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Keywords: Food safety, Mad cow diseases, consumer expenditure survey, scanner data, futures prices.
JEL code: D12, Q18, M31

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1 Introduction

There is an active discussion how best to inform consumers about food safety issues. Policy makers have a keen interest in assessing the effectiveness of various channels through which such information could be transmitted. Possible channels are product labels (e.g., the case of cigarettes), warnings by the government agencies like the Food and Drug Administration or the Department of Agriculture (e.g., the case of mercury in fish), media coverage by news outlets, or liability rules (e.g., recall efforts for the drug Vioxx by pharmaceutical giant Merck).

The focus in this paper is to assess how consumers in the United States react to two mad cow scares. The foundation of any event study, or empirical study in general, is the availability of reliable, representative data. While researchers currently use a wide array of data sources, event studies traditionally examined changing buying habits by looking at the Consumer Expenditure Survey (CES). One contribution of our paper is to compare estimates using the CES with the estimates using two easily available data sources, and provide evidence that micro-level scanner data and futures prices are a better alternative to the traditionally used consumer expenditure survey files when accessing market level micro responses to information releases, policy interventions, and food scare events on buying habits.

The two mad cow scares we examine are the publication of the first infected cow in the United States as well as a report about the potential harmful effects of mad cow disease in a prime-time TV show. In each case we examine how the scare changes meat, especially beef, consumption. Both events reached a large audience and hence are a prime example of how information can influence consumers. The warning about the harmful effects of eating beef aired on April 16, 1996 on the Oprah-Winfrey show, an afternoon show with a large audience among stay-home parents that make food purchase decisions in a household. In the show Oprah Winfrey commented on the fact that the disease spreads by feeding ground-up cows to other cows by saying: "It has just stopped me cold from eating another burger!" More than seven years later the first outbreak of the disease was reported in the United States on December 23, 2003, and there was repeated news coverage in the newspapers, TV and radio for at least the next month.

Building on this news coverage, the hypothesis underlying this research is that the consumption of beef decreased significantly following these two highly publicized events. While there are several articles that have examined similar effects in Europe following the large-scale outbreak of mad-cow disease, all previous studies either only addressed the issue methodologically or used aggregate data. One of the major contribution of our study is to assemble a unique micro-level scanner data set of a large U.S. grocery chain for the years around the actual outbreak in 2003. The analysis is then replicated using the diary files of the Consumer Expenditure Survey, which has traditionally been used to measure buying habits. The Consumer Expenditures Survey recruits roughly 100 new households each week to record all their purchases. A household stays in the survey for two consecutive weeks, which results in a sample size of around 200 households a week. While we find no significant change in purchasing decisions using the Consumer Expenditure Survey, the scanner data set reveals a statistically significant and robust drop in beef purchases in excess of 20% following the discovery of the first infected cow. The discrepancy in results between the two data sets casts some doubts on the Consumer Expenditure Survey and earlier studies that used it as the sample frame might simply be to small to detect changes. The CES should give accurate estimates of average purchasing decisions in a calendar year. However, as our study suggests, it is too small to track *changes* in buying habits over time. Given the increased availability of scanner data, we believe it should be used more widely in empirical research on consumer buying habits.

To provide additional information, changing buying habits of consumers are then contrasted to changes in cattle futures prices. In theory, financial markets should give an accurate assessment of consumer responses as financial markets are forward-looking. Systematic differences between the futures market and consumer buying habits allows us to examine whether there is excess volatility in financial markets. For example, Rausser and Walraven (1990) find that agricultural markets can overreact to disturbances, with repercussions in other markets. We find that a drop in futures prices of similar magnitude as the consumer response obtained in the scanner data set for futures with a two months maturity. Longer maturity dates show decreasingly lower abnormal returns, suggesting that the market expected the change in buying habits to be transitory.

Unfortunately, the detailed scanner data is deleted after 4 years, and it is hence impossible to obtain data dating back to 1996, when the Oprah-Winfrey show aired. Since the futures data exhibited comparable abnormal changes to our scanner data set in 2003, we use it to contrast abnormal changes following the discovery of the first infected cow in 2003 with observable market movements following the Oprah-Winfrey show. It warned U.S. consumers about the potential health effects of mad cow disease, although there had not been any reported case in the U.S. yet when it aired in April 1996. We find that the market response of this single show resulted in an abnormal return of more than half the drop we observed after the first discovery of an infected cow including the wide-spread media coverage.

The paper is organized as follows. The next section provides a brief discussion of the literature on food safety in general and in meat markets in particular, setting up the background for analyzing mad-cow events. Section 3 outlines our data in more detail. Section 4 describes the model, before Section 5 presents our empirical results. Section 6 concludes and discusses potential policy implications.

2 Background and Motivation

There is evidence that consumers are increasingly responsive to new information about the safety of food. Food safety alerts can result in "food scares", a sudden heightened level of concern about the safety of a particular product that can stimulate rapid and significant reductions in demand that may or may not eventually recover to pre-scare levels in the medium or long-term.

A number of previous studies have examined the impact of food safety-related information on consumer demand and, in some cases, the consequent implications for consumer and producer welfare. For example, Smith et al. (1988) analyze the impact of an incident involving contamination of milk with Heptachlor in Hawaii during 1982 and find that negative media coverage has a larger impact than positive coverage. Consumers tend to be susceptible to "scares", but it is much harder to restore consumer confidence once the damaging health effects have been resolved. Foster and Just (1989) use the same event to construct a model that examines the welfare losses associated from withholding "safety information" (leaving consumers in the dark) or losses due to artificially exaggerating the true nature of the threat. The latter arises as consumers not only respond to actual food crisis, but also to information about the potential risk associated with consuming various products. The response to risk-related information has significant economic consequences for food businesses. Some authors have used these findings to suggest that food-retailers should seize on food safety as a market segmentation mechanism (see for example Caswell et al. (1994); Henson and Northen (1998); Caswell (1998)).

While the Hawaiian milk scare was eventually resolved, new medical evidence about food-related health problems can sometimes permanently alter preferences. Examples include the case of cholesterol in shell eggs (Yen et al. 1996, Brown and Schrader 1990) and Alar contamination in apples (van Ravenswaay and Hoehn 1991). Traditional demand modeling becomes inadequate as there is a clear structural break in the relationship between the dependent variable (food expenditure) and the explanatory ones (prices, income, or other socio-economic characteristics). Chavas (1983) presents a framework of how to deal with structural breaks in meat demand models. It is even more difficult to determine how permanent these structural changes are and in an attempt to recover information, demand models often require some assumptions on the time pattern around a crisis. We hence include year fixed effects in our approach to pick up general shifts in consumption patterns.

There has also been an interest in assessing how heterogenous responses are between various socio-economic groups. Burton et al. (1996) show that the influence of socio-economic characteristics on meat consumption changes over the years 1973-1993 in Great Britain. Shimshack et al. (2006) use a reduced-form approach to evaluate the effect of government warnings about mercury in fish on fish consumption in the U.S. using the Consumer Expenditure Survey, and find that responses vary greatly by socio-economic characteristics. We follow their approach and rely on a reduced-form.

The occurrence of BSE (mad-cow) scares throughout Europe have recently led many researchers to investigate how consumers react to news about BSE. Burton and Young (1996) find that the continued BSE scare in the United Kingdom has resulted in a long-term reduction of beef market shares by 4.5%. Yet it is unclear how much of this shift is attributable to long-run trends. Moschini and Meilke (1989) argue that in the U.S. there has been a shift away from beef to fish and chicken. There are also studies examining the effects of the BSE scare on purchasing decisions in the United States, but they usually rely on more aggregate data. E.g., Crowley and Shimazaki (2005) use aggregate demand data from the pre-BSE period to develop an ARIMA model for changes in demand. In addition to the one-month-ahead forecast, they develop a dynamic forecast to estimate revenue loss due to the announcement.

The contribution of our paper is to use a much more detailed scanner data set to precisely estimate consumer responses in the wake of media reports about the first discovery of an infected cow and compare them to changes following a report about the *potential* risks associated with mad-cow disease that aired before an actual case was observed in the United States. We contrast our scanner data with the Consumer Expenditure Survey that is specifically designed to track purchasing habits, as well as cattle futures prices. We follow an event-study approach and focus on a reduced form impact in a narrow time window around when the new was made public, net of seasonal effects. To allow for possible structural shifts between years as estimated in earlier studies we include year-fixed effects and interact them with our other fixed effects.

Event study analysis can be carried out to measure the impact of food scares or food safety related information on financial markets. Economists are often interested in the impact of these events on the value of a firm or price of a product. This might appear to be a difficult undertaking, requiring detailed analysis of the impact on, for example, individual firm's productivity or the marginal willingness to pay for a product. Event studies, however, provide a relatively straightforward way in which to undertake such an analysis using data from financial markets. The assumption here is that measurement of the short-term impact on financial markets reflects the assessment of shareholders regarding the firm-level impact of the announcement, or a shift in marginal willingness to pay for a product. For example, cattle futures are forwarding-looking predictions of how beef prices will develop, and an event that will lower prices in the future should immediately be reflected in futures prices. Lusk and Schroeder (2002) examine the effect of beef and pork recalls on futures prices. Thus, a measure of the economic impacts can be derived based on changes in security or futures prices. An excellent review of the event study methodology is given by MacKinlay (1997), and Binder (1998) provides a survey of empirical issues raised by recent event studies. The use of event studies dates back to the late 1960s when a number of attempts were made to assess the impact of new information about annual earnings on security prices (Fama et al. 1969). These early studies, however, were hampered by the lack of readily available data on daily security prices. This made it difficult to isolate the impact of the specific event from other background influences. The subsequent availability and use of daily price series has improved the scope and precision of event analysis, but at the same time has necessitated the use of more sophisticated statistical techniques. Event study methodology has since been applied to assess the impact of a wide range of firm-specific and economy-wide events which include new government regulations (Broder and Morrall III 1991, Maloney and McCormick 1982); financial market predictions (Dimson and Marsh 1986) and product- and workplace-related deaths (Borenstein and Zimmerman 1988, Chalk 1987, Broder 1990, Broder and Morrall III 1991, Mitchell 1989).

