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**Contributed paper prepared for presentation at the
International Association of Agricultural Economists Conference,
Gold Coast, Australia, August 12-18, 2006**

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THE EFFECTS OF *E. COLI* 0157:H7, FMD AND BSE ON JAPANESE RETAIL BEEF PRICES: A HISTORICAL DECOMPOSITION

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CONTRIBUTED PAPER PREPARED FOR PRESENTATION AT THE INTERNATIONAL ASSOCIATION OF AGRICULTURAL ECONOMISTS ANNUAL MEETING, QUEENSLAND, AUSTRALIA, 12-18 AUGUST 2006.

ABSTRACT

This study examines the time-varying Japanese price reactions to the 2001 *Bovine Spongiform Encephalopathy* (BSE) discovery, the 2000 outbreak of foot and mouth disease (FMD), and the 1996 *E. coli* food poisoning events. Historical decomposition of retail-level price-series aids in explaining the behavior of beef prices in a neighborhood (period-by-period time interval) of the three events. This is based on an application of directed acyclic graphs, constructing orthogonal innovations to determine causal patterns behind contemporaneous innovations. The results show the beef safety events had different negative impacts on Japanese retail beef prices, suggesting that consumers understood and differentiated among the health risks. The results provide incentives for beef producers and retailers to proactively inform consumers about ongoing beef safety measures. Understanding consumer reaction to BSE, FMD and *E. coli* helps the beef industry restore consumer confidence after future food safety crises, and provides policy makers a basis for countermeasures and compensations. [EconLit citations: Q11, Q13.]

Key Words: Japan, beef prices, BSE, FMD, *E. coli*, historical decomposition.

1. Introduction

Public awareness of food safety scares increased worldwide during the past two decades, with highly publicized cases of *E. coli* food poisoning, FMD outbreaks and BSE scares reported in the EU, US, Canada, Japan, and other regions. Food safety events are one of the few shocks that can abruptly eliminate an entire nation from export markets. Such events have short-run and long-run impacts on consumer preferences.

The Japanese beef industry faced three such major events: *E. coli* food poisoning in the summer of 1996, an outbreak of FMD in March of 2000, and a BSE crisis in September of 2001. *E. coli* 0157:H7 contamination has been detected throughout the world and many outbreaks have been documented in Canada, the United Kingdom, and the United States. The largest outbreak occurred in Japan in 1996, which led to 12 deaths. While all people are susceptible to infection from *E. coli* 0157:H7, children, the elderly and immuno-compromised individuals are more likely to become infected and develop complications. Consumers of bovine products may be at higher risk since most outbreaks reported have involved consumption of improperly cooked ground beef. *E. coli* 0157:H7 has been found in other animals such as sheep, pigs, goats, poultry, and deer.

Initial clusters of *E. coli* infection in Japan occurred in Hiroshima and Okayama prefectures and an extraordinarily large outbreak affected the city of Sakai, Osaka prefecture in July 1996. Most of the reported cases were children from elementary schools, which seemed to be closely related with the intake of school lunches on particular days. The reported number of infections reached 11,000, including 12 deaths and sporadic infections that continued into 1997.

FMD was reported in cattle in Miyazaki City, Japan during March 2000. This was the first outbreak in Japan since 1908. FMD is a highly contagious disease, so FMD-free countries usually ban imports in many animal and animal products from the infected country when it is detected. Importing countries often have a difficult time in keeping the disease outside their country and from spreading once it enters. Transmission of FMD most commonly occurs during physical or close contact between acutely infected and susceptible animals. As knowledge of FMD has grown it has been possible to track the different viruses and their strains, but it is still possible for new and significantly different FMD viruses to appear. It is difficult to predict the

impact that any new strain will have on world animal health.

The first case of BSE in Japan was reported by the Ministry of Agriculture, Forestry and Fisheries (MAFF) on September 10, 2001. BSE is a fatal neurological disease caused by prions, which typically occurs in adult animals aged five years or older. The exact cause of BSE is not known, but it is primarily transmitted by feeding of diseased animal products. Consumption of contaminated beef by humans is suspected to cause Creutzfeldt-Jakob disease. After the BSE discovery in Japan, demand for beef fell drastically, resulting in considerable economic damage to Japanese beef producers as well as food service industries. By the end of November 2001, Japanese beef consumption had fallen by 70%, in part due to actions by Japanese beef industry and government officials that eroded consumer confidence (Zielenziger, 2001; McCluskey, et al. 2004). In response to the crisis, the Japanese government launched an aggressive marketing campaign promoting the safety of Japanese beef (Fox and Peterson, 2002). BSE testing of all slaughter cattle was instituted, as was removal and incineration of specified risk materials from all cattle. Farm-level measures include mandatory BSE testing of all downer animals aged 24 months and older.

