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Over the past twenty years, there has been an increasing trend in the number of recalls. Despite increased safety control standards, foodborne disease outbreaks continue to impact the food supply. A common source of foodborne illness and fatal infection is beef from diseases such as E. coli 0157:H7, Listeria Monocytogenes, and Salmonella. Certain companies have even been bankrupted, unable to overcome the social costs and economic losses associated with recalls. We examine beef recalls over a twenty year period through an accumulated two-year index to see if there is a prolonged effect of recalls on current weekly cattle prices. We find that recalls act together, adversely impacting prices and decreasing farm-level revenue. The revenue drop is economically small; therefore, it is uncertain if beef recalls financially incentivize cattle producers to invest in food safety safeguards.

Key words: futures market, food safety, recalls, revenue loss

Introduction

In the past 20 years, there has been considerable research into the effects of food recalls on consumer demand, perhaps due to the increase in the number of recalls over the same period. From 1996 to 2016, the meat and poultry industry witnessed an increasing trend in the number of recalls. The Food Safety Inspection Service (FSIS) reports that, despite industry and government efforts to safeguard food, product contamination by adulterants continues to be an ongoing concern (USDA, 2016). Food safety issues can result in severe economic losses to food companies and even worse social costs for society, ranging from company bankruptcy to consumer illness or death. The Centers for Disease Control (CDC) estimates that each year roughly 1 in 6 Americans (or 48 million people) get sick, 128,000 are hospitalized, and 3,000 die from foodborne diseases (CDC, 2016). Recalls are designed not only to protect consumers by removing contaminated product from commerce but also to incentivize companies to prevent foodborne disease outbreaks from happening.

It is hypothesized that recall events can lead to negative price impacts because the recalls suggest lower product quality or ineffective quality control, resulting in a loss of consumer confidence (Marsh et al., 2004). In turn, traders in derivatives markets react to the sudden, negative news, resulting in a drop in futures prices for the implicated commodity. While there has been considerable research examining the effects of recalls on short-term price movements (McKenzie and Thomsen 2001; Lusk and Schroeder 2002; Moghadam et al. 2016), there is no research on the cumulative impact recalls play in shifting long-term consumer demand preferences. Lusk and Schroeder (2002) concluded that if meat recalls resulted in a systematic change in the structural demand for meat, the change only occurs gradually and must be examined through an extended period of time. If recalls do have a more prolonged effect, then knowing this would help identify the effectiveness of recall policy. Therefore, this paper aims to build on existing literature by investigating the long-term impact of recalls on weekly live cattle futures markets using a recall index. More specifically, the objective of this paper is to analyze if additional meat recalls have long run impacts on weekly live cattle futures prices.

The following section presents a literature review related to the long-run impacts of recalls on futures market prices. This is followed by an account of the meat recall process, then the data used are described. Empirical methodology is explained followed by empirical results. Conclusions and further research are discussed in the last section.

Literature Review

An early, related literature, while not explicitly studying the impacts of recalls, identified health information as a demand factor in consumer response. Moschini and Meilke (1989) introduced modeling the structural change in demand for meat. In their seminal paper, they found that the dynamics of prices and incomes cannot fully explain consumer demand shifts from meat to chicken; however, dietary concerns provided the best explanation for shifts towards white meats. Kinnucan et al. (1997) examined the combined effects of advertising and health information on meat demand. Their study hypothesized that health information, such as linkages between cholesterol and heart disease, impacted beef demand, which was confirmed by the positive and negative cross- and own-price elasticity for poultry and beef, respectively. The first study conducted to see the short-run impact of health information was by Robenstein and Thurman (1996), which revealed insignificant effects of Wall Street Journal articles on livestock futures markets. Food safety information differs, however, from health information in that such information, for example pathogenic contamination, can result in a short-term, a long-term, or fatal consequences. These events are mostly unanticipated and the shock severity may cause a considerable market reaction.