3 Data

To estimate the impact of media coverage about mad cow disease on consumer purchasing decisions we use various data sources. The first is a unique scanner data set from one of the largest US grocery store chains. Our data set includes 298 stores in Maryland, Virginia, Washington, and the District of Columbia. The first mad-cow outbreak occurred in Washington state. Observations in this data set are daily sales at the UPC and store level, e.g., store 15 sold $18.50 of beef franks on December 23, 2004. The data set includes all meat (beef, lamb, pork, chicken, and turkey) sales for the period November 18 through March 23 in the winters 2001/2002 through 2004/2005, thus spanning the period 5 weeks prior and 13 weeks past the event date.[1] The scanner data reports both sales revenues and quantity sold. The summary statistics are given in the top rows of Table 1. We obtained the exact location for each of the 298 stores and were able to merge it with socio-economic statistics from the Census based on which zip code a store is located.

A Lexis-Nexis search gave us the daily count of articles that appeared on the topic. Our 13-weeks post-event window seems appropriate as media attention had subsided well before the end of this 13-weeks period.

The analysis is replicated using the diary files of the Consumer Expenditure Survey for the years 1990-2004. This survey is specifically designed to track purchasing decision of approximately 200 households a week. Each household stays in the survey for only two weeks and the sample frame is hence not a panel but a repeated cross-section. The survey has been used in many studies examining purchasing decision, and we use it to compare with the results from an analogous analysis using the previously mentioned scanner data. For comparison, there are on average more than 80,000 purchases of beef products per week in our scanner data set, while there are on average 133 purchases of beef products in the Consumer Expenditure Survey in a week. The descriptive statistics for the 126 days surrounding our two events are given in Table 1.

Finally, cattle futures prices were obtained from Iowa State University.[2] Arbitrage requires that futures prices rise at the risk-free rate of interest, and we hence also obtained the London Interbank Offered Rate for US Dollars from the British Bankers' Association.[3]

4 Analytical Framework

Our goal is to estimate the average price and quantity effects of the two mad-cow related events. We will first examine average effects for those close to the actual outbreak (Washington State) and a control group comprised of Maryland, Virginia, and DC. In a later section we examine whether there are heterogenous impacts attributable to demographic statistics.

[1] The end date is March 22nd in 2004 as it is a leap year.

[2] http://www.econ.iastate.edu/faculty/lawrence/Futures.html. We would like to thank Johns Crespi and John Lawrence for assisting us in obtaining these data.

[3] http://www.bba.org.uk/bba/jsp/polopoly.jsp?d=141&a=627

The baseline reduced form econometric model for estimating the effect of a mad cow event is:

$$y_{nsut} = \alpha_{sut} + \beta_n + \gamma_{n,2003} + \epsilon_{nsut} \tag{1}$$

where y_{nsut} are log expenditures by UPC code u (e.g., beef franks, ground beef, etc) in store s in week number n of winter / period t.[4] The fixed effects α_{suw} allow for a shift of average purchases in each store s by UPC code u and period t. I.e., our identification comes from changes within a UPC code and store in the given year of interest. The fixed effects β_n pick up seasonal effects, e.g., week 1 is always the week after Christmas from December 26-January 1 for the regressions examining consumer responses to the first infected cow, and the week starting eight days past Easter Sunday in the regression that examines the effects of the Oprah-Winfrey show. These days are chosen such that the week-number fixed effects pick up seasonal holiday effects of Christmas (which occurs on the same day every year) and Easter (which is based on a lunar calendar and occurs on different days between years). Finally, $\gamma_{n,2003}$ are the abnormal returns in week n in winter 2003/2004 net of store-by-winter-by-UPC fixed effects and seasonal effects. If the media coverage about mad cow outbreak changed consumer buying habits, there should be no abnormal returns prior to the mad cow scare, i.e., $\gamma_{n,2003} = 0$ for $n <= 0$ and there will be reduction in expenditures after the publication for $n > 0$.

We cluster the error terms ϵ_{nsut} by store and week, thereby allowing the error terms within a week and store to be correlated between UPC codes. If there are local shocks to a store in a given week, e.g., dismal weather that causes inhabitants to postpone shopping trips, all UPC codes will show lower sales. There is very little serial correlation between weeks, and hence the potential problems raised by Bertrand et al. (2004) do not apply to our analysis.

Our hypothesis is that beef consumption dropped following the Oprah-Winfrey show or following the discovery of the first outbreak. It is less clear to hypothesize what happens to other meats (chicken, pork, etc). On the one hand one would expect that consumers substitute away from beef to other meat products (a with-in meat substitution effect). On the other hand, some concerned consumers might choose to reduce all meat consumption, leading a decline in chicken or pork consumption. Which of the two effects dominates is an empirical question.

In a second step we examine how the changing consumption habits behave over time, i.e.,

[4]Since news of the first infected cows were published on December 23th, a time period t includes the weeks prior and past that event and hence includes weeks from two calendar years.

was there a permanent preference shift induced by either event or do consumption patterns revert to previous levels? To answer this question we relax the weekly aggregation and revert to a localized regression of the *daily* abnormal returns. To do so we first estimate day-of-year, weekday, and store-by-winter-by-UPC fixed effects for all periods but the one where the publication occurred. In the second step we smooth the residuals net of day-of-year, weekday, and store-by-UPC fixed effect using the Epanechnikov Kernel with a window of 10 days.[5]

We replicate analogous analyzes for cattle futures prices. In an efficient market, arbitrage requires that futures prices of financial products equal the current spot price deflated by the interest rate for the remaining maturity net of any "growth" of the underlying commodity.[6] While this is not necessarily true for commodity futures (because of storage cost and convenience yields), we are only interested in changes of the futures price and not the absolute level. We hence construct a variable that specifies price movements net of changes in the interest rate.

5 Empirical Results

In the following section we report our empirical estimates of how consumers and financial markets responded to the report about the possible health concerns associated with mad cow, as well as to the first actual outbreak.

Consumer Responses to First Reported Mad Cow Case Using Scanner Data

Results from the impact analysis of the 2003 mad-cow outbreak using scanner data are presented in the first two columns of Table 2. The dependent variable are weekly expenditures for each UPC code in each store in Washington state (west) or Virginia, Maryland, and DC (east). The reported coefficients are the abnormal weekly changes $\gamma_{n,2003}$ from equation (1). Local events and customs might lead to error terms that are correlated within a store for a given week, e.g., due to exceptional weather more or fewer shopping trips might be done. We hence cluster error terms within a store and week, thereby allowing error terms of various UPC codes to be correlated. The weekly treatment effects following the first reported mad cow outbreak in December 2003 are not only large in magnitude (approximately 30% in the

[5]Prices are fixed for seven consecutive days, so we use a 10-days window to have a cutoff at roughly a week and a half, i.e., only observations within a week and half before or after the event are counted.

[6]The futures price data we use have two, four, and six months maturities, and the net return on growing cattle should hence be limited as the cows are maturing.

eastern states and 25% in the west), but also highly statistically significant.

The magnitude of the abnormal reductions in beef consumption appears to decrease with time, yet the coefficient on the weekly dummies remains negative for all 13 weeks following the outbreak. Our analysis uses UPC codes, a very small aggregation measure. For example, beef franks of different vendors have different codes. One potential problem with such an analysis is that some UPC codes might sell very infrequently in a given store, i.e., the average number sold is close to zero. Hence, most weeks will show a zero. Every week where at least one product is sold will show up as a very large abnormal return, as the identifications comes from deviations in sales within a UPCs. The last four columns of Table 2 therefore examine the sensitivity of the results to various specification checks. Columns (3) and (4) use year fixed effects instead of year-by-store-by-UPC fixed effects, but the results are very robust. Columns (5) and (6) aggregate all beef purchases within a store and week (note how the number of observations drops dramatically as all purchases in a week are lumped into one observations). Again, the results are very robust.

The robustness to various weekly aggregation measures is also displayed in Figure 1, where the aggregation increases along rows. The top row displays the coefficient estimates and 95% confidence interval from the analysis based on UPC codes, i.e., the regression results in column (1) and (2) of Table 2. On the other hand, the last row displays the coefficients if all beef purchases in a store and week are aggregated into a single observation, i.e., columns (5) and (6) of Table 2. Finally, the second and third rows use an intermediate aggregation measure. The grocery chain from which we obtained the scanner data groups UPC codes into sub-sub-classes, where similar products from various vendors have the same sub-sub code, e.g., all beef franks are lumped together, no matter who produced them. Accordingly, the second row aggregates all sales of UPC codes with the same sub-sub-classification. The third row, furthermore, limits the analysis to sub-sub-classes that sell on average at least $100 per store and week. While the regression results vary slightly between the chosen aggregation, the overall picture is very robust.