There is no question that these health/safety shocks impact producers and consumers in the affected countries. The impacts of health and safety scares are a dynamic process, where some consumers change consumption during the scare and return to their past behavior afterward. These dynamics are interesting and important to capture when estimating impacts. The objective of this study is to investigate the impact of the *E. coli*, FMD and BSE events on Japanese retail beef prices, as evidenced by price changes in the temporal neighborhood of each event. We use cointegrated VAR models, directed acyclic graphs, and historical decomposition to test the

hypothesis that price changes were consistent with well-informed, rational consumer responses. Historical decomposition of beef prices, which breaks down the price series at a specific date into historical shocks, aids in explaining the effects of such shocks on the behavior of beef prices. Specifically, orthogonal innovations are constructed using graph theory to determine causal patterns behind the correlation in contemporaneous innovations of a structural VAR model.

Historical decomposition is usually applied to macroeconomic shocks. To our knowledge, this is only the second study to apply historical decomposition to retail-level price responses in the neighborhood of a food safety event, the first being Chopra and Bessler's (2005) examination of short-run and long-run BSE and FMD impacts in the United Kingdom. The authors showed that price responses in the neighborhood of BSE and FMD events were dissimilar, but they were consistent with relatively well-informed, rational consumers. Finding comparable results in the Japanese market would suggest that economic theory allows generalizable predictions about price responses to future food safety scares, even across diverse cultures. An alternative possibility is that price responses to each event are idiosyncratic.

The next section provides some background information for the Japanese beef market and a short review of the literature for impact of beef safety scares on demand and retail prices. In section 3, we present description of the data used in this research, and develop the cointegrated VAR/VEC model, directed acyclic graphs and historical decomposition functions. Results are presented in section 4. In the last section, we present a summary and our concluding remarks.

2. BACKGROUND INFORMATION AND LITERATURE

2.1 Japanese Beef Market

Fish is the traditional source of animal protein in the Japanese diet. Beef was not considered a substitute for fish until recently because of culture, eating habits, and cooking methods. As Japanese social structures changed and real per capita income increased, consumers gradually accepted beef and its consumption grew faster than any other meat. Annual per capita consumption increased from 4.12kg in 1986 to 7.7kg in 1996 (just before the *E. coli* outbreak). Japanese beef consumption hit 542,800 metric tones in April-September 2000, just as the FMD outbreak was beginning. This consumption was up 3.2% from the total reached over the same period in 1999 (MAFF; Japan's Ministry of Agriculture, Forestry, and Fisheries).

The way beef dishes are served impacts the Japanese beef market. In 1991, 48% of the beef consumed in Japan was eaten in the home while 42% was consumed through the foodservice market. By 1996, the picture had changed considerably with only 41% eaten at home and 50% in the foodservice sector. A MAFF survey shows that, of the beef eaten at home in 1996, over 80% was domestically-produced Japanese beef compared to just 60% in 1994. However, the opposite was the case in the foodservice sector where imported beef accounted for over 90% of the market, up from 70% in 1993.

For the time frame of this study, the Japanese beef market was mainly made up of four types: two domestic types, wagyu and dairy and two imported types, from the U.S. and Australia.¹ Japan was the largest beef importing country in the world in terms of value and second (behind the U.S.) in terms of volume. Japanese beef imports are almost exclusively in the form of boneless cuts. Chilled beef imports for fiscal year 1998 were 56% chuck, clod, and round, 20% loins, and 23% ribs (ALIC). Frozen beef imports for fiscal year 1998 were 17% chuck, clod, and round, 7% loins, 48% ribs, and 28% other cuts.

¹ Canada and New Zealand also exported beef to Japan, but their exports were quite small relative to Australia and the U.S.

In fiscal year 1999 (the last full year before the FMD scare), Japan imported 683 thousand metric tonnes of beef, accounting for 13% of world beef import volume and 17% of world beef import value. Australian beef had the highest overall market share in volume terms for chilled muscle cuts, accounting for 30.8% of the Japanese market. They were followed by Japanese dairy beef (26.1%), Japanese wagyu beef (21.6%), and U.S. beef (21.3%). The cut/origin combination with the largest market share in 1999 was Australian chucks (including clods and rounds) with 19.9%, while the cut/origin with the smallest market share was wagyu ribs with 3.0% (the Livestock Industry Promotion Corporation.)

Beef types are specifically identified at retail outlets by type for domestic cuts (wagyu is specifically identified) and country of origin labeling on imports. In most stores, domestic and imported beef cannot be displayed in the same case, so consumers clearly know the origins of their beef purchases. The quality and retail beef prices by country of origin (and by type of domestically produced beef) vary widely in the Japanese market. There is a clear preference for domestic beef and Japanese consumers are willing to pay higher prices for chilled beef products and BSE-tested beef (Kerr et al., 1994; Erikson et al., 1997; McCluskey, et al., 2004).