The shock of a food recall can cause a lack of consumer confidence, drive prices down and ultimately impact traders' decisions, which has been the focus among much research. For instance, Henson and Mazzocchi (2002) found that processors of beef, dairy and pet food products were negatively affected by the reported linkage between BSE and Creutzfeldt–Jacob disease. Thomsen and McKenzie (2001) studied the effects of recalls on shareholder wealth to find that serious health concerns did cause a drop in stock prices. In a second paper, McKenzie and Thomsen (2001) concluded that wholesale prices were impacted by recalls, yet this impact did not transmit to farm-level derivative prices. On the other hand, using food recalls as a proxy for food quality, Lusk and Schroeder (2002) found that medium-sized, serious food recalls did impact short-run farm level derivatives prices for live cattle and lean hog. Furthermore, Moghadam et al. (2013) revisited the McKenzie and Thomsen (2001) result to find that there was, in fact, a significant reaction in live cattle futures markets from *E. coli 0157:H7* contamination. The researchers of the more recent publications concluded that modeling the role of recalls on futures prices was incomplete without the introduction of gradual effects. This finding suggests further investigation into the long-term effect of meat recalls.

There are a number of studies that explore the long-run effects of food safety on meat demand, many of which utilized food safety indexes for empirical methodology. One of the principal studies in this branch of research is Burton and Young (1996), which used media articles and popular press to measure the impact of food safety on beef demand. In their AIDS model, they found a short and long-term effect of publicity on consumer expenditure for meat and a drop in meat market share. Flake and Patterson (1999) extended the literature concerning the effects of

BSE, E. coli, and salmonella on meat demand by studying Associated Press articles. Both of these papers found a negative impact on demand, confirming that the market responds to food safety occurrences, and media informational indexes have effective explanatory power. Piggott and Marsh (2004) incorporated similar empirical methodology with a food safety index for publicized recalls. Overall, their paper revealed small changes over time in average consumer response to food safety with some periods of large, short-lived impacts. Marsh, Schroeder, and Mintert (2004) built upon this research by examining demand responses to food recalls from newspaper articles and FSIS meat product recalls. While meat product recalls significantly impacted demand, with elasticity measures indicating a change from meat to non-meat consumption, media indices had no effect.

The early literature analyzed prices following USDA announcements, while more recent studies have incorporated media articles as a primary source of consumer information and decision making. Schlenker and Villa-Boas (2009) compared the two information sources and found that independent news media created a more adverse impact on prices than a government report warning of the first BSE outbreak. Nevertheless, government reports on food scares are typically the first information traders and consumers have access to. Therefore, it is still believed that USDA recall announcements contain relevant information to gauge how market participants respond to food safety events. This study will follow the recent literature in that an index measure will be used to quantify the food safety impact. However, being that information contained in the reports (recall size, severity and description) has consistently yielded significant results, the index will only include information that market participants could access through the USDA announcements.

The existing literature has succeeded in determining the immediate market response of meat recalls on futures market prices. It is hypothesized in this paper that current cattle prices reflect many factors, one of which being food recalls from years past. It is, then, believed that the indexed effect of cumulative recalls will give a more accurate representation of how traders update prices in response to new outbreaks. Specifically, the results will show the revenue lost by cattle producers due to an increase or decrease in an index of recall events over the past two years. This is possible through using a rolling index, allowing for the inclusion of all recalls within a 24-month time window.[2]

Recall Background

The Food Safety and Inspection Service (FSIS) is an agency of USDA that handles product recalls for meat, poultry and egg products. According to FSIS's recall policy, a recall can begin in several different ways. First, the company can identify an adulterant or other product defect and notify USDA officials immediately. FSIS will investigate the claim and issue a Recall Notification Report (RNR) for non-serious, Class III recalls or publish a press release if the recall is serious (Class I or II). The recall process can also begin with FSIS, the state government, or

[2] The previous literature (Moghadam et al. 2013; McKenzie and Thomsen 2001) used event study methods for estimation. To have an accurate measure of normal returns, surrounding recall events were dropped so that the abnormal return of one event did not influence normal return estimation of another. This guaranteed independence required for the test statistics; however, it potentially led to losing meaningful data from the analysis.

third party plant inspectors identifying a non-compliance issue that warrants product removal (USDA, 2016).

