The Impact of North American BSE Events on Live Cattle Futures Prices

Yanhong H. Jin, Gabriel J. Power, and Levan Elbakidze

Outbreaks of animal disease such as Bovine Spongiform Encephalopathy (BSE) can have substantial adverse consequences for consumers, producers, international trade, and financial markets. The December 2003 discovery of a BSE-infected cow in Washington State, for instance, sharply reduced beef sales for a period of three months (Schlenker and Villas-Boas 2008). Even if the domestic demand for beef is not substantially affected by North American BSE events, prices and revenues fall as a result of strong reactions by foreign governments (Marsh, Brester, and Smith 2008). As of April 2008, three cases of BSE have been identified in the United States and thirteen in Canada (CDC 2008; CFIA 2008).[1]

In this article, we investigate the effects of all sixteen North American BSE cases on daily live cattle futures prices of six maturities. Our objective is to examine (*a*) whether any of these sixteen BSE cases may have caused a structural break in live cattle futures prices; and (*b*) the magnitude and persistence of the effect of BSE cases on futures prices and price volatility by BSE case origin, chronology, and contract maturity month.

We find that the live cattle futures market experienced a structural break detected in October 2003. Several factors may have contributed to this structural break, including the 2003 Canadian BSE case followed by an immediate import ban by the United States on Canadian cattle and beef products; the partial lift of the import ban in August which allowed imports of boneless meat from cattle younger than thirty months; and speculation about further lifting the import ban on Canadian cattle between October and November (CBC 2003). The confirmation of the 2003 Canadian BSE case on May 20 caused an immediate drop in futures prices, but the latter started to rise the following day, and no persistent negative impact was found. The 2003 U.S. BSE case significantly decreased live cattle futures prices beyond an immediate price drop following the confirmation. The adverse impact was, however, different according to maturity. The effects were generally stronger and more persistent on the nearby futures. The adverse impacts were not permanent—they dissipated in approximately five months for the (nearby) December and February maturity futures prices and even sooner for other series. Both the 2003 Canadian and U.S. BSE cases increased price volatility, and the impact was stronger for nearby maturities than for more distant maturities.

This study contributes to the literature by examining all sixteen North American BSE cases, by using daily futures settlement prices to precisely identify the timing of the structural breaks and to assess the differentiated impact of BSE cases by contract maturity month, and by analyzing their impact on futures price volatility.

The Impact of Food Scares on Commodity Futures Prices: Previous Research

There is a rich literature on the impacts of food scares, including BSE events, on demand and price of meat products. Given our focus, we only discuss results from the literature on the impact of food scares on futures prices in commodity markets.

A number of papers have found that futures prices have only minor and seldom statistically significant reactions to health scares and food scare events other than BSE events. Futures prices do not appear to react much

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[1] U.S. BSE cases: December 23, 2003; May 24, 2004; and March 13, 2006 (CDC 2008). Canadian BSE cases: December 1, 1993; May 20, 2003; January 2 and 11, 2005; January 22, 2006; April 16, 2006, July 3 and 13, 2006; August 23, 2006; February 7, 2007; May 2, 2007; December 18, 2007; and February 26, 2008 (CFIA 2008).