Japanese consumers consider wagyu to be the highest quality beef. Japanese dairy beef is considered to be lower in quality than wagyu, yet higher than imported U.S. grain-fed beef (Saghaian and Reed, 2004). Domestic beef is viewed as fresher than imported beef and this is a major consideration in purchasing decisions. Wagyu beef and high-quality cuts of Japanese dairy beef are characterized as the so-called “super beef”. The prime wagyu beef is well marbled and is generally used for traditional beef dishes such as *sukiyaki*, *shabu-shabu*, or other variants collectively known as *nabemono*. The marbling and texture of wagyu beef allows its use in these dishes; other beef types are much less desirable for these cooking techniques.

2.2 The Impact of Beef Safety Scares

The impact of beef safety scares on consumer demand has been extensively investigated in the literature. This literature mostly focuses on changes in the demand structure, or on methods of contingent valuation, experimental auction markets, hypothetical valuation, and consumers' willingness to pay for food safety/security information and quality assurance (e.g., Lusk and Schroeder, 2000; McKenzie and Thomsen, 2001; Dickinson and Bailey, 2002; Jin and Koo, 2003; Marsh, Schroeder and Mintert, 2004; Pigott and March, 2004; McCluskey, et al., 2004; Peterson and Chen, 2005; Livanis and Moss, 2005; Chopra and Bessler, 2005). The results of these studies generally show that food safety scares have affected beef prices and demand adversely, and that consumers are willing to pay premiums as high as 50%-75% for beef safety and beef quality assurance.

3. DATA AND MODEL DEVELOPMENT

3.1 Data

Four beef types identified by type and origin, namely, U.S., Australian, Japanese wagyu, and Japanese dairy are evaluated. The monthly time-series retail data used by Peterson and Chen (2005) are used in this study.² While their focus was on the impact of BSE in Japan, this study also addresses the impacts of two other important events: the 1996 *E. coli* and 2000 FMD outbreaks. The sample contains 105 observations from April 1994 to December 2002. Retail prices for beef were obtained from Agriculture and Livestock Industries Corporations (ALIC) data. Beef prices were the weighted prices of four cuts (chuck, loin, round and flank) reported by ALIC based on Nikkei Point-of-Sales. Table 1 contains the descriptive statistics of the price series in levels. These price series were transformed into natural logarithmic form for the

² The assistance of Hikaru Peterson in providing the data used in this study is gratefully acknowledged.

analysis.

<Insert Table 1 here>

3.2 Model Development

The multivariate VAR model has the four price series as endogenous variables. Given the nature of the underlying data series, stationary tests of the series are conducted using the Augmented Dickey-Fuller (ADF) test to determine the order of integration of each univariate series. This test involves running a regression of the first difference of the series against the series lagged one period, lag difference terms, and a constant as follows:

$$\Delta Z_t = \alpha_0 + \alpha_1 Z_{t-1} + \sum_{j=1}^n \beta_j \Delta Z_{t-1} + \varepsilon_t$$

where ΔZ_t is the first difference of the time series. Second, a co-integration test is performed to determine whether there exists a long-run relationship among the series in the system. Co-integration tests were performed using Johansen's method. The Johansen co-integration test is designed to determine whether the series are co-integrated and to determine the co-integrating rank, r , the number of co-integrating vectors in the system using the likelihood ratio (LR) (Holden and Perman, 1994).

The rank, r , can be at most one less than the number of endogenous variables in the model. Two null hypotheses are tested in the co-integration tests: 1) that the series has no equilibrium condition or no co-integration and 2) there are r co-integrating vectors against the alternative hypothesis of $r+1$ co-integrating vectors. In each test, the null hypothesis is rejected if the test statistic is larger than the critical value. Empirically, the first difference of each variable is represented as a function of its own lagged value, the lagged values of the other variables, and

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + e_t$$

the co-integration equation. The specification of the VAR and VEC model used to conduct the analysis is as follows:

where ΔX_t is a (4x1) matrix (ΔX_{1t} , ΔX_{2t} , ΔX_{3t} , and ΔX_{4t} represent the four price series); α_0 is a (4x1) vector of intercept terms; the $\Gamma_i \Delta X_{t-1}$ terms reflect the short-run relationships among elements of the X_t matrix, and the Π matrix captures the long-run relationship among the variables.

The Π matrix can be decomposed into two $p \times r$ matrices, α and β , where $\Pi = \alpha\beta'$. The matrix β contains the co-integrating vectors that represent the underlying long-run relationship and the α matrix describes the speed of adjustment at which each variable moves back to its long run equilibrium. Co-integration requires that the β matrix contain parameters such that Z_t , where $Z_t = \beta' X_t$, is stationary (Johansen and Juselius, 1992; Schmidt, 2000).

If the series is integrated, but not co-integrated, then a VAR (Vector Autoregressive Model) is appropriate. If the series is integrated and co-integrated, then a VEC (Vector Error Correction Model) is more appropriate to characterize the multivariate relationships among the price series (Engle and Granger, 1987; Enders, 1995). The difference between the VAR and VEC model is that the VEC model also captures the co-integrating equation, which represents the long-run relationship among the variables due to the presence of co-integration.