The RNR or Recall Release contains all the information concerning the recall, such as company, reason for recall, date of recall, method of discovery, recall class, pounds recalled, reported consumer illness, and other related information. In addition to the reason for the recall and product, each report notifies the public of the recall severity by categorizing the event into one of three groups: Class I, Class II or Class III. According to the FSIS website, "A Class I recall involves a health hazard situation in which there is a *reasonable* probability that eating the food will cause health problems or death" (USDA, 2016). Class II involves a contaminant that presents a remote probability of health concern and Class III involves situations expected to result in no negative health side effects. After a report has been issued on the size and class of the recall, FSIS works with the company throughout the recall process to ensure all contaminated products are removed from commerce before lifting the ban.

Data

Weekly Futures

Using Datastream software, weekly live cattle futures prices were gathered from the Chicago Mercantile Exchange (CME). CME contains information for different commodities, contracts and frequency. Specifically, live cattle contracts were presented in daily, weekly and monthly increments for expiration months of February, April, June, August, October and December. A frequency of weekly prices better fits the frequency of recall announcements and abstracts from the noise of daily price changes. To organize prices into a continuous series, contracts were rolled over to the next nearest contract at the start of the expiration month. Following the logic of the previous literature, it is believed that futures prices–specifically, live cattle futures–will respond most strongly to a USDA recall.

USDA Catalogue

The recall information was pulled from USDA's FSIS website catalogue of meat, poultry and egg recalls from 1982 through 2017. The Recall Case Archive provides summary information on completed recalls beginning in year 1994. We limit our examination of recalls to the period from January 1, 1995 to December 31, 2015. The information contained in each data frame is the press release information listed above, including company, reason for recall, date of recall, method of discovery, recall class, pounds recalled, and consumer illness – if there was one. For the purpose of this study, the information extracted and used for analysis will be company, date, recall class and pounds recalled for beef recalls. Beef recalls were selected because they remain a common source of food contamination, which the literature has already closely analyzed. Since recalls often necessitate the removal of multiple meat products, the criteria was restricted to include only beef-specific events. Table I summarizes the information we collected on beef recalls.

Table I

Number and volume of beef recalls per year.

Year	All Recalls # of Recalls	Total (lb.)	Mean (lb.)	Std (lb.)
1995	6	963,956.00	160,659.33	176,190.02
1996	7	171,734.00	24,533.43	56,337.99
1997	10	26,322,529.00	2,632,252.90	7,861,897.91
1998	18	4,946,491.00	274,805.06	635,835.08
1999	14	3,396,154.00	242,582.43	557,261.94
2000	25	2,925,476.00	117,019.04	230,259.44
2001	29	1,600,682.00	55,195.93	154,198.14
2002	41	24,133,913.00	588,632.02	2,981,869.68
2003	23	1,776,945.00	80,770.23	170,399.92
2004	14	1,509,515.00	107,822.50	153,897.00
2005	11	1,740,982.00	158,271.09	269,905.06
2006	16	5,021,153.00	313,822.06	1,069,512.08
2007	26	33,485,915.00	1,287,919.81	4,350,286.16
2008	20	150,549,632.00	8,363,868.44	33,720,083.09
2009	29	3,777,014.00	130,241.86	227,842.61
2010	26	24,561,504.00	944,673.23	3,092,721.06
2011	27	1,248,938.00	49,957.52	94,650.12
2012	12	124,777.00	10,398.08	15,055.14
2013	15	382,915.00	27,351.07	37,939.40
2014	9	11,253,356.00	1,250,372.89	2,870,911.44
2015	26	1,077,624.00	43,104.96	107,043.80

The reasons for recalls range from labeling to bacteria contamination. From 1995 through 2015, the leading cause of beef recalls was *E. coli O157:H7*. The second leading reason for a recall fell in the category 'Other' which included misbranding, extraneous materials, or a non-life-threatening chemical/spoilage exposure. Therefore, the data reflect higher class I and class II/III recalls for the former and latter, respectively. Table II displays a chart with the various types of recall reasons and number of occurrences for each.