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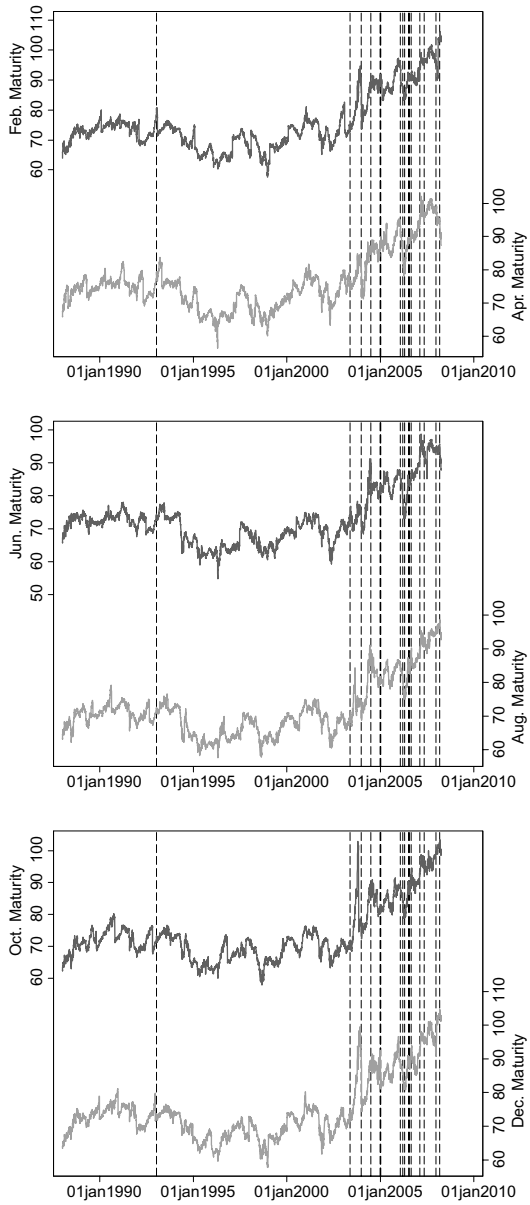
to pork or beef recalls (Lusk and Schroeder 2002), to recalls due to *E. coli* (McKenzie and Thomsen 2001), or to health-risk-related news like dietary cholesterol or heart disease related to the consumption of red meat (Robenstein and Thurman 1996). On the other hand, U.S. live cattle futures prices were found to be negatively affected by BSE cases in the UK (Paiva 2003) and by the 2003 U.S. BSE case (Schlenker and Villas-Boas 2008). As Tse and Hackard (2006) show, it appears that the market did not efficiently process the news of the 2003 Canadian and U.S. BSE discoveries and instead followed a pattern of a "herd behavior." It took several days for live cattle and feeder cattle futures prices to recover, as traders realized that the ban on Canadian cattle imports would increase demand for the U.S. beef.

Data and Variable Specification

We focus on futures contracts for live cattle, which are animals that are ready for slaughter and for which it is expected that news of a BSE case will have the strongest effect (e.g., Tse and Hackard 2006). Data on daily live cattle futures settlement prices from the Chicago Mercantile Exchange, over the time period of January 4, 1988, to April 1, 2008, are collected through DataStream, an electronic database system providing historical financial data. We construct a daily live cattle price series for each of the six monthly maturities (February, April, June, August, October, and December) by splicing together observations using the contracts that are closest to expiry for each maturity series. In the month of maturity, the price series for the contract expiring in that month switches to the following year's contract for that month's maturity. This approach allows us to evaluate the impact of BSE cases on the nearby maturity, such as the effect of the December 23, 2003, BSE case on December 2003 futures prices. There are 5,126 observations for each maturity series and a total of sixteen BSE cases that were confirmed in North America.

Figure 1 plots futures prices for all six maturity series from January 4, 1988, to April 1, 2008. Dashed vertical lines represent all sixteen North American BSE cases. Figure 1 suggests that futures prices with different maturities have a similar time trend in general. Our results presented below show that different maturities responded differently to BSE cases. Overall, futures prices decreased immediately following the confirmation of BSE cases. For example, the nearby maturity futures prices decreased by 2% for the 2003 Canadian BSE case and by 7% for the first U.S. case.



Note: The dashed vertical lines represent all sixteen North American BSE cases by April 2008.

