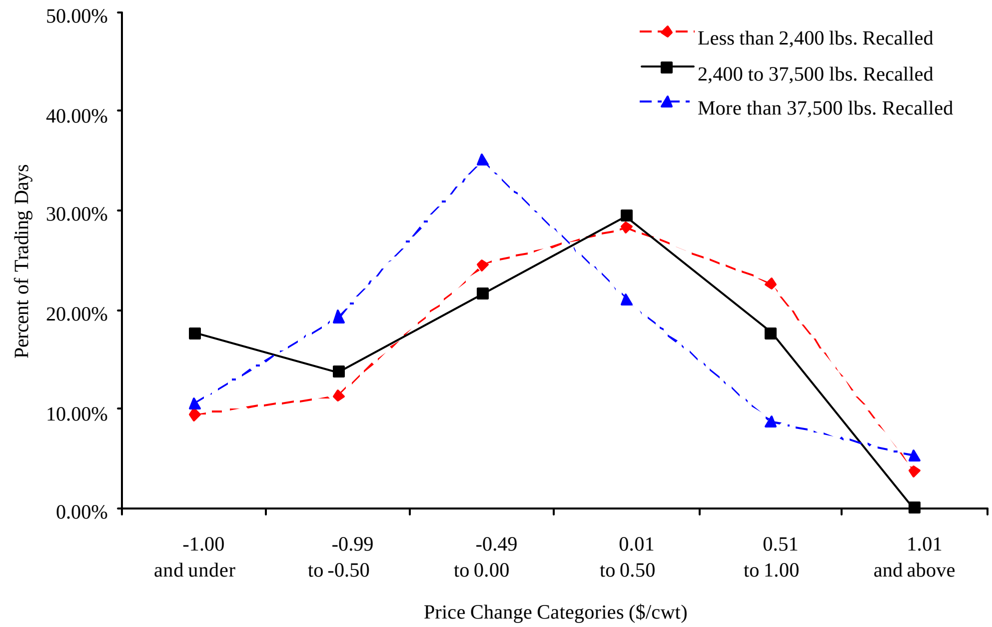

Figure 7 - Percentage Distribution of Changes in Nearby Lean Hog Futures Prices One Day After a Pork Recall by Size, 1982-1999

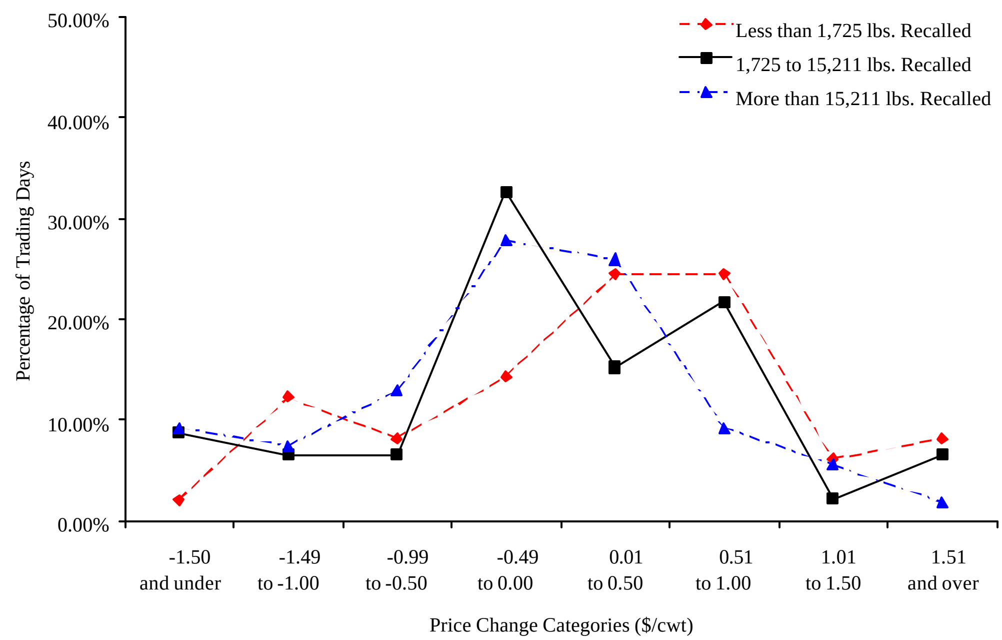

Table 1 – Beef and Pork FSIS Recalls by Date and Type, 1982-1999

	1982 to 1990		1991 to 1999		1982 to 1999	
Recall Type	**Beef**	**Pork**	**Beef**	**Pork**	**Beef**	**Pork**
Serious	26	24	74	69	100	93
Non-Serious	38	27	31	37	69	64
Total	**64**	**51**	**105**	**106**	**169**	**157**
Small[a]	23	10	33	42	56	52
Medium[b]	19	19	37	33	56	52
Large[c]	22	22	35	31	57	53
Total	**64**	**51**	**105**	**106**	**169**	**157**

[a]Small beef recalls were less than 2,400lbs and small pork recalls were less than 1,725lbs.
[b]Medium recalls were between 2,400lbs and 37,500lbs for beef and between 1,725lbs and 15,211lbs for pork.
[c]Large were greater than 37,500lbs for beef and 15,211lbs for pork.