The VAR/VEC analysis is followed by the calculation of the covariance matrix of the model, which is used to investigate the causal relationship among the variable by directed acyclic graphs as in Bessler and Akleman (1998); Saghaian, Hasan, and Reed (2002); and Babula, et al. (2004). A PC algorithm is used to assign causal flows based on the existing data's partial correlations (Spirtes, Glymour, and Scheine, 2000). The algorithm begins with an undirected graph in which all the variables are originally connected. The program removes adjacent edges when partial

correlations are not statistically significant from zero at an identified significance level and assigns causal flow directions for the remaining edges.

Directed graphs allow writing the price vectors in terms of orthogonalized innovations. Non-zero, off-diagonal elements of the residual matrix allow for a shock in one variable to affect other variables in the model contemporaneously, which determines the causal structure behind the correlation in innovations (Swanson and Granger, 1997). Traditionally, the recursive method of Choleski factorization was used to create a causal ordering for the interactions among a set of contemporaneous innovations. However, this method may not reflect the “true” ordering among series’ innovations. More recently, the Bernanke (1986) ordering has been used to specify a causal pattern among innovations. In this method, a contemporaneous causal pattern is specified a priori among innovations, if such information exists (Chopra and Bessler, 2005).

Finally, historical decompositions based on directed graphs and causal patterns decompose the price series into historical shocks in each series of the structural VAR model to determine price responses in a neighborhood (time interval) of the *E. coli*, BSE, and FMD events. The historical decomposition is based on partitioning each series in the representative VAR model into two parts: one is due to innovations (shocks) that drive the joint behavior of beef prices for period $t+1$ to $t+j$, the horizon of interest, and the other is the forecast of price series based on information available at time t , the date of an event -- that is, how prices would have evolved if there had been no shocks (Chopra and Bessler, 2005). Historical decomposition highlights the complex interplay among the variables in the model and how price responses vary with different events.

4. RESULTS

The results of the unit-root test are estimated by OLS and presented in Table 2. The second

column of the table summarizes the ADF test results for each original variable in log form, while the third column presents the results for the first log difference of each series. The second column of the table shows that the null hypothesis of zero first-order autocorrelation cannot be rejected at the 5% level of significance using the Durbin-Watson bounds test for each country. As shown in the second column, the ADF test statistics in absolute value for most series are smaller than the critical value. Given the MacKinnon critical value, the null hypothesis cannot be rejected meaning that those series are non-stationary. Based on the ADF test results, all series need to be transformed to make them stationary. The right-most column of Table 2 gives the results of the ADF test for the first difference transformation of the series. The null hypothesis is rejected for all variables so each series becomes stationary after first differencing. Based on this, we conclude that each series is an integrated process of order 1 or I(1) and therefore, co-integration is possible.

<Insert Table 2 here>

Table 3 presents the results of co-integration tests for the price series. As indicated by these results, the null hypothesis that $r = 0$, $r \leq 1$, and $r \leq 2$ is rejected at the 5% level. However, the null hypothesis cannot be rejected at the 5% level that the co-integrating rank of the system is at most 3. Thus, there exists a long-run stationary relationship among the price series and specifically the beef price series are part of the cointegration space; so the VEC model is appropriate in order to determine the directed graphs and causal patterns.

<Insert Table 3 here>

The estimation results for the VEC model are not reported as this study focuses on using the residuals of the estimated VEC model that determine the dynamic relationships among the prices through contemporaneous innovations. The residual correlation matrix of the estimated VEC

model provides the contemporaneous innovations (errors). Table 4 shows this correlation matrix. It is evident from the correlation among residuals that the strongest correlation exists between the Japanese wagyu and dairy prices (0.674). This makes sense as pricing policies for Japan's beef industry are mutually applied to wagyu and dairy beefs. These results also show that residuals associated with the two import origins are more strongly correlated to residuals from Japanese wagyu beef than from Japanese dairy beef. Finally, there is little correlation in residuals for U.S. and Australian beef prices (0.067).

<Insert Table 4 here>

Any inference on responses of beef prices to scare shocks requires a careful investigation of contemporaneous correlation among corresponding innovations. In a case where contemporaneous correlation among the errors is present, historical decomposition functions may be distorted because of the effects of innovations in another variable in the system at the same time. Piggott and Marsh (2004), using U.S. quarterly data showed that the effects of food safety concerns were only contemporaneous. A formal test of contemporaneous causal structures is performed here, where innovations are orthogonalized to obtain the historical decomposition functions.

The TETRAD IV software is applied to the correlation matrix to generate the causal patterns among the beef price series (Spirtes et al., 1999). Figure 1 presents the causal structure of the four beef price series on innovations from the four variables. Only edges that are significantly different from zero at the 5% significance level are included. The results show that innovations

<Insert Figure 1 here>

in both U.S. and Australian price variables directly affect residuals in wagyu prices, and there is a direct residual relationship from wagyu to dairy beef prices. The effect of beef import prices on

dairy beef price residuals is indirect through wagyu prices. The results indicate no relationship, direct or indirect, between the U.S. and Australian beef prices from the residual data.