Figure 1. Six futures price series maturing in February, April, June, August, October, and December (January 4, 1988 to April 1, 2008)

Diagnostic Testing

Many economic and financial time series are characterized by a unit root (Hendry and

Table 1. Unit Root Tests for Daily Cattle Futures Settlement Prices by Maturity

Data Series By Maturity	Dickey-Fuller Test	Augmented Dickey-Fuller Test	Phillips-Perron Test	Zivot-Andrews Test[a]	
		Level			
Feb.	−1.58	−1.59	−1.44	−4.59	6/20/03
April	−2.44	−2.45	−2.32	−4.86	2/5/04
June	−2.12	−2.13	−1.94	−4.62	2/5/04
Aug.	−1.77	−1.77	−1.65	−4.52	1/2/04
Oct.	−2.07	−2.07	−1.93	−5.09	6/20/03
Dec.	−1.50	−1.51	−1.61	−4.69	6/20/03
		First difference			
Feb.	−71.36*	−71.36*	−71.46*	−25.99*	
April	−71.67*	−71.67*	−71.80*	−27.27*	
June	−71.83*	−71.84*	−72.05*	−27.47*	
Aug.	−71.31*	−71.31*	−71.39*	−30.69*	
Oct.	−71.63*	−71.63*	−71.72*	−31.34*	
Dec.	−69.25*	−69.26*	−69.26*	−27.50*	

Notes: The asterisk (*) indicates that the null hypothesis is rejected at the 1% significance level. The critical value for Dickey-Fuller, Augmented Dickey-Fuller, and Phillips-Perron tests is −3.43 at the 1% significant level, while it is −5.43 for the Zivot-Andrews test.

[a]The results of the Zivot-Andrews tests of nonstationarity are reported here only for the case of assuming a possible structural break in the mean. However, the results are similar under the alternative assumptions of a structural break in trend or in both mean and trend.

Massmann 2007). Commonly used are the (Augmented) Dickey-Fuller (DF, ADF) and Phillips-Perron (PP) tests, which examine the null hypothesis of a unit root against the alternative of a constant deterministic trend. These tests are, however, biased in the presence of omitted structural breaks (Zivot and Andrews 1992), leading to forecast failure (Hendry and Massmann 2007). An alternative is the Zivot and Andrews (ZA) unit root test, which allows for one possible shift in mean, trend, or both.

As shown in table 1, the DF, ADF and PP tests as well as the ZA test that considers the possibility of a structural break all fail to reject the null hypothesis that the futures prices in level contain a unit root at the 5% level of significance for all the maturity series. The same tests are then applied to the first order differences of each series, whereby the unit root hypothesis is rejected at the 1% level of significance in all cases. Therefore, the evidence suggests that daily live cattle futures price series contain a unit root (i.e., they are nonstationary) in level but their first order differences are stationary. Lastly, as shown in table 1, the endogenously identified structural break using the ZA test for each price series is dated close to the dates of the BSE cases.

The results of unit root tests suggest using a Vector Error Correction Model (VECM) to jointly model all six maturities. Using the entire data series, we conclude that the optimal lag length is 2 based on the information matrices and further that the cointegration rank is 5 based on Johansen's (1995) trace test. To further characterize the cointegration space, we conduct exclusion tests to determine whether any of the data series do not belong to these five cointegration vectors. We also conduct weak exogeneity tests to find out whether each series responds to a perturbation in the long-run relationships. The tests suggest that all six series belong to the cointegration space, and each of them responds to a perturbation in the long-run relationships.

Empirical Results

We present empirical results pertaining to the following three questions: (*a*) Is there a structural change in the live cattle futures prices? If so, are any of the BSE cases and/or subsequent changes in trade policy partly responsible for the structural change? (*b*) How significant are the impacts of the BSE cases on live cattle futures prices, and how long do those impacts last? and (*c*) Do BSE discoveries affect the volatility of futures prices?