To further investigate how reactions evolve over time, we relax the weekly aggregation and instead present results of smoothed abnormal daily returns as outlined in the modeling section. Our smoothing window stretches 10 days and the weight decreases quadratic in time, i.e., any abnormal return on the day of question receives a relative weight of one, while abnormal returns one, two, seven, or nine days apart receive a relative weight of 0.99, 0.96, 0.51, and 0.19, respectively.[7] The window is not allowed to cross the event day, e.g., the

[7]Prices, including special sales items, are usually fixed for seven days.

smoothed abnormal return for day 2 will only include days *after* the first outbreak (days 1 through 12), even though day -1 would theoretically be within 10 days of day 2.[8] The smoothed abnormal returns are displayed in Figure 2. The top row uses log expenditures, while the bottom row uses log quantity sold. There is a clear discontinuity at the event day, when sales drop sharply compared to pre-event levels. The large national supermarket chain that provided us their scanner data mentioned to us that they did *not* systematically change prices as a response to the reported mad cow event, at least initially as they were unprepared for such an incidence.[9] The smoothed changes in log expenditures and log quantity look very comparable. The only difference is for abnormal returns in Washington state two months after the outbreak occurred: while expenditures are still below historic levels, quantities sold are already above these levels, suggesting that sales prices must have fallen. Since the infected cow was found in Washington state, it appears that prices in stores in that state were reduced to counterbalance the drop in sales.[10]

Similar to Smith et al. (1988) we also observe that consumers react more strongly to negative than to positive news. On December 30th, 2003, the Department of Agriculture announced a new meat tracking system that should make it easier and faster to identify infected cows. Figure 2 shows that this had limited effects in Washington state, as the curve is relatively flat around day 7. In eastern states there is a brief upward trend following day 7, but is of smaller size than the drop following the discovered cow. Since the outbreak occurred in Washington state, a meat tracking system might hence be of greater importance to citizens of eastern states as it ensures that no meat from the infected area enters their supply chain.

Generally, the results seem comparable for both eastern and western states in our sample. We next examine whether different responses in various stores can be attributed to difference in socio-economic characteristics. Each store is matched with the average socio-economic characteristics from the Census for the zip code a store is located. We rerun the analysis using weekly aggregates by incorporating the interaction of a monthly dummy (for the first and second 4-weeks period following the outbreak) times the income in the zip code as well as the percent of minority groups.[11] The results are given in column (1) and (2) of

[8] This is purposefully done to ensure that the effect of the outbreak is not diluted by pre-event data.

[9] Prices are changed once a week and then valid for a week. There was no system in place to react to the mad cow outbreak quickly enough to change prices right away.

[10] The supermarket chain advised us that the expenditure data is more reliable than the quantity data as all sales are reported in dollars, while some of the packaging units change over time. In the remainder we therefore focus on the sales expenditure.

[11] We include people who classify themselves as Black or Hispanic.

Table 3. For the eastern states, each additional \$10,000 in mean income leads to an additional 0.9% reduction in log expenditures during the first four weeks after the outbreak, and an additional average 0.3% reduction in week five through eight. The effect is slightly stronger for Washington state, where the corresponding numbers are 1.9% and 1.8%. Yet, given that the overall reductions was in excess of 20%, our estimates suggest that there is a limited income elasticity. A word of caution is in order: we were only able to match the socio-economic characteristics for the zip code of each store, and it is quiet possible that more affluent people would go to high-end grocery stores (like Whole Foods or Wild Oats), and our estimates could hence suffer from selection bias. However, the authors visited several stores in the Washington D.C. area, and the socio-economic groups in the Georgetown store were noticeably different from other stores in the southeastern part of the city, as one would have expected from the Census data.

The sign on the minority variable was opposite of what we expected: Each additional percentage point of the population that was either Black or Hispanic resulted in an additional 0.11% and 0.02% drop during the first four weeks in the eastern states, or a 0.23% and 0.16% drop in Washington state. This might partly explained by the fact that both ethic groups have a higher per-capita beef consumption to begin with than other socioeconomic groups.

Meat that is attached to bones carries a higher risk of transmitting mad cow diseases. In a further sensitivity check we therefore interact dummies for the first and second month following the outbreak with whether the UPC description included the word "bone" or "boneless". Health conscious consumer should reduce their purchases of meat with bones even more, as it caries a higher risk. UPC codes that had the word "bone" in their description did indeed encounter larger sales drops in the first month following the publication of the first infected cow as shown in columns (3) and (4) of Table 3. There is, however, one anomaly: in Washington state (west) "boneless" meat encountered larger sales drop in the second month following the publication than meat with "bones". Finally, columns (5) and (6) include both socio-economic controls as well as the interacted dummies for meat with and without bones. The coefficients hardly change at all compared to when each group is included by itself.

While the drop in beef consumption is consistent across time and space, we now turn to the impact on other meats. As mentioned before, the mad-cow scare could induce a meat-substitution effect where consumers switch to other meats and thereby increase their expenditures, or to an overall reduction in meat purchases due to a perceived health risks of all meats in general. Since these effects work in opposite directions, it is unclear a prior how expenditures on these goods respond. Table 4 reports the regression results of abnormal weekly changes using week-number and store-by-UPC-by-year fixed effects. Figure 3 displays the smoothed abnormal returns. The results are much more mixed: while some of the weekly returns are statistically significant, the significance levels are much lower than for beef. Moreover, the sign sometimes switches between consecutive weeks. Similarly, there is no consistent pattern in the smoothed abnormal daily returns: While there appears to be substitution towards poultry (chicken and turkey) in Washington State (west) where the mad cow was discovered, there is no comparable effect in the eastern United States.

Consumer Responses Using Consumer Expenditure Survey

In the following we replicate the analysis using data from the diary files of the Consumer Expenditure Survey, a data set that is specifically designed to track buying habits from consumers. Each week, about 100 representative households enter the consumer expenditure survey and keep records of all their purchases. Each household remains in the survey for two consecutive weeks before it drops out, giving a total sample size of approximately 200 households per week. The sample size is hence limited, but the advantage of the survey is that detailed socio-economic characteristics of the household are available. However, since the survey comprises a representative sample of households, omitting socio-economic characteristics from the regression should still give the right average effect.

We will first focus on the discovery of a cow with BSE in the United Sates. The results from a regression using week-number fixed effects[12] as well as winter fixed effects are presented in Table 5. We use a weighted regression that incorporates the sample weights for each household from the consumer expenditure survey. The table reports the results for the entire United States, as well as Washington state (west) and the eastern states we use in the comparable regression for the scanner data. The geographic location of households was not available in earlier years of the Consumer Expenditure Survey, and hence our sample decreases from 14 to 11 periods when we limit the analysis to western/eastern states. Since there are only 200 households in each week in the entire United States, the sample frame is even smaller for the subset of states. Accordingly, the results are fairly erratic when we look at subregions, as purchases by a single household in a given week get picked up as abnormal changes. But even for the entire United States there is no reduction in beef expenditures, the coefficients are all close to zero in magnitude and statistically insignificant. The smoothed abnormal change in average weekly log expenditures for all households in the U.S. are shown in the left column of Figure 4. Again, there is no noticeable drop.

[12]Recall that we set week 1 to be the first week past Christmas, December 26th - January 1st.

There are several possible explanations why the scanner data set gives us consistent reduction in sales of a fairly large magnitude while the consumer expenditure data do not. We will address each one of them in turn. First, the scanner data set included store-by-year-by-UPC fixed effects, hence forcing the identification to come from variation in sales for a given UPC code in a given period and store. On the other hand, the consumer expenditure survey lumps all beef purchases together as we do not have detailed sub-categories of various beef products. As a cross-check we rerun the scanner data analysis using only year fixed effects instead of store-by-year-by-UPC fixed effects in columns (3) and (4) of Table 2 and an analysis where we aggregate all beef purchases in a store and week in columns (5) and (6) of Table 2. Yet, these revised regressions still give us a significant drop in beef sales even if we omit the UPC information, which suggests that differences in results between the two data sets are not due to differences in how aggregated the data are reported.

Second, the consumer expenditure survey is designed to be representative of the entire population, while the scanner data is from one of the largest grocery store chains in the United States. It is hence possible that the scanner data is either not representative of the entire population or that we have a selection effect. The latter could arise if the mad-cow outbreak leads consumers to switch to higher-end stores that supposedly sell better-quality beef. Both effects could explain in principle why one observes a significant drop in beef sales in a particular store, but not for the overall population. There are, however, several factors that speak against this theory. Our results barely change when we included socio-economic characteristics, suggesting that they are not particularly sensitive to the chosen socio-economic subgroup. The authors visited the relevant stores in Washington DC, some of which are in very affluent neighborhoods like Georgetown, while others are in low-income areas with vastly different customers, yet we get similar results for each store. Moreover, in many rural areas there is a very limited number of high-end stores that would count as viable higher-quality substitutes, yet again, our results remain robust. It is harder to argue that there is any significant substitution effect to high-end stores in these areas as alternatives are simply not available. It hence appears unlikely that the data are not representative or there is a selection effect large enough to explain the entire discrepancy in the results between the two data sets. Moreover, in the next subsection we show that the cattle futures market, which supposedly measures the overall effect, had similar abnormal returns as the scanner data set.

Third, it is possible that the sample frame of the consumer expenditure survey with 200 households from all over the U.S. is simply to narrow to pick up changes, especially since it is a revolving cross-section where households stay in the survey for only two weeks. This concern is amplified by the observation that week-number fixed effects are much larger in magnitude and more significant in the scanner data than in the consumer expenditure survey, i.e., the former is better at picking up seasonal effects than the later even though the former only consist of 4 years, while we obtained 14 years of data for the latter. The revolving cross-section of only 200 households with vastly different composition (single household versus family with multiple kids) makes it difficult to obtain a concise picture.

Finally, the longer sample size of the consumer expenditure survey also makes it possible to examine the effects following the Oprah-Winfrey show addressing the potential health effects of mad cow diseases in April 1996.[13] The smoothed abnormal daily changes are displayed in the right column of Figure 4. Again, there are no significant changes in expenditures, but given the proceeding discussion, this might simply be a consequence of the limited sample frame. We therefore turn to another data source: cattle futures. In an efficient market, futures prices should give an accurate forecast of changes in cattle prices, which are directly tied to changes in demand.

Cattle Futures Responses

Figure 5 display the abnormal changes in live cattle futures prices following the first reported mad cow outbreak in the US (left column) as well as corresponding changes following the Oprah-Winfrey report (right column). We construct the event windows around these two days (i.e., the event is called day 0, negative x-values are the number of days preceding the event, positive x-values are the number of days following the event). The y-values are changes in futures prices compared to the last trading day preceding the event day.[14] Rows one through three report changes in futures prices with a maturity of two, four, and six months after the event day.