Historical decomposition functions track the evolution of beef safety shocks through the system. It traces the response of forecasted prices in the absence of a shock as well as actual values in the presence of the shock to the beef price innovations. The historical decomposition estimates the percentage deviation in the actual prices explained by the food safety shocks compared with the forecasted prices. Figures 2 to 4 present the corresponding historical decomposition results for the four price series from the BSE, FMD, and *E. coli* shocks over a five month horizon to see the impact of these events in the event's vicinity.³

Peterson and Chen (2005) estimated that the period of structural change in demand following the September, 2001 discovery of BSE lasted through November, 2001. Similarly, we defined the temporal “neighborhood” around the beef safety events as the period beginning two months before the event and three months after the event. The dynamic impacts of the shocks, though, can last many months. We don't look at prices very far into the future because we are more interested in the contemporaneous nature of their impacts. Further, it is likely that other shocks would normally occur after a few months to cloud their impacts. We show the impacts over a one year period. Figure 2 shows the impacts of the 1996 *E. coli* outbreak on beef prices in Japan by comparing the actual prices (solid line). Notice that the actual prices of all four beef types increased right after the event, with the highest price increases displayed by the imported Australian and domestically produced dairy beef.

<Insert Figure 2 here>

At first glance these results look suspicious and surprising. This was, after all, a major *E. coli* contamination in Japan with some 12,000 cases of infection reported. However, most of the

³ The assistance of Aviral Chopra with the historical decomposition graphs is gratefully acknowledged.

reported cases were in children consuming ground beef. Ground beef poses a greater contamination risk than the cuts evaluated in this study because it has greater exposed surface area. McKenzie and Thomsen (2001) concluded that short-run demand changes due to *E. coli* 0157:H7 were most readily observed in wholesale products destined into ground beef. If consumers accordingly reserved their greatest concern for ground beef and did not avoid the four cuts comprising our data, the *E. coli* event would produce little impact on prices, consistent with the results.

Figure 3 shows that the impact of the 2000 FMD outbreak on beef prices in Japan was quite different. These results are indicative of a negative impact, especially on the two prices of domestically produced beef, wagyu and dairy, and on the imported Australian beef. Since FMD was discovered in live domestic cattle and with 92% of the live cattle imports in 2000 coming from Australia, Japanese consumer reaction is reflected by a sudden fall in the prices of Australian and dairy beef prices. These results are understandable because FMD affects consumers' perception of quality, though it may not affect beef safety directly. The results indicate some sophistication among Japanese beef consumers as they reacted less negatively against U.S. imports, which were mostly frozen.

<Insert Figure 3 here>

Australian beef prices took the largest hit with the FMD outbreak. It is estimated that they dropped 12% due to the outbreak by May and they were 13% lower by July. They were still 7% below in December. In contrast, the largest negative impact on wagyu prices was only 6% and that occurred in November. They rebounded to only 3% down by December. Japanese dairy beef prices were generally 4% to 6% lower due to the outbreak until December when they rebounded sharply. U.S. beef prices were the only ones that increased for some months with the

FMD outbreak. Yet, U.S. beef prices were 4.5% lower in September due to the outbreak. However, on average, the outbreak had little impact on U.S. beef prices.

The results show that, except for the U.S. beef prices, it took several months after the incident for the actual beef prices to recover. The FMD outbreak reached its largest impact on Australian and wagyu beef prices in July, and on dairy prices it reached its largest impact in May. These three beef prices were on their way to recovery by November 2000. U.S. beef prices displayed an up-down pattern with actual and forecasted prices mimicking each other closely. By October 2000 actual prices had recovered completely and reached the highest point in that year. This pattern suggests that FMD had little impact on U.S. beef prices in Japan.

Figure 4 presents the impact of the 2001 BSE discovery on beef prices. The response of domestically produced beef prices in Japan after the BSE shock contrasts with the pattern for imported beef prices in the early months. Imported beef prices in Japan fell immediately in response to the BSE discovery, but domestic beef prices actually increased. Eventually, though, all beef prices were adversely impacted by the BSE discovery. Immediately after the BSE discovery, U.S. beef import prices fell the most dramatically and saw the widest difference between the actual and forecasted prices. U.S. beef prices rebounded after the first two months, but they took another quick dive until after December, reaching their lowest point in May (an 8% drop relative to no-BSE), approximately seven months after the outbreak. Australian beef prices followed a similar pattern to U.S. prices except there was no dramatic drop during the first month. They also reached their lowest point in May, a 10% drop because of BSE.

<Insert Figure 4 here>

Japanese wagyu and dairy beef prices rose after the BSE outbreak; certainly not what one would expect. They remained rather close to what was projected before the outbreak. Yet by

December, those prices began to fall absolutely and relative to what they would have been without an outbreak. Wagyu prices reached a low point in May at 5.1% below the no-BSE case and dairy prices reached a low in April at 7.8% below the no-BSE case.