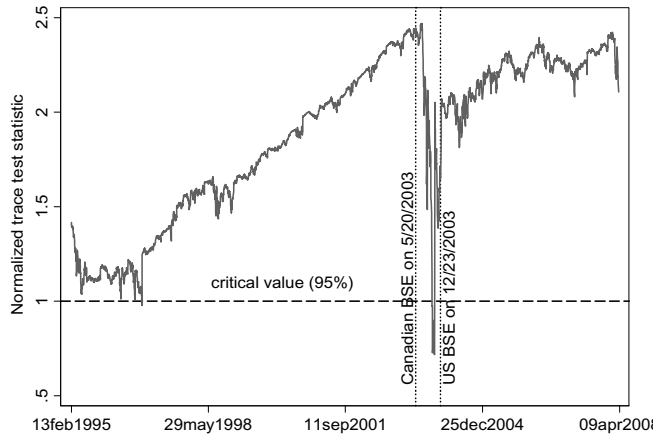


Figure 2. Recursive time-varying cointegration methods to endogenously detect structural break(s)

Structural Change in the Live Cattle Futures Prices

Time-varying cointegration methods have been used to examine whether the nature of the long-run relationships varies over time (Mjelde, Bessler, and Jerko 2002). Cointegration instabilities, such as switching between rejecting and failing to reject the null hypothesis of at most r cointegration vectors, suggest possible structural breaks (Juselius 2006). According to figure 2, we reject the null hypothesis of $r \leq 4$ at the 5% level of significance because the normalized trace test statistic exceeds the critical value of one for all periods except for the period between October 10 and 31, 2003, which suggests a structural break during that period.[2]

The identified structural break occurs five months after the 2003 Canadian BSE case and approximately two months before the first U.S. BSE case. One possible explanation for this structural break is that immediately after the first Canadian BSE case was confirmed on May 20, 2003, the United States imposed an import ban on live cattle, beef, and related products from Canada (LeBlanc 2007). Starting from August 8, 2003, the United States allowed imports of boneless meat from cattle younger than thirty months old from Canada (LeBlanc 2007). During October and November of 2003, there was speculation that Canadian cattle older than thirty months would be allowed to be imported into the United States by early December (CBC 2003). This speculation may be responsible for the timing of the structural break in live cattle futures prices.

Intensity and Persistence of BSE Impacts

The structural break falls between the 2003 Canadian and U.S. BSE confirmation dates. We therefore focus on these two BSE cases to investigate the intensity and persistence of BSE event impacts on live cattle futures prices. We do not find evidence of a significant impact by the other fourteen North American BSE cases on live cattle futures prices.

Given the VECM estimation using observations predating confirmation of the BSE cases, we forecast the six futures price series about seven months ahead and beginning about three weeks prior to the BSE confirmation. The forecasted futures prices use all available information prior to the date that the BSE case was announced, while the actual prices are affected by the BSE event. The difference between actual price and forecasted prices should reflect the magnitude and duration of the BSE impact.

For the Canadian BSE case confirmed on May 20, 2003, we estimate a VECM using observations from January 4, 1988, to April 30, 2003, and then forecast futures price for the period of May 1, 2003, to November 11, 2003. As shown in figure 3, the confirmation of this BSE case did not have a strong impact on the futures prices beyond the immediate price drop following the confirmation of the BSE case

[2] The Zivot-Andrews test presented in the diagnosis testing section identifies a structural break in a single futures prices series, whereas the structural break suggested by the normalized trace test using the time-varying cointegration method is based on the complete six-maturity system of futures prices.