Index Construction

Serious consideration and research was taken in developing our index. Lusk and Schroeder (2004) determined that seriousness and size of recall determine market response. Other papers, too, identified recall class and size as key variables in price response to food safety events. Pozo and Schroeder (2016) found recall size to be significant, causing abnormal stock returns to become more negative when increased by one percent. The literature consistently finds that recalls involving serious health consequences or death have significant impact on financial variables (Lusk, 2004; Thomsen and McKenzie, 2001; Pozo and Schroeder 2016). Therefore, this study treats recall size and severity as primary measures for the index construction, yielding a higher index value for more serious recalls.

Table II
Type of Recalls 1995 - 2015

Year	All Recalls					
	Listeria Monocytogenes	E. coli O157:H7	Allergen	Other Bacteria	Other	Proc
1995	0	5	0	0	0	1
1996	3	2	0	0	2	2
1997	0	6	0	0	4	0
1998	1	12	0	1	4	1
1999	2	9	0	0	3	2
2000	5	18	0	0	2	0
2001	5	21	1	1	1	1
2002	3	31	1	1	5	2
2003	3	10	1	1	8	1
2004	2	5	4	0	2	1
2005	3	5	1	1	1	0
2006	0	8	2	1	5	0
2007	1	22	0	0	3	2
2008	2	15	1	0	2	0
2009	4	13	1	3	8	0
2010	2	11	4	2	7	2
2011	2	12	5	2	6	2
2012	1	3	1	1	6	0
2013	1	5	3	2	4	1
2014	0	1	2	0	6	2
2015	1	7	9	0	9	0
Total	41	221	36	16	89	20

Following Lusk and Schroeder (2004), this paper includes size categories as follows: size1 = less than 1,162 lbs., size2 = between 1,162 and 4,516 lbs., size3 = between 4,516 and 32,000 lbs., size4 = between 32,000 and 175,288 lbs., and size5 = greater than 175,288 lbs. For each of these categories, we assign an index of odd numbers 1 through 9 with 9 being assigned to the category with the most pounds recalled. Next, we index the classes by 3, 2 and 1 for Class I, II and III, respectively, giving a larger weight to events more likely to cause a serious illness. These two numbers are then summed to arrive at the contribution to the index for each recall event.

The two-year frame for our index was divided into four subperiods that consist of 6 months of recall data for each group. All of the recalls in a six month period were summed together to find the total index measure per six months. Each subperiod is then weighted decreasingly by distance from the current week. The most recent 6 months have a weight of 1, the following 6 months a weight of .75, and the remaining two six month subperiods receive weights of .5 and .25, respectively. Then all the weighted values are summed to arrive at the final index value for that week.

In turn, this window will move through the entire dataset of recalls, re-indexing every week, creating an index based on a rolling window of two years of recalls. We calculated the index from December 31, 1996 through December 22, 2015, totaling 989 weekly observations.

Empirical Methodology

Based on demand theory, we treat the food safety index as a demand shifter. This method was successfully used by Marsh et al (2004) and Attavanich et al (2011). We use a simple autoregressive model of live cattle futures prices with the addition of several exogenous variables. The explanatory variables included in this study were chosen from previous literature and economic theory, specifically as it relates to food recall events.

The main exogenous variable consists of a two-year accumulated recall index. Since beef, like most agricultural commodities, demonstrates seasonality, the empirical model also includes dummy variables for months, and yearly fixed effects were included to model inflation. The logarithm of the weekly price series was used as the dependent variable and, when tested for nonstationarity with an augmented Dickey-Fuller test, was found to be stationary. Two lagged values of logged futures prices were included as regressors to account for past prices influencing present prices. Modeled autocorrelation and partial autocorrelation graphs were the criteria used to justify the number of autoregressive dependent variables used. Thus, the equation used to model prices is given by

$$(1)\quad Log(P_t) = \beta_0 + \beta_1 RValue_{t-i} + \beta_2 \log(P_{t-1}) + \beta_3 \log(P_{t-2}) + \sum_{j=2}^{12} \beta_j Month_t + \sum_{j=2}^{19} \beta_j Year_t + \varepsilon_t$$

where P is the nearby futures price with t indicating the week; Index denotes the accumulated index by $Index = \sum_{i=1}^{104} \omega_i RValue_{t-i}$; β_{i2} and β_{i3} are the two lagged values of weekly logged futures prices, $Month_t$ are the seasonal monthly variables, $Year_t$ are yearly fixed effects, and ε_t is the stochastic error term.