The pattern for imported beef prices may be explained by the way Japanese authorities handled the news of the BSE discovery. The immediate negative responses observed for the U.S and Australian beef prices may be attributed to the widely published remarks of a Japanese meat company that imported beef was the most likely source of BSE in Japan, as explained by Zielenziger (2001), Jin and Koo (2003), and McCluskey, et al. (2004). After a two-week delay in publicly announcing the first confirmed case, the government's assurances of healthy domestic animals were contradicted by a second case a month later, prompting anxiety among consumers (McCluskey, et al., 2004). Yet domestic beef prices fell less than imported prices, which suggests that Japanese consumers still had more confidence in domestic beef production, despite the BSE outbreak.

5. Summary and Concluding Remarks

The objective of this study was to explore the dynamic responses of Japanese consumers (measured by prices prevailing) to the impact of *E. coli*, FMD, and BSE food safety shocks. In this study, we employed monthly retail-level beef prices in a structural VAR model in which directed acyclic graphs were used to estimate causal relationships among residuals. The historical decomposition of beef prices with contemporaneous innovations showed that Japanese consumers understood the differences and reacted differently to the three beef safety scares they have experienced in recent years.

Judging by the distinctive price responses to each food safety scare, the results indicated that Japanese consumers paid attention to what was reported regarding the origin and type of

contaminated beef products, as well as the source and type of contamination. This evidence conflicts with the observation of Paarlberg, Lee, and Seitzinger (2003) that consumers may not understand the difference between the health risks associated with beef safety crises. Yet it is clear that Japanese consumers have a more positive overall view of their own beef products and this keeps their domestic products from falling in price as much as imported products.

Comparison between the BSE results and those of Peterson and Chen (2005) is useful, because the same data but completely different methods were used. Peterson and Chen concluded that large government expenditures were at least modestly effective in minimizing damage to consumer confidence, but they recognized that long-term impacts were potentially substantial. Figure 4 provides evidence that depressed beef prices for all four types, even several months after the initial discovery, were largely attributable to BSE.

The results of this research help beef producers and exporters better understand Japanese consumer reactions to beef safety scares. Generally, the consumers react initially to the shock with avoidance of the suspect food item, but concern gradually decreases, leading to establishment of a new equilibrium. Producers need to be cognizant of the length of consumer reactions. Overall, the crisis has increased awareness of potential future safety problems in the industry, forcing beef producers and marketers to pay greater attention to beef safety issues. Any new information that consumers gained during these shocks might change their behavior as future shocks occur. For instance, if Japanese consumers learned that FMD may not affect meat safety, their reactions to another FMD outbreak could be different. Also, if they learned the negative consequences of BSE on beef safety, their reaction to future outbreaks might be heightened.

This situation has created opportunities for branding and beef product differentiation based

on traceability and beef quality. Quality labeling is now more widely applied in Japan to gain consumer confidence than ever before. McCluskey, et al. (2004) argue the need for monitoring and validation to build credibility among consumers for credence attributes such as labeled BSE testing. Marketing beef safety and quality as an attribute and using quality assurance labels on meat products can effectively restore consumer confidence as well as potentially create niche markets to increase both producer and consumer surplus.