The drop in futures price with the shortest maturity (two months) is comparable in size to the reduction in log sales. Note that the units are slightly different, as our regression results are based on a semi-log model, and hence a coefficient of -0.25 implies a reduction of $1 - e^{-0.25}$ = -22%, yet the futures return are already reported as relative changes. The maximum drop in futures prices after the Christmas holidays is almost 20%, close to drops we observe in the smoothed daily returns in Figure 2, and slightly below the ones from the

[13]Unfortunately we were not able to obtain scanner data dating back as far.

[14]We corrected for changes in the risk-less interest rate by using the London Interbank Offered Rate (LIBOR) as well as cash prices, where applicable. However, there were no significant interest rate movements that coincided with our event window, so these effects are very small and negligible.

weekly regression results in Table 2.

Prices revert to pre-event levels over time as the dust settles. New precautionary systems were put in place, e.g., the Department of Agriculture introduced a new meat tracking system. Furthermore, no additional cases of mad cow diseases were found over the following weeks, which seems to have appeased both consumers and, accordingly, financial markets. Yet, the rate of recovery is much slower than the immediate sudden drop following the announcement. An interesting side effect is that the market seems to have correctly anticipated this eventual recovery, as the abnormal return of futures with a longer maturity are lower.

Since futures prices are available for a longer time period than our scanner data set, we can compare the response following the Oprah-Winfrey show (right column of Figure 5) that warned about the potential health effects with the wide-spread reporting of the media following the actual outbreak. The hypothetical warning in the Oprah-Winfrey show lead to an initial reduction of more than half the size of the one following the actual outbreak, yet this effect vanishes faster as futures prices recovered quicker.[15] As Foster and Just (1989) have pointed out, exaggerating the potential threat level can lead to welfare losses as consumer restrict their purchasing decisions.

6 Conclusions

We estimate the change in consumer buying habits following the first reported case of mad-cow disease in the United States in December 2003. We find statistically significant drops for various states and socio-economic subgroups using a unique UPC-level scanner data set we obtained from one of the largest grocery chains. Higher mean income in the zip code a store is located resulted in additional reduction in sales, as did a higher fraction of minority groups, but the latter is not always statistically significant. The overall effects of these socio-economic characteristics is very small compared to the average consumer response. While the effects are initially large and significant, they vanish slowly over the next three months. There was no permanent shift in consumer buying habits.

We replicate a similar analysis using the diary files of the Consumer Expenditure Survey, a data set compiled specifically to examine consumer purchasing decisions. The survey is a repeated cross-section, where each week about 100 representative households enter the survey

[15]Unfortunately, we don't have a control group to disentangle whether prices recovered due to other abnormal shocks that fell within our event window. However, the media coverage continuing for several more weeks after the actual outbreak as evident as in Lexis-Nexis article counts. It hence appears plausible to assume that it indeed took longer for consumers to revert to pre-existing buying habits.

and remain in it for two consecutive weeks. This makes it harder to detect changes following a particular event as the sample size is too small and the population changes frequently. The discrepancy in results between our novel scanner data set and the Consumer Expenditure Survey has important policy implications, as other studies using the consumer expenditure survey have sometimes found limited effects of food scares, which might in part be due to the survey design.

Finally, we also replicate the analysis using futures prices for live cattle and find that market responses where of similar magnitude as our estimates from the scanner data. Surprisingly to us, a report about the potential danger of mad cow diseases seven years earlier on a single afternoon TV-show, the Oprah-Winfrey show, resulted in future price drops of more than 50% of the drop we observed after the actual outbreak. However, the continued media coverage after the actual outbreak in 2003 implied that it took longer for prices to return to pre-existing levels. Receiving coverage in one of America's most watched afternoon television programs hence can impact markets in a sizable way compared to government warnings combined with continued general news coverage.

References

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan, "How Much Should We Trust Differences-in-Differences Estimates?," *Quarterly Journal of Economics*, February 2004, *119* (1), 249–275.

Binder, John J., "The Event Study Methodology Since 1969," *Review of Quantitative Finance and Accounting*, September 1998, *11* (2), 111–137.

Borenstein, Severin and Martin B. Zimmerman, "Market Incentives for Safe Commercial Airline Operation," *American Economic Review*, December 1988, *78* (5), 913–935.

Broder, Ivy E., "The cost of accidental death: A capital market approach," *Journal of Risk and Uncertainty*, March 1990, *3* (1), 51 – 63.

___ **and John F. Morrall III**, "Incentives for firms to provide safety: Regulatory authority and capital market reactions," *Journal of Regulatory Economics*, December 1991, *3* (4), 309–322.

Brown, Deborah J. and Lee F. Schrader, "Cholesterol Information and Shell Egg Consumption," *American Journal of Agricultural Economics*, August 1990, *72* (3), 548–555.

Burton, Micheal and Trevor Young, "The impact of BSE on the demand for beef and other meats in Great Britain," *Applied Economics*, June 1996, *28* (6), 687–693.

___ **, Richard Dorsett, and Trevor Young**, "Changing preferences for meat: Evidence from UK household data, 197393," *European Review of Agricultural Economics*, 1996, *23* (3), 357–370.

Caswell, Julie A., "How Labeling of Safety and Process Attributes Affects Markets for Food," *Agricultural and Resource Economics Review*, 1998, *27* (2), 151–158.

___ **, Tanya Roberts, and C.T. Jordan Lin**, "Opportunities to Market Food Safety," in Lyle P. Schertz and Lynn M. Daft, eds., *Food and agricultural markets: the quiet revolution*, Economic Research Service, U.S. Department of Agriculture: Food and Agriculture Committee Washington, DC 1994, p. 326. Business HD9005 .F648 1994.

Chalk, Andrew J., "Market Forces and Commercial Aircraft Safety," *The Journal of Industrial Economics*, September 1987, *36* (1), 61–81.

Chavas, Jean-Paul, "Structural Change in the Demand for Meat," *American Journal of Agricultural Economics*, February 1983, *65* (1), 148–153.

Crowley, Christian S. L. and Yoshiaki Shimazaki, "Measuring the Impact of a BSE Announcement on U.S. Retail Beef Sales: A Time-Series Analysis," *Journal of Agribusiness*, Spring 2005, *23* (1).

Dimson, Elroy and Paul Marsh, "Event study methodologies and the size effect : The case of UK press recommendations," *Journal of Financial Economics*, September 1986, *17* (1), 113–142.

Fama, Eugene F., Lawrence Fisher, Michael C. Jensen, and Richard Roll, "The Adjustment of Stock Prices to New Information," *International Economic Review*, February 1969, *10* (1), 1–21.

Foster, William and Richard E. Just, "Measuring welfare effects of product contamination with consumer uncertainty," *Journal of Environmental Economics and Management*, November 1989, *17* (3), 266–283.

Henson, Spencer and James Northen, "Economic Determinants of Food Safety Controls in Supply of Retailer Own-Branded Products in United Kingdom," *Agribusiness*, March/April 1998, *14* (2), 113–126.

Lusk, Jayson L. and Ted C. Schroeder, "Effects of Meat Recalls on Futures Market Prices," *Agricultural and Resource Economics Review*, April 2002, *31* (1), 47–58.

MacKinlay, A. Craig, "Event Studies in Economics and Finance," *Journal of Economic Literature*, March 1997, *35* (1), 13–39.

Maloney, Michael T. and Robert E. McCormick, "A Positive Theory of Environmental Quality Regulation," *Journal of Law and Economics*, April 1982, *25* (1), 99–123.

Mitchell, Mark L., "The Impact of External Parties on Brand-Name Capital: The 1982 Tylenol Poisonings and Subsequent Cases," *Economic Inquiry*, October 1989, *27* (4), 601–618.

Moschini, Giancarlo and Karl D. Meilke, "Modeling the Pattern of Structural Change in U.S. Meat Demand," *American Journal of Agricultural Economics*, May 1989, *72* (2), 253–261.

Rausser, Gordon C. and Nicholas A. Walraven, "Linkages Among Commodity Futures Markets and Dynamic Welfare Analysis," *Review of Economics and Statistics*, November 1990, *72* (4), 631–639.

Shimshack, Jay, Michael B. Ward, and Timothy K.M. Beatty, "Mercury Advisories: Information, Education, and Fish Consumption," *mimeo*, 2006.

Smith, Mark E., Eileen O. van Ravenswaay, and Stanley R. Thompson, "Sales Loss Determination in Food Contamination Incidents: An Application to Milk Bans in Hawaii," *American Journal of Agricultural Economics*, August 1988, *70* (3), 513–520.

van Ravenswaay, Eileen O. and John P. Hoehn, "The Impact of Health Risk Information on Food Demand: A Case Study of Alar and Apples," in Julie A. Caswell, ed., *Economics of food safety*, Elsevier New York, NY 1991, p. 356. Bioscience TP373.5.E26 1991.

Yen, Steven T., Helen H. Jensen, and Qingbin Wang, "Cholesterol information and egg consumption in the US: A nonnormal and heteroscedastic double-hurdle model," *European Review of Agricultural Economics*, 1996, *23* (3), 343–356.