Table 2 - Effects of Beef Recall on Daily Price Changes in Nearby Live Cattle Futures Prices, All Trading Days, 1982-1999

Variable	**Number of Occurrences**	**Parameter Estimate[a]**	**Standard Error**
Constant	-	0.017***	0.009
Recall	147	0.104	0.085
Medium Recall	45	0.127	0.159
Large Recall	53	-0.181*	0.150
Medium Serious Recall	26	-0.374****	0.177
Large Serious Recall	31	0.053	0.164
ΔMarket	-	0.031****	0.006
Sigma[b]	-	0.588****	0.006

Dependent variable = $P_{t+1} – P_t$
[a]Parameter estimates are obtained from a double limit tobit model – there were a total of 118 "limit-moves"
[b]Sigma is the disturbance standard deviation from the tobit likelihood function
Number of observations=4643; log likelihood = -4200; Durbin Watson from OLS regression = 1.99
****Significant at the 95 percent confidence level
***Significant at the 90 percent confidence level
*Significant at the 80 percent confidence level

Table 3 - Effects of Beef Recall Size and Severity on Nearby Live Cattle Futures Prices, Only on Days After a Recall, 1982-1999

Variable	**Parameter Estimate**[a]	**Standard Error**	**Joint F Statistic**[b]
One Day After Recall			
Constant	0.121	0.081	1.70
Medium Recall (2,400 to 37,500 lbs.)	0.130	0.154	
Large Recall (Over 37,500 lbs.)	-0.187*	0.146	
Medium Serious Recall	-0.378****	0.172	
Large Serious Recall	0.063	0.159	
ΔMarket	0.039*	0.030	
Two Days After Recall			
Constant	0.202***	0.107	1.06
Medium Recall (2,400 to 37,500 lbs.)	0.085	0.203	
Large Recall (Over 37,500 lbs.)	-0.197	0.193	
Medium Serious Recall	-0.379***	0.227	
Large Serious Recall	0.049	0.210	
ΔMarket	0.042**	0.028	
Three Days After Recall			
Constant	0.302****	0.136	1.61
Medium Recall (2,400 to 37,500 lbs.)	0.081	0.257	
Large Recall (Over 37,500 lbs.)	-0.153	0.245	
Medium Serious Recall	-0.627****	0.286	
Large Serious Recall	-0.115	0.267	
ΔMarket	0.024	0.030	
Four Days After Recall			
Constant	0.303****	0.148	2.03
Medium Recall (2,400 to 37,500 lbs.)	-0.161	0.279	
Large Recall (Over 37,500 lbs.)	-0.126	0.265	
Medium Serious Recall	-0.528***	0.311	
Large Serious Recall	0.035	0.290	
ΔMarket	0.057***	0.030	

[a]Parameter estimates ordinary least squares estimates. There were only 3 limit moves one day after the recall and no consecutive limit moves 2,3, or 4 days after a recall.

[b]Test of the hypothesis that $"_1 = "_2 = "_3 = "_4 = 0$ from equation 2. F critical value at 95% significance level = 2.45.

Note: Each regression consists of 147 observations; R^2 for each equation was between 0.07 and 0.05.

Dependent variable = $P_{t+k} - P_t$

****Significant at the 95 percent confidence level

***Significant at the 90 percent confidence level

**Significant at the 85 percent confidence level

*Significant at the 80 percent confidence level

Table 4 – Effects of Pork Recall on Daily Price Changes in Nearby Lean Hog Futures Prices, All Trading Days, 1982-1999

Variable	**Number of Occurrences**	**Parameter Estimate**[a]	**Standard Error**
Constant		0.016	0.013
Recall	143	0.202**	0.123
Medium Recall	43	-0.190	0.239
Large Recall	52	-0.113	0.210
Medium Serious Recall	26	0.187	0.264
Large Serious Recall	27	-0.317*	0.236
ΔMarket	-	0.099****	0.009
Sigma[b]	-	0.848****	0.009

Dependent variable = $P_{t+1} – P_t$

[a]Parameter estimates are obtained from a double limit tobit model – there were a total of 175 "limit-moves"

[b]Sigma is the disturbance standard deviation from the tobit likelihood function

Number of observations=4643; log likelihood = -5864; Durbin Watson from OLS regression = 1.98

****Significant at the 95 percent confidence level

**Significant at the 85 percent confidence level

Table 5 – Effects of Pork Recall Size and Severity on Nearby Lean Hog Futures Prices, Only on Days After a Recall, 1982-1999

Variable	**Parameter Estimate**[a]	**Standard Error**	**Joint F Statistic**[b]
One Day After Recall			
Constant	0.201***	0.115	1.37
Medium Recall (1,725 to 15,211 lbs.)	-0.178	0.226	
Large Recall (Over 15,211 lbs.)	-0.100	0.197	
Medium Serious Recall	0.193	0.249	
Large Serious Recall	-0.310**	0.222	
ΔMarket	0.122****	0.053	
Two Days After Recall			
Constant	0.304***	0.158	0.91
Medium Recall (1,725 to 15,211 lbs.)	-0.336	0.313	
Large Recall (Over 15,211 lbs.)	-0.038	0.271	
Medium Serious Recall	0.431	0.345	
Large Serious Recall	-0.328	0.306	
ΔMarket	0.165****	0.051	

[a]Parameter estimates ordinary least squares estimates. There were only 5 limit moves one day after the recall and no consecutive limit moves 2 or 3 days after a recall.

[b]Test of the hypothesis that $"_1 = "_2 = "_3 = "_4 = 0$ from equation 2. F critical value at 95% significance level = 2.45.

Note: Each regression consists of 143 observations; R^2 for each equation was 0.08 and 0.09.

Dependent variable = $P_{t+k} - P_t$

****Significant at the 95 percent confidence level

***Significant at the 90 percent confidence level

**Significant at the 85 percent confidence level