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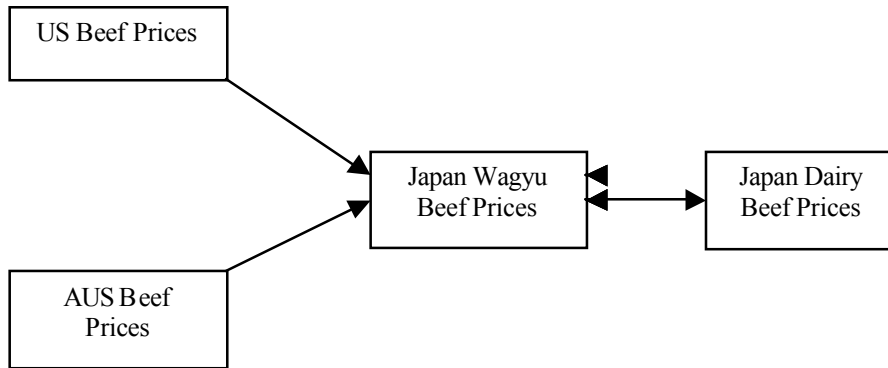
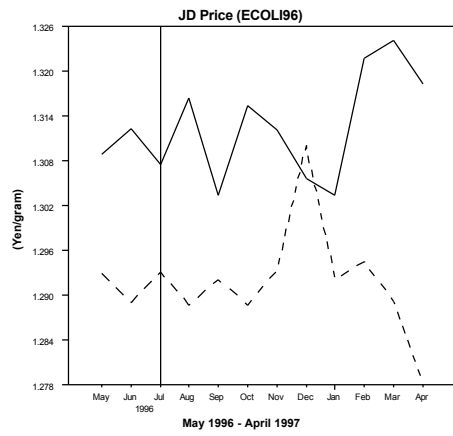
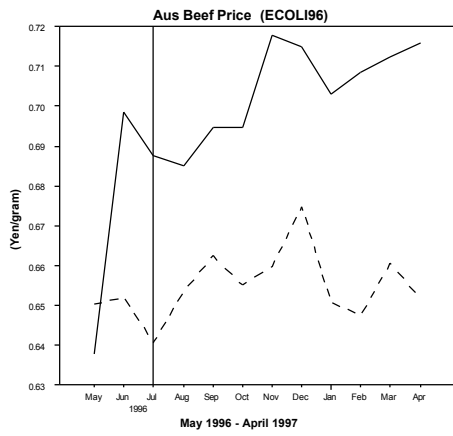
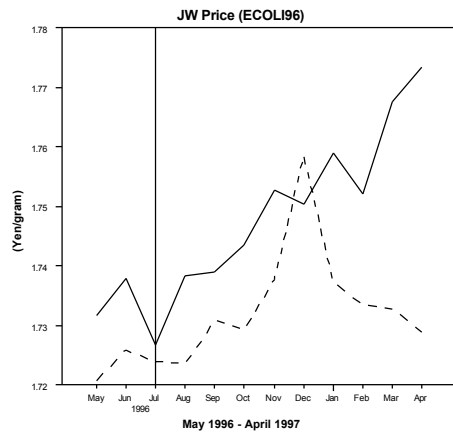
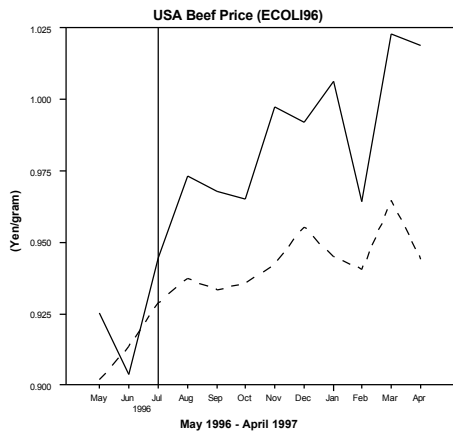
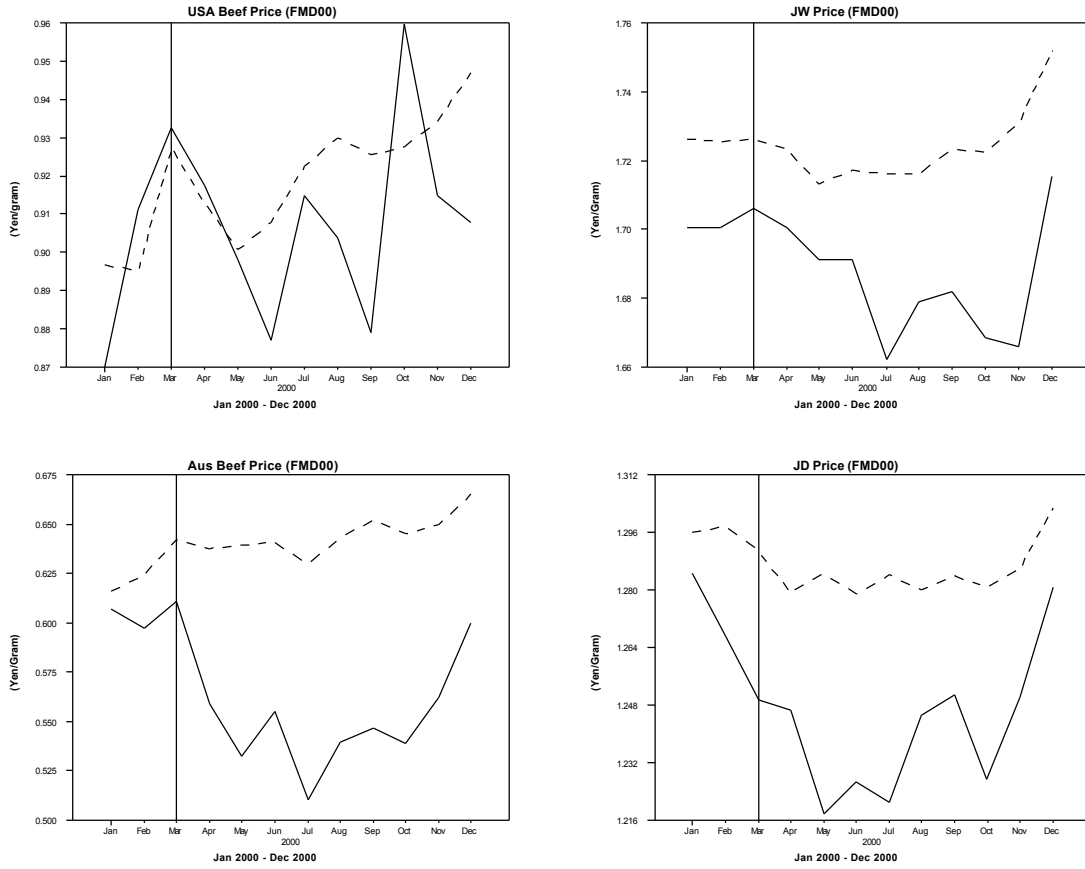