Empirical Results

Equation (1) is estimated using OLS. The main variable of interest, $RValue_{t-i}$, is statistically significant at the 5% level. The magnitude of effect is moderate with a -.0000893 impact on prices for a one unit increase in the index. The coefficient for the index variable is negative, which supports our hypothesis that an accumulation of recalls will put downward pressure on cattle prices. Table III provides a list of the variables with their corresponding significance and magnitude. Interpreted economically, if the index increases by 1 unit, we expect prices to change by -.0089%. Therefore, an additional recall, even of sizable and serious proportions (which can add at most 12 to the index), cannot increase the index enough to push farm-level prices downward by an economically significant amount according to these results. However, this percentage can be a sizable drop for any trader who has invested in a large quantity of cattle futures or options. Importantly, these results confirm our hypothesis that live cattle futures are adversely impacted by recalls over time.

Table III

Regression Results

Log(CattlePrice)	Coefficient
Intercept	0.474141***
RValue	-0.0000893**
loglag1	0.864624***
loglag2	0.0235929
Year	
1998	-0.0032287
1999	0.0100219**
2000	0.0186498***
2001	0.0242005***
2002	0.0231801**
2003	0.0366203***
2004	0.0403879***
2005	0.0369993***
2006	0.03269993***
2007	0.0483277***
2008	0.0536078***
2009	0.0406223***
2010	0.0629274***
2011	0.0792005***
2012	0.0803203***
2013	0.0776352***
2014	0.099077***
2015	0.0902816***
Month	
February	0.005189
March	0.0012397
April	-0.0138146***
May	-0.0037933
June	-0.0008868
July	0.0000182
August	0.0065322*
September	0.0041931
October	0.0093504**
November	0.004419
December	0.0060679
R^2	0.9927

Note: * significant at 10%, ** significant at 05%, *** significant at 01%

Economic Impact

Fewer recalls means increased farm revenue, to the extent that higher futures prices translate into higher revenue to farmers. The weekly, monthly, and annual changes in index values were calculated to identify periods of change that would facilitate putting the results into economic context. The annual index changes in Table IV below give the cumulative changes over each year of recall information. The recall index increased the most in 1998 (80.75), while its biggest drop was in 2012 (-100.75). Using all yearly index measures, the percentage change in futures prices was multiplied by the average settlement price for that year to calculate the average yearly loss or gain per hundredweight. That amounted to -$0.46/cwt and $1.10/cwt change in price for 1998 and 2012, respectively. Applying these numbers to USDA total disappearance statistics and the average yield of meat per cow[3], cattlemen clearly suffered millions of dollars in losses from contaminated food. Elevated levels of recalls cost the cattle industry as much as $240 million in 1998. On the opposite side, by limiting severe recalls of serious health concerns, farm-level revenues are estimated to have increased $567 million in 2012.

Table IV
Economic gains and losses from food safety

Date	Annual Index Change	% Price Change	Avg Yearly Loss ($/cwt)	Tot. Beef Cons. (Billion lb.)	Loss in Dollars
12/30/1997	31	-0.27435	-0.18	25.61	-$93,480,435.31
12/29/1998	80.75	-0.71464	-0.46	26.31	-$240,211,084.78
12/28/1999	-8.75	0.077438	0.05	26.94	$27,519,866.97
12/26/2000	62	-0.5487	-0.39	27.34	-$210,661,302.34
12/26/2001	24.75	-0.21904	-0.16	27.03	-$86,377,785.50
12/31/2002	63	-0.55755	-0.39	27.88	-$215,281,809.15
12/30/2003	-40	0.354	0.28	27	$152,647,693.34
12/21/2004	-81.5	0.721275	0.6	27.75	$333,276,244.77
12/27/2005	-50.75	0.449138	0.39	27.75	$216,479,512.76
12/26/2006	-7.5	0.066375	0.06	28.14	$32,158,613.69
12/26/2007	7.5	-0.06638	-0.06	28.14	-$35,346,902.54
12/30/2008	-9	0.07965	0.08	27.19	$41,143,339.27
12/22/2009	33.75	-0.29869	-0.25	26.84	-$135,605,483.35
12/28/2010	5	-0.04425	-0.04	26.39	-$22,223,049.58
12/27/2011	-11.5	0.101775	0.12	25.54	$59,786,730.04
12/26/2012	-100.75	0.891638	1.1	25.75	$567,097,572.72
12/31/2013	-25.75	0.227888	0.29	25.48	$147,298,381.29
12/30/2014	-32.25	0.285413	0.43	24.68	$211,896,288.16
12/22/2015	33.25	-0.29426	-0.43	24.77	-$212,294,668.12