Table 1: Descriptive Statistics

	Obs.	Mean	Min	Max	Std.
Scanner Data Set - Mad Cow Outbreak					
Log Beef Sales	5,801,763	3.11	-4.61	9.42	1.08
Log Chicken Sales	2,279,464	2.93	-3.91	8.40	1.12
Log Turkey Sales	1,103,370	2.50	-4.61	7.92	1.04
Log Pork Sales	2,965,034	2.68	-4.61	8.30	0.928
Log Lamb Sales	417,309	2.23	-3.51	6.91	0.939
Periods	4	(2001-2004)			
Days Per Period	126				
Stores	298				
Socio-economic Data For Zip-Code from Census					
Income in $10,000	298	56.5	21.1	154.8	20.8
Percent Black or Hispanic	298	18.9	1.1	98.4	21.2
Consumer Expenditure Survey - Mad Cow Outbreak					
Log Beef Sales	33,393	1.84	-1.61	6.04	0.758
Log Poultry Sales	26,843	1.70	-2.04	6.40	0.671
Log Pork Sales	30,219	1.63	-1.83	5.88	0.793
Periods	14	(1990-2003)			
Days Per Period	126				
Households	27276				
Consumer Expenditure Survey - Oprah Winfrey Show					
Log Beef Sales	32,294	1.86	-3.22	6.72	0.762
Log Poultry Sales	25,017	1.68	-2.04	5.07	0.646
Log Pork Sales	27,707	1.63	-2.30	5.93	0.770
Periods	15	(1990-2004)			
Days Per Period	126				
Households	24899				

Notes: Table displays descriptive statistics for various data sources. The first discovery of a mad cow case occurred on December 23, 2003, while the report by Oprah Winfrey aired on April 16, 1996. Each time the event window spans five weeks prior to the event to thirteen weeks past the event.

Table 2: Abnormal Changes in Log Beef Expenditures Following Publication of Mad Cow Case on December 23, 2003 Using Scanner Data

	(1) West	(2) East	(3) West	(4) East	(5) West	(6) East
Dec 26 - Jan 1	-0.255	-0.302	-0.212	-0.222	-0.3617	-0.2936
	(23.80)**	(20.63)**	(13.03)**	(11.54)**	(28.87)**	(19.08)**
Jan 2 - Jan 8	-0.160	-0.241	-0.128	-0.163	-0.262	-0.2235
	(15.95)**	(19.59)**	(7.89)**	(8.44)**	(20.92)**	(14.52)**
Jan 9 - Jan 15	-0.174	-0.152	-0.111	-0.082	-0.246	-0.1623
	(18.66)**	(13.89)**	(6.81)**	(4.22)**	(19.64)**	(10.57)**
Jan 16 - Jan 22	-0.150	-0.308	-0.105	-0.262	-0.2343	-0.301
	(16.35)**	(22.67)**	(6.49)**	(13.57)**	(18.71)**	(19.60)**
Jan 23 - Jan 29	-0.169	-0.051	-0.171	-0.049	-0.1746	-0.045
	(18.02)**	(4.49)**	(10.54)**	(2.54)*	(13.94)**	(2.93)**
Jan 30 - Feb 5	-0.175	-0.240	-0.164	-0.201	-0.1148	-0.2785
	(19.57)**	(18.30)**	(10.25)**	(10.49)**	(9.17)**	(18.14)**
Feb 6 - Feb 12	-0.069	-0.228	-0.043	-0.146	-0.1144	-0.2246
	(7.33)**	(18.67)**	(2.67)**	(7.68)**	(9.14)**	(14.63)**
Feb 13 - Feb 19	-0.146	-0.137	-0.114	-0.061	-0.1798	-0.0171
	(17.36)**	(11.15)**	(7.11)**	(3.21)**	(14.36)**	(1.11)
Feb 20 - Feb 26	-0.126	-0.268	-0.092	-0.181	-0.1264	-0.2208
	(14.22)**	(24.77)**	(5.67)**	(9.41)**	(10.10)**	(14.38)**
Feb 27 - Mar 4	-0.083	-0.173	-0.035	-0.090	-0.0278	-0.2763
	(9.16)**	(16.13)**	(2.18)*	(4.71)**	(2.22)*	(18.00)**
Mar 5 - Mar 11	-0.037	-0.107	0.018	-0.049	0.0064	-0.0514
	(3.97)**	(9.00)**	(1.14)	(2.54)*	(0.51)	(3.35)**
Mar 12 - Mar 18	-0.094	-0.127	-0.034	-0.041	-0.0743	-0.1473
	(9.01)**	(11.64)**	(2.08)*	(2.14)*	(5.94)**	(9.60)**
Mar 19 - Mar 25	-0.051	-0.115	-0.061	-0.026	-0.1494	-0.0761
	(5.13)**	(10.23)**	(3.76)**	(1.33)	(11.94)**	(4.96)**
Observations	807172	549063	807172	549063	11736	9183
R-squared	0.007	0.011	0.001	0.002	0.414	0.341
Store By Year By UPC FE	Yes	Yes	No	No	No	No
Store By Year FE	No	No	No	No	Yes	Yes
Year FE	No	No	Yes	Yes	No	No
Number of FE	76380	47936	21	21	672	531

Notes: Table displays abnormal weekly changes in log beef consumption net of week number fixed effects. Columns (1) and (2) use store-by-UPC-by-winter fixed effects, while columns (3) and (4) use winter fixed effects. Columns (5) and (6) aggregate all beef purchases in a store.

Table 3: Abnormal Changes in Log Beef Expenditures Following Publication of Mad Cow Case on December 23, 2003 Using Scanner Data

	(1) West	(2) East	(3) West	(4) East	(5) West	(6) East
Dec 26 - Jan 1	-0.294	-0.279	-0.239	-0.293	-0.278	-0.271
	(23.17)**	(17.78)**	(22.29)**	(19.93)**	(22.00)**	(17.18)**
Jan 2 - Jan 8	-0.199	-0.218	-0.146	-0.232	-0.185	-0.209
	(16.38)**	(16.15)**	(14.42)**	(18.66)**	(15.24)**	(15.41)**
Jan 9 - Jan 15	-0.213	-0.129	-0.159	-0.143	-0.199	-0.121
	(18.26)**	(10.39)**	(16.93)**	(12.83)**	(17.01)**	(9.60)**
Jan 16 - Jan 22	-0.189	-0.285	-0.136	-0.300	-0.175	-0.277
	(16.00)**	(19.62)**	(14.56)**	(21.73)**	(14.71)**	(18.87)**
Jan 23 - Jan 29	-0.200	-0.046	-0.169	-0.050	-0.201	-0.045
	(18.03)**	(3.66)**	(18.15)**	(4.31)**	(18.04)**	(3.53)**
Jan 30 - Feb 5	-0.208	-0.236	-0.176	-0.239	-0.209	-0.235
	(18.81)**	(16.61)**	(19.38)**	(18.02)**	(18.63)**	(16.39)**
Feb 6 - Feb 12	-0.101	-0.223	-0.070	-0.227	-0.102	-0.222
	(8.96)**	(16.90)**	(7.44)**	(18.27)**	(9.00)**	(16.59)**
Feb 13 - Feb 19	-0.179	-0.132	-0.148	-0.136	-0.180	-0.131
	(17.33)**	(10.02)**	(17.23)**	(10.91)**	(17.18)**	(9.82)**
Feb 20 - Feb 26	-0.127	-0.268	-0.127	-0.268	-0.127	-0.268
	(14.08)**	(24.82)**	(14.24)**	(24.77)**	(14.10)**	(24.82)**
Feb 27 - Mar 4	-0.084	-0.173	-0.084	-0.173	-0.084	-0.173
	(9.03)**	(16.08)**	(9.20)**	(16.15)**	(9.07)**	(16.10)**
Mar 5 - Mar 11	-0.038	-0.107	-0.037	-0.107	-0.038	-0.107
	(3.98)**	(9.05)**	(4.00)**	(9.00)**	(4.00)**	(9.05)**
Mar 12 - Mar 18	-0.094	-0.127	-0.094	-0.127	-0.094	-0.127
	(9.01)**	(11.60)**	(9.03)**	(11.65)**	(9.03)**	(11.61)**
Mar 19 - Mar 25	-0.054	-0.115	-0.051	-0.115	-0.054	-0.115
	(5.40)**	(10.20)**	(5.12)**	(10.23)**	(5.39)**	(10.19)**
Income x Dec 26 - Jan 22	-0.019	-0.009			-0.019	-0.009
	(4.83)**	(2.89)**			(4.83)**	(2.87)**
Income x Jan 23 - Feb 19	-0.018	-0.003			-0.018	-0.002
	(4.91)**	(0.97)			(4.91)**	(0.96)
Minority x Dec 26 - Jan 22	-0.002	-0.001			-0.002	-0.001
	(4.73)**	(3.91)**			(4.79)**	(3.88)**
Minority x Jan 23 - Feb 19	-0.002	0.000			-0.002	0.000
	(3.80)**	(0.61)			(3.71)**	(0.59)
Bone x Dec 26 - Jan 22			-0.227	-0.079	-0.225	-0.079
			(13.39)**	(4.27)**	(13.08)**	(4.23)**
Bone x Jan 23 - Feb 19			0.053	-0.033	0.052	-0.033
			(2.81)**	(1.77)	(2.77)**	(1.77)
Boneless x Dec 26 - Jan 22			0.144	-0.024	0.149	-0.024
			(6.55)**	(1.21)	(6.72)**	(1.21)
Boneless x Jan 23 - Feb 19			-0.126	0.031	-0.128	0.031
			(5.42)**	(1.57)	(5.44)**	(1.57)
Observations	788177	549063	807172	549063	788177	549063
R-squared	0.007	0.011	0.007	0.011	0.007	0.011
Number of FE	74541	47936	76363	47936	74524	47919

Notes: Table displays abnormal weekly changes in log beef consumption net of week number fixed effects. All columns use store-by-UPC-by-winter fixed effects but include other controls. Income is the per-capita income of the zip code in which the store is located (in $10,000), minority measures the percentage points of the population in the zip code that is either Black or Hispanic, the dummies bone/boneless are one if the UPC description included the word ”Bone” or ”Boneless”.