Figure 1. Directed Graph on Innovations from the Beef Price Series



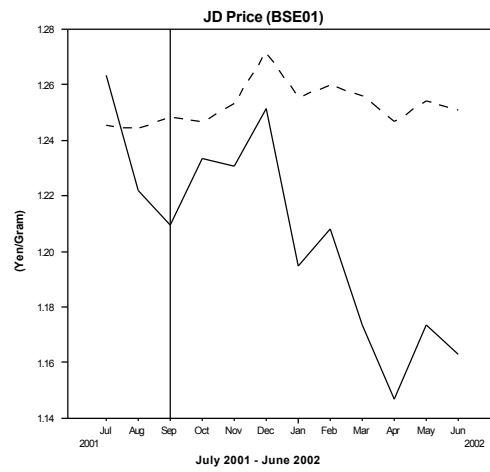
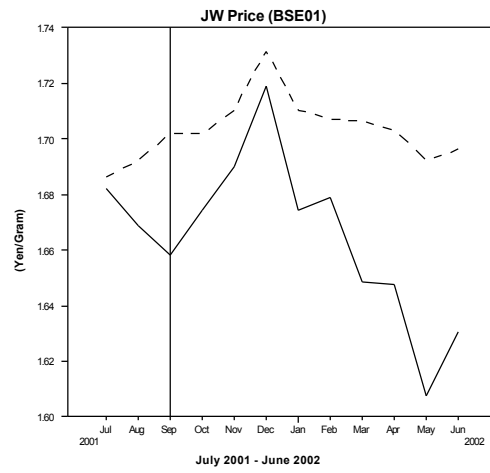
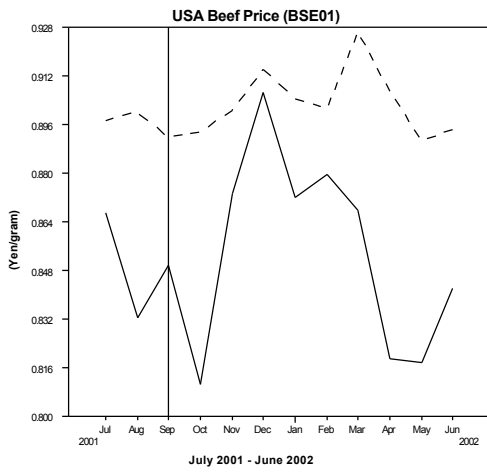
Actual Price: _____
 Forecasted price before the event: - - - - -
 Vertical line is the Event of interest: |

Figure 2. Impact of *E.Coli* 1996 on Beef Prices in Japan



Actual Price: _____
 Forecasted price before the event: - - - - -
 Vertical line is the Event of interest: |

Figure 3. Impact of FMD 2000 on Beef Pieces in Japan



Actual Price: _____
 Forecasted price before the event: - - - - -
 Vertical line is the Event of interest: |

Figure 4. Impact of BSE 2001 on Beef Prices in Japan

Table 1. Descriptive Statistics of Beef Price Series in the Empirical Model

Variables	US	AUS	Wagyu	Dairy
Mean	2.56	1.90	5.59	3.58
Median	2.58	1.91	5.56	3.56
Maximum	2.83	2.11	6.00	3.86
Minimum	2.22	1.67	4.99	3.15
Std. Dev.	0.15	0.11	0.23	0.16
Skewness	-0.31	-0.24	-0.17	-0.35
Kurtosis	2.20	1.97	2.45	2.51
Jarque-Bera Probability	4.54 0.10	5.68 0.06	1.84 0.40	3.14 0.21
Observations	105	105	105	105

Table 2. Augmented Dickey-Fuller (ADF)^a Test Results

Variable	Test Results for Variables in Levels	Test Results for Variables after First-Differencing
US Beef Price	2.64	9.47**
AUS Beef Price	2.39	11.60**
Japan Wagyu Beef Price	2.13	11.11**
Japan Dairy Beef Price	1.64	13.05**

Note: ** 1% significance level, * 5% significance level.

^a In absolute value and compared to MacKinnon (1996) one-sided p-value.

Table 3. Johansen Cointegration Test Results

Null Hypothesis ^a	Trace Statistics	5% Critical Value	Eigenvalue
$r = 0$	206.18	125.62	0.54
$r \leq 1$	128.64	95.75	0.42
$r \leq 2$	74.64	69.82	0.29
$r \leq 3$	41.05	47.85	0.17

^a r is the cointegrating rank, MacKinnon-Haug-Michelis (1999) p-value.

Table 4. Residual Correlation Matrix of the Estimated VEC model

AUS price	1.00			
US Price	0.07	1.00		
Wagyu Price	0.47	0.29	1.00	
Dairy Price	0.38	0.22	0.67	1.00