For the 19 years, changes in the level of recalls were responsible for decreasing revenue for 9 years and increasing it for 10. Table I indicated that recalls soared from 2000 to 2002. It was also in these years that *E. Coli O157:H7* was attributed to more recalls and contaminated more food products than any other time frame on record. Therefore, these results reflect the significant losses farmers faced when the beef industry was experiencing distress during this time. In 2000, there were 19 confirmed cases, 19 likely cases, and 49 suspected cases of *E. coli O157:H7* originating from several Wendy's stores in Oregon (Knowlton, 2003). In the same year a young girl died and 65 fell ill from an outbreak stemming from Sizzler restaurants in Wisconsin. In 2002, the third largest recall in history occurred when ConAgra distributed ground beef contaminated with *E. coli O157:H7*. The outbreak sickened about 19 people in six different states, forcing ConAgra to recall over 19 million pounds of ground beef (Becker, 2002). Another

[3] Since beef disappearance is in pounds of meat and futures prices are in pounds of cattle, we need to convert between these two using an estimated yield for beef. This number is variable, but generally somewhere in the 40s in terms of percent (e.g., a cow yields 45% of its weight in retail beef pounds) (Nold, 2013). We use 50% here to make our loss estimates somewhat conservative.

company the same year recalled over 2.8 million pounds of ground beef after 57 people in 7 states fell ill to *E. coli O157:H7* contaminated ground beef.

By examining the data, one can see that the only other years to result in losses comparable to 2000-2002 are the years that also experienced abnormally high *E. coli O157:H7* outbreaks, such as 1998 and 2007. In 2007, the second largest beef recall in history (21.7 million) occurred due to *E. coli O157:H7* contamination in ground beef. Interestingly, the year with the most pounds recalled, 2008, benefitted economically at $41,143,339.27. Therefore, this indicates that recall severity plays as fundamental a role in prices as size. Specifically, the results support the findings of Moghadam (2013) who finds *E. coli O157:H7* recalls responsible for adverse returns in live cattle markets. Moreover, this study adds to his work by including some very large recalls that were excluded in the years studied in the previous literature.

Conclusions and Further Research

This study set out to investigate the gradual impact of recalls over an extended period of time, as was suggested by previous food safety literature. Our results offer important information for the cattle industry. Whereas before the impact of recalls on daily cattle prices was known and believed to be temporary, this research uncovers a more prolonged impact. Here, the results indicate not only a significant impact on weekly commodity prices, but it shows that accumulated recalls act together

Thus, traders' responses to a recall event are based on present and past knowledge of food safety events for the same product. Consumer theory applied to the interaction between traders and consumers suggests that consumers are substituting meat for other products temporarily, or the market is experiencing a long-run structural change in meat caused by consumers' perceptions of meat due to recalls. The structural change hypothesis is consistent with Moschini and Meilke (1989).

Rather than excluding relevant recalls, which is often necessary for event studies, no recalls were dropped from 1995 through 2015. This expanded data set is a significant contribution to this field of research. We provide results for the effect of beef recalls on the cattle industry over the past 20 years. Based on the results, recalls are costing cattle producers economically significant amounts of money when the losses to the industry as a whole are considered. Disaggregating these losses across individual farms may result in only marginal changes in farm revenue. Therefore, it is uncertain whether recall costs financially incentivize producers to invest in food safety safeguards.

Nevertheless, beef recalls adversely affect futures market prices for an extended period. And although it is unclear whether recall information is a concern to livestock farmers, the results here indicate that futures market participants react apprehensively over time to such food safety events. Furthermore, farm-level revenue is impacted by the continued discoveries and requested return of defected beef products.

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