Table 4: Abnormal Changes in Log Expenditures of Other Meats Following Publication of Mad Cow Case on December 23, 2003 Using Scanner Data

	Lamb		**Pork**		**Chicken**		**Turkey**	
	West	**East**	**West**	**East**	**West**	**East**	**West**	**East**
Dec 26 - Jan 1	0.326	-0.016	0.166	0.010	0.224	-0.051	0.222	0.055
	(10.39)**	(0.55)	(13.75)**	(0.70)	(18.21)**	(3.09)**	(9.93)**	(2.97)**
Jan 2 - Jan 8	0.141	-0.016	0.227	0.006	0.220	-0.009	0.219	-0.014
	(4.71)**	(0.59)	(20.58)**	(0.42)	(20.50)**	(0.60)	(10.16)**	(0.79)
Jan 9 - Jan 15	0.001	0.075	0.234	0.104	0.143	0.099	0.297	0.181
	(0.03)	(2.86)**	(20.99)**	(7.38)**	(12.88)**	(6.69)**	(14.01)**	(11.06)**
Jan 16 - Jan 22	0.335	-0.039	0.113	-0.007	0.225	-0.075	0.195	-0.029
	(11.23)**	(1.43)	(10.41)**	(0.49)	(18.16)**	(4.82)**	(9.30)**	(1.63)
Jan 23 - Jan 29	0.242	0.023	0.070	0.064	0.140	0.181	0.286	0.237
	(8.00)**	(0.84)	(6.34)**	(4.60)**	(12.03)**	(13.10)**	(14.04)**	(14.39)**
Jan 30 - Feb 5	0.268	-0.120	0.011	-0.117	0.028	-0.143	0.197	0.118
	(9.57)**	(3.94)**	(1.02)	(6.94)**	(2.49)*	(8.49)**	(10.44)**	(6.63)**
Feb 6 - Feb 12	0.288	-0.053	0.075	-0.132	0.039	-0.182	0.131	0.003
	(9.45)**	(1.90)	(6.99)**	(7.57)**	(3.61)**	(12.80)**	(6.59)**	(0.15)
Feb 13 - Feb 19	0.322	-0.078	0.125	-0.134	-0.046	-0.072	0.182	-0.143
	(10.83)**	(2.96)**	(12.28)**	(10.53)**	(4.21)**	(5.01)**	(9.13)**	(8.64)**
Feb 20 - Feb 26	0.219	-0.052	0.086	-0.044	-0.007	-0.171	0.190	-0.135
	(7.25)**	(1.99)*	(7.66)**	(2.79)**	(0.62)	(11.25)**	(9.32)**	(7.35)**
Feb 27 - Mar 4	0.079	-0.104	0.031	0.007	0.024	-0.081	0.042	-0.090
	(2.59)**	(3.94)**	(2.67)**	(0.53)	(2.19)*	(6.17)**	(1.89)	(4.97)**
Mar 5 - Mar 11	0.133	-0.032	0.058	0.005	0.094	-0.042	0.101	0.023
	(4.61)**	(1.12)	(5.39)**	(0.36)	(8.62)**	(3.17)**	(5.00)**	(1.33)
Mar 12 - Mar 18	0.173	-0.056	0.063	0.013	0.129	0.079	0.105	0.063
	(5.59)**	(2.14)*	(5.90)**	(0.94)	(11.90)**	(5.24)**	(5.11)**	(3.69)**
Mar 19 - Mar 25	0.091	-0.435	0.148	0.025	0.192	0.026	0.115	0.040
	(2.88)**	(13.35)**	(12.45)**	(1.84)	(17.02)**	(1.86)	(5.33)**	(2.04)*
Observations	68690	77625	452967	323443	288243	241739	149497	159942
R-squared	0.015	0.018	0.022	0.013	0.034	0.026	0.067	0.074
Number of FE	10357	9787	44265	31790	22638	20022	19555	15635

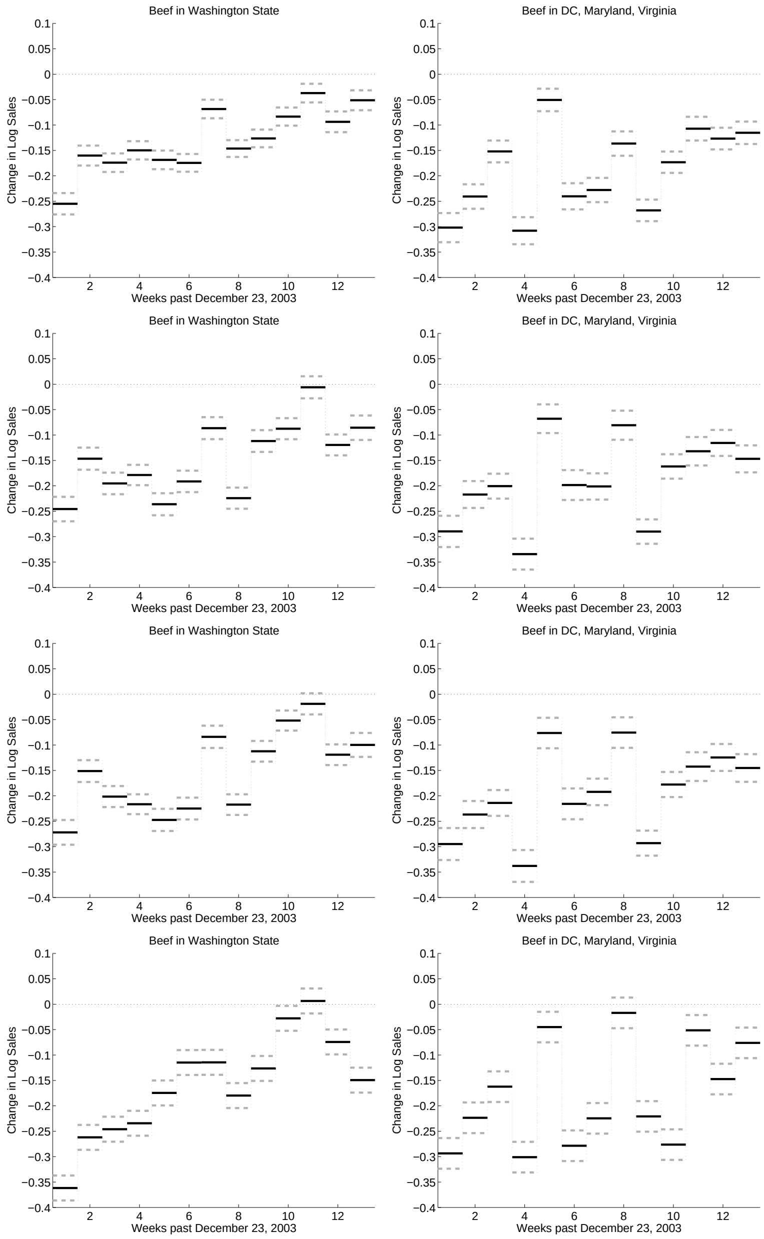
Notes: Table displays abnormal weekly changes in log meat consumption net of week number and store-by-UPC-by-winter fixed effects.

Table 5: Abnormal Changes in Log Expenditures Following Publication of Mad Cow Case on December 23, 2003 Using Data from Consumer Expenditure Survey

	Beef			Pork			Poultry		
	US	**West**	**East**	**US**	**West**	**East**	**US**	**West**	**East**
Dec 26 - Jan 1	0.095	0.478	1.060	-0.063	-1.027	-1.257	0.096	0.000	0.059
	(0.78)	(0.51)	(1.62)	(0.54)	(1.07)	(1.55)	(0.91)	(.)	(0.12)
Jan 2 - Jan 8	-0.038	0.246	1.010	0.005	0.591	0.259	0.098	0.036	-0.118
	(0.36)	(0.36)	(1.55)	(0.05)	(0.54)	(0.32)	(0.98)	(0.05)	(0.23)
Jan 9 - Jan 15	0.108	-0.096	1.280	-0.047	-0.980	-0.609	-0.003	0.666	0.073
	(1.04)	(0.14)	(2.11)*	(0.43)	(0.89)	(0.93)	(0.03)	(1.00)	(0.16)
Jan 16 - Jan 22	0.032	0.295	0.156	-0.054	-1.227	-0.605	0.098	0.131	-0.147
	(0.30)	(0.39)	(0.21)	(0.48)	(1.36)	(0.81)	(1.02)	(0.21)	(0.31)
Jan 23 - Jan 29	0.079	0.000	0.467	-0.204	0.000	-0.623	0.165	0.000	0.429
	(0.71)	(.)	(0.80)	(1.74)	(.)	(0.88)	(1.57)	(.)	(0.95)
Jan 30 - Feb 5	0.044	0.636	0.998	-0.118	-1.266	-0.010	0.083	-0.034	0.189
	(0.41)	(0.69)	(1.87)	(1.04)	(1.40)	(0.02)	(0.82)	(0.04)	(0.44)
Feb 6 - Feb 12	0.058	-0.492	0.839	-0.040	0.000	-0.130	0.123	-0.655	-0.023
	(0.54)	(0.65)	(1.28)	(0.35)	(.)	(0.20)	(1.24)	(0.82)	(0.05)
Feb 13 - Feb 19	-0.059	-0.304	0.274	0.043	-1.026	-0.275	0.001	-0.302	0.000
	(0.55)	(0.33)	(0.49)	(0.37)	(1.06)	(0.37)	(0.01)	(0.49)	(.)
Feb 20 - Feb 26	0.240	0.364	0.377	-0.025	0.149	0.168	0.197	-0.287	-0.052
	(2.29)*	(0.53)	(0.58)	(0.23)	(0.16)	(0.21)	(2.00)*	(0.47)	(0.11)
Feb 27 - Mar 4	0.081	-0.824	1.027	-0.061	-1.479	-0.023	0.133	-0.784	-0.108
	(0.78)	(1.21)	(1.78)	(0.54)	(1.63)	(0.03)	(1.32)	(1.27)	(0.26)
Mar 5 - Mar 11	0.049	-0.167	0.770	-0.066	-0.715	-0.505	0.040	0.064	-0.419
	(0.47)	(0.22)	(1.27)	(0.59)	(0.75)	(0.77)	(0.41)	(0.10)	(0.81)
Mar 12 - Mar 18	0.093	0.000	0.471	-0.019	-0.741	0.134	0.118	0.000	0.107
	(0.90)	(.)	(0.86)	(0.16)	(0.77)	(0.20)	(1.15)	(.)	(0.21)
Mar 19 - Mar 25	-0.045	0.494	1.123	-0.010	-1.003	-0.565	0.143	0.273	0.301
	(0.41)	(0.53)	(1.84)	(0.09)	(0.90)	(0.87)	(1.37)	(0.41)	(0.67)
Nov 28 - Dec 4	0.128	-0.218	1.378	0.005	-1.058	-0.395	0.232	-0.627	-0.369
	(1.24)	(0.29)	(2.66)**	(0.04)	(1.11)	(0.62)	(2.23)*	(0.95)	(0.86)
Dec 5 - Dec 11	-0.052	-0.240	0.672	-0.070	-0.972	-0.651	0.129	-0.263	-0.041
	(0.49)	(0.32)	(1.10)	(0.61)	(1.13)	(0.95)	(1.27)	(0.40)	(0.10)
Dec 12 - Dec 18	0.202	-0.544	1.580	0.019	-0.504	-0.927	0.058	-0.001	0.449
	(1.92)	(0.72)	(2.60)**	(0.18)	(0.52)	(1.32)	(0.60)	(0.00)	(1.00)
Dec 19 - Dec 25	0.180	-1.174	0.939	-0.052	0.000	-0.693	0.015	0.210	0.655
	(1.71)	(1.27)	(1.43)	(0.49)	(.)	(1.04)	(0.15)	(0.26)	(1.45)
Observations	36171	568	1104	32729	518	1065	30188	486	1073
R-squared	0.003	0.071	0.040	0.010	0.076	0.039	0.015	0.094	0.055
Years in Sample	14	11	11	14	11	11	14	11	11