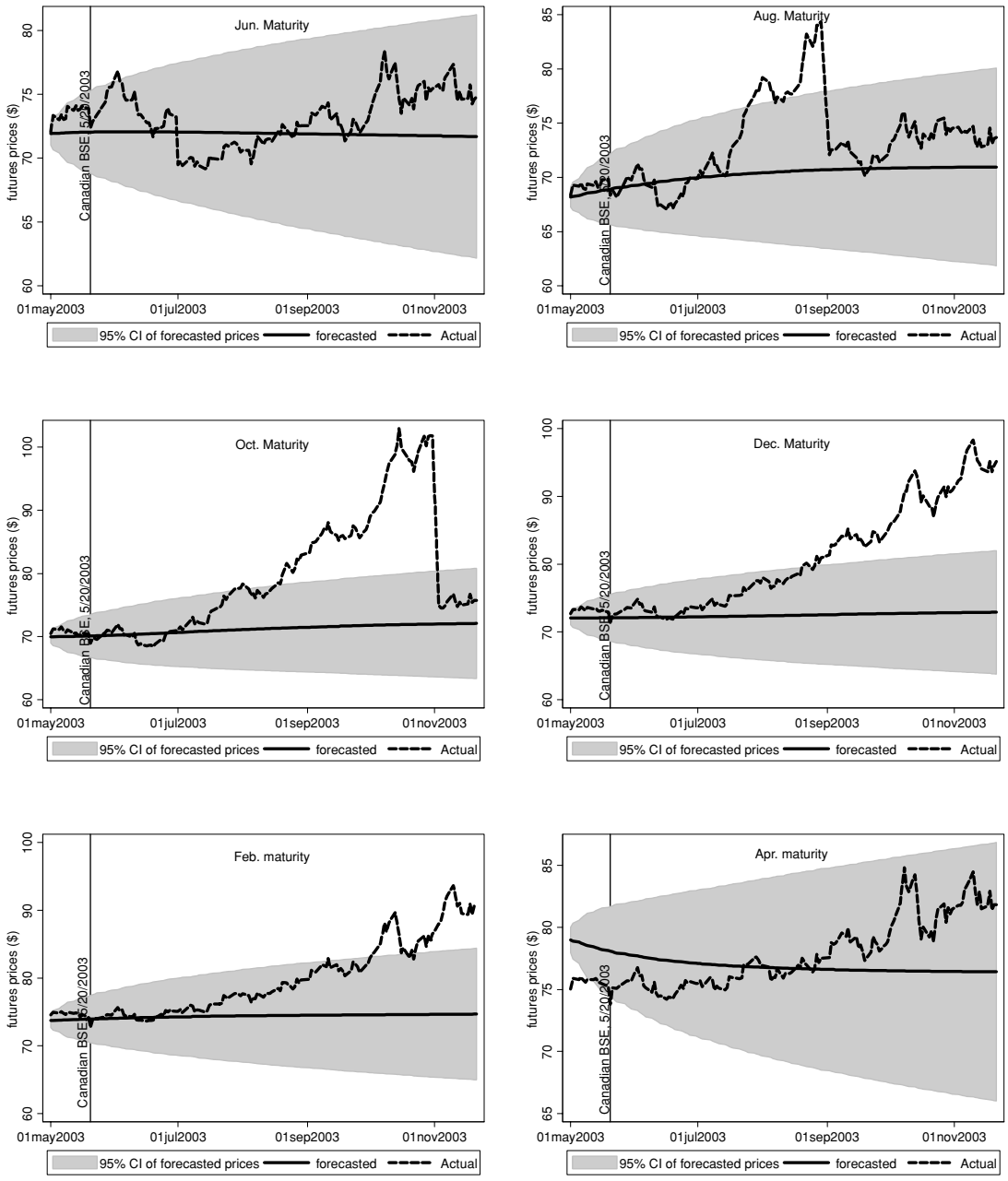


Figure 3. The impact of the Canadian BSE case confirmed on May 20, 2003, on live cattle futures prices of the nearby to distant maturities

on May 20, 2003. On that day, prices of the first four nearby futures contracts decreased by the daily limit of $1.50 per hundredweight (cwt), yet they started rising again the following day. The short-lived, insignificant effect of the official confirmation of the BSE case may be explained by preceding media speculation of the infected cow's diagnosis that started on January 31 (Tse and Hackard 2006; *Highplain Midwest Agriculture Journal* 2004). Indeed, the April 2003 live cattle futures contract dropped steadily from $79.975/cwt on January 31 to $73.35/cwt on March 16. The media coverage and speculation after January 31 may have contributed to the insignificant effect of the official confirmation.