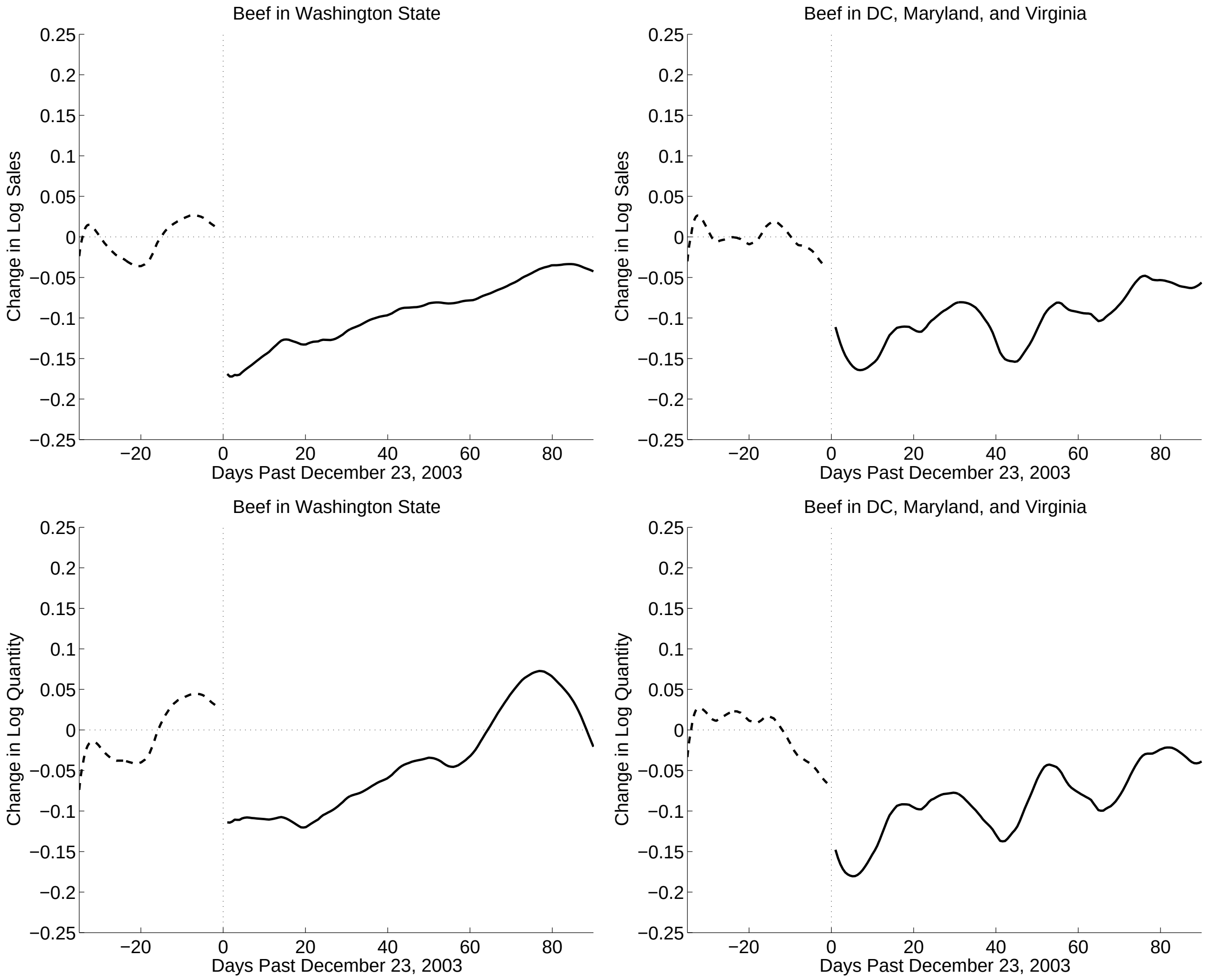
Notes: Table displays abnormal weekly changes in log meat consumption net of week number and winter fixed effects.

Figure 1: Robustness of Changes in Beef Expenditures to Various Weekly Aggregation Measures. (First Reported Mad Cow Case using Scanner Data)



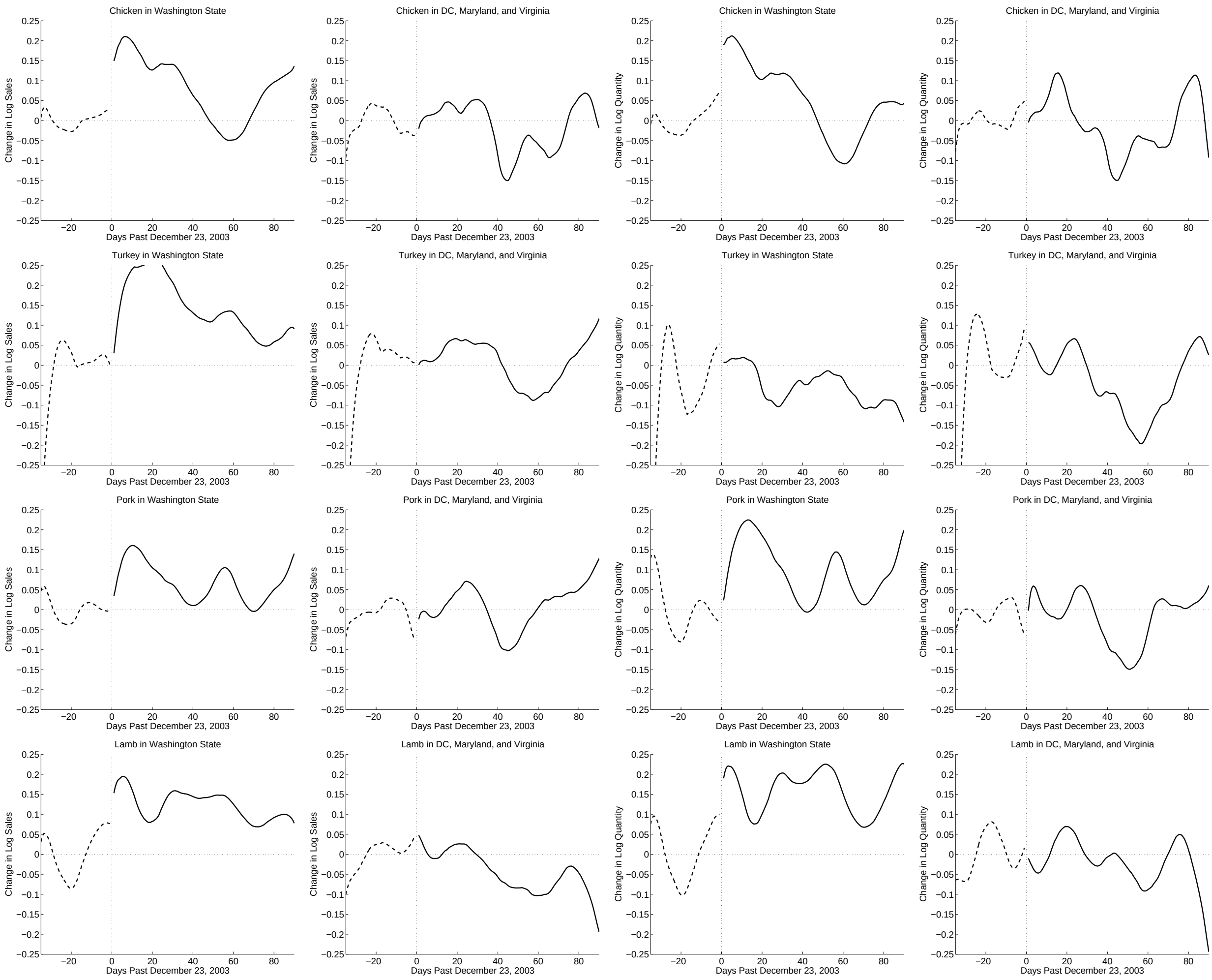
Notes: All panels reports the weekly changes following the first publication of an infected cow in the United States. The left column uses stores in Washington State, while the right column uses stores in DC, Maryland, and Virginia. The top row uses year-by-store-by-UPC fixed effects. The second row aggregates UPC on a subsubclass level and uses year-by-store-by-subsubclass fixed effects. The third row uses the same aggregation as the second, but limits the analysis to subsubclasses that sell on average at least 100 dollars per week and store. The forth row aggregates all beef sales and uses year-by-store fixed effects.