For the first U.S. BSE case we use all observations from January 1988 to the end of

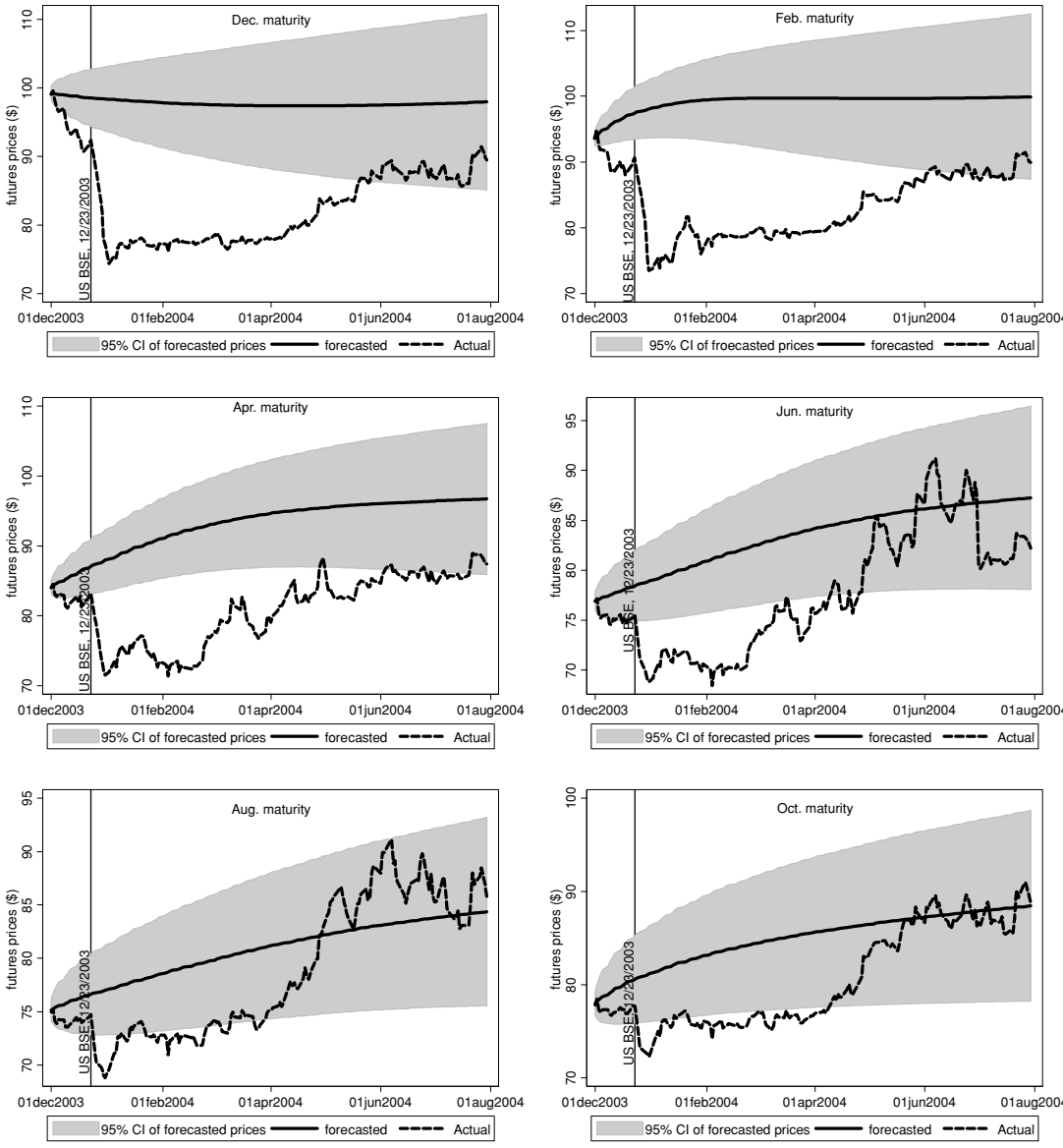


Figure 4. The impact of the first U.S. BSE event on live cattle futures prices of the nearby to distant maturities

November 2003 to fit a VECM and forecast the futures prices starting December 1, 2003, until August 1, 2004.[3] Figure 4 plots the forecasted and actual prices as well as the 95% confidence interval of the forecasted prices of different maturities for the first U.S. BSE case. This BSE discovery clearly had a significant impact on live cattle futures prices, as each price series experienced a sharp drop immediately after the confirmation of the BSE case. The adverse impact persisted up to six months in the case of futures prices maturing in December, February, and April.

The impact of the first U.S. BSE case on futures prices was maturity specific. It was generally strongest on the nearby futures (the December, February, and April maturity series), relatively smaller but still significant on

[3] For the first U.S. BSE case, we can use either a large sample (from January 1988 to December 2003) despite the structural change, or a small sample that includes observations beginning after the structural break and ending before the first U.S. BSE case. Both the mean squared forecast error (MSFE) and the modified Diebold-Mariano test (Harvey, Leybourne, and Newbold 1997) suggest that the large sample model has a better forecast performance.

the June maturity futures prices, and weakest for the most distant maturities in August and October. Except for the significant price decrease in the first two weeks following the confirmation of the BSE case, the impact on the August and October maturities was not statistically significant. The duration of the impact was likewise longer for nearby and shorter for distant maturities. Futures prices that mature in December, February, April, and June recovered within half a year, but the impact on the August and October maturity futures dissipated in less than a month.

Impact of BSE Cases on Futures Price Volatility

To evaluate the impact of BSE cases on the volatility of futures prices, we examine the conditional variance estimated by a GARCH model separately for each event and for each maturity series. For an event occurring at date *t,* we use data from $(t - 250)$ to $(t - 1)$ to produce a 50-step-ahead volatility forecast (from t to $t + 50$), which is compared with the actual volatility estimated. Given the space limit, we only summarize the overall results: (*a*) only the 2003 and 2006 U.S. BSE cases and the 2003 Canadian BSE case have had significant effects in increasing volatility for more than one day; (*b*) the impact was generally stronger for nearby maturities than for more distant maturities; and (*c*) the first U.S. BSE case had by far the strongest and longest-lasting effect on volatility. Indeed, following the 2003 U.S. BSE case, volatility did not fall back to its original level until about eleven weeks later for the nearby maturities, while it recovered in one to two weeks following the other BSE cases.

Conclusions

This study analyzes the size and persistence of the impact of North American BSE cases on futures prices and volatility, according to event chronology, country of origin, and maturity of futures contracts. We show that most of the North American BSE events appear not to have had a significant effect on live cattle futures prices and volatility. Two notable exceptions are the 2003 Canadian and U.S. BSE cases. The effect of the first U.S. BSE case on live cattle futures prices did not last more than six months and was generally stronger and more persistent for nearby maturities than it was for more distant maturity futures. Both the 2003 Canadian and U.S. BSE cases increased the volatility of the futures prices, and the increase in volatility was stronger for nearby maturity contracts than it was for more distant ones. The much stronger reaction by traders to the first U.S. BSE case may be explained by "herd"-like behavior (Tse and Hackard 2006) due to substantial uncertainty associated with the potential implications of this BSE discovery, while subsequent BSE cases were associated with less uncertainty. Another explanation may be that among all the considered BSE cases the first U.S. BSE event (2003) caused the most significant change in the U.S. beef trade due to the loss of export markets.

Space limitation precludes a detailed analysis of the effect of beef recalls that have at times occurred very closely to the date of a BSE case. There was, for example, a severe beef recall dated near the May 20, 2003, Canadian BSE case. Occurrence of a beef recall may confound the impact of a BSE case on live cattle futures prices, although our preliminary results suggest that the effect is insignificant. Further research seems warranted to jointly investigate the impact of beef recalls and BSE events. Perhaps other factors such as international trade regulations and input costs (e.g., rising corn prices) should be more explicitly taken into account in continued research on livestock futures prices.

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