Figure 2: Changes in Beef Expenditures / Consumption Following First Reported Mad Cow Case using Scanner Data



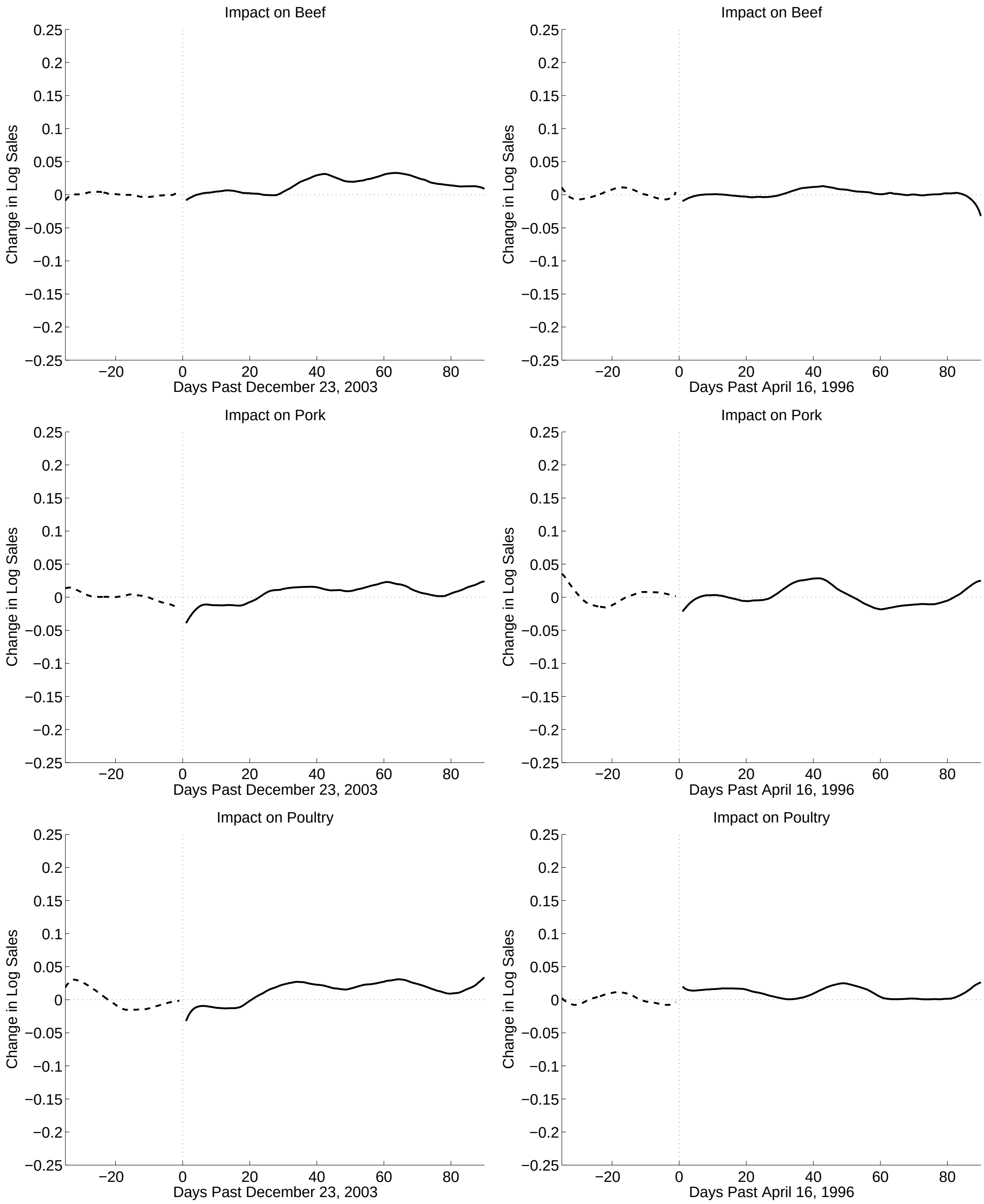
Notes: The top row displays abnormal changes in log beef consumption over time, while the bottom row displays abnormal changes in the log of the quantity consumed. The left column use sales from all beef-related UPC codes for stores in Washington state, while the right column uses sales is Maryland, Virginia, and the District of Columbia. Day 0 is December 23, 2003, when the first case of a mad cow outbreak in the United States was made public. Abnormal changes are net of year-by-store-by-UPC, day-number, and weekday fixed effects.

Figure 3: Changes in Expenditures / Consumption of Other Meats Following First Reported Mad Cow Case using Scanner Data



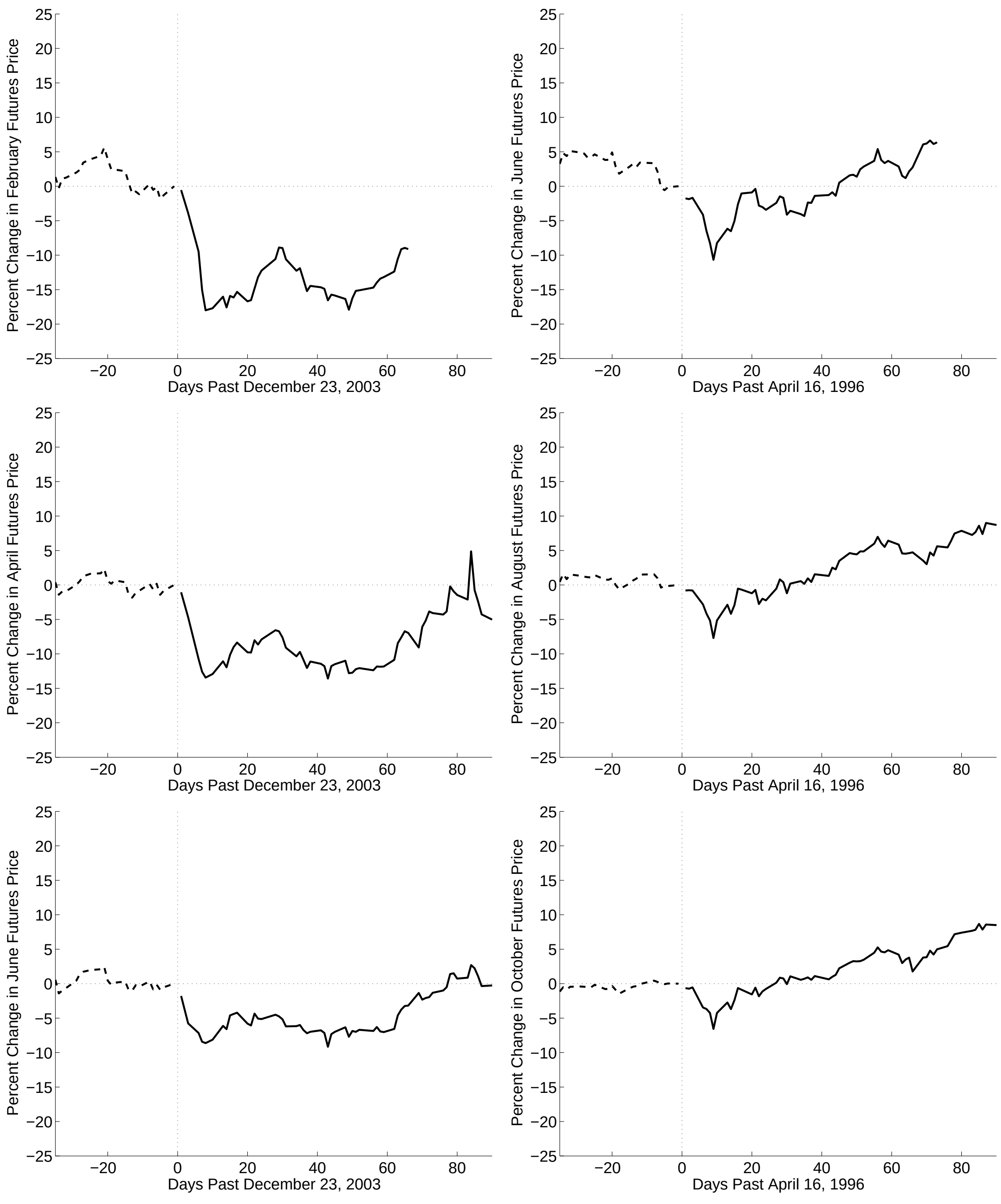
Notes: Rows display Chicken, Turkey, Pork, and Lamb sales, respectively. In each row, the first two columns display abnormal changes in log consumption over time, while the last two columns display abnormal changes in the log of the quantity consumed. The first and third column use sales from all UPC codes for stores in Washington state, while the second and fourth column uses sales is Maryland, Virginia, and the District of Columbia. Day 0 is December 23, 2003, when the first case of a mad cow outbreak in the United States was made public. Abnormal changes are net of year-by-store-by-UPC, day-number, and weekday fixed effects.

Figure 4: Changes in Expenditures using Consumer Expenditure Survey



Notes: Rows display Beef, Pork, and Poultry expenditures, respectively. The left column uses the first publication of the first discovery of a mad cow case as day 0 (December 23, 2003), while the second column uses the report by Oprah Winfrey (April 16, 1996).

Figure 5: Changes in Cattle Futures Prices



Notes: Rows display futures prices of Iowa cattle with maturities in two, four, and six months, respectively. The left column uses the first publication of the first discovery of a mad cow case as day 0 (December 23, 2003), while the second column uses the report by Oprah Winfrey (April 16, 1996). Abnormal changes are net of year fixed effects. Futures with a maturity of roughly two months (top row) expire before the end of the 90-day window and hence only a partial time series is displayed.