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Three Essays on the Economic Impact of Bovin Spngiform Encephalopathy in the United States

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THREE ESSAYS ON THE ECONOMIC IMPACT OF BOVINE SPONGIFORM ENCEPHALOPATHY IN THE UNITED STATES

by

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ABSTRACT

Three Essays on the Economic Impact of Bovine Spongiform Encephalopathy in the United States

by

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The first native-born case of Bovine Spongiform Encephalopathy (BSE or commonly known as Mad Cow Disease) in North American continent was reported on 20 May 2003 in central Alberta, Canada. The first case of BSE in the United States was announced on 23 December 2003.

My dissertation is divided into three essays on the economic impact of the outbreak of Bovine Spongiform Encephalopathy (BSE) in the United States in December 2003. The first essay focuses on quantifying the impact of the outbreak of BSE in the United States and Canada on the stock returns of major publicly traded agribusiness firms and restaurant companies in the United States. Event study methodology has emerged to be the best way to analyze the impact of such events on the stock prices. The results of the analysis showed that at an aggregate level firms did not respond significantly to the announcement in May 2003 but the same firms did react to the news of BSE in the

United States in December 2003. The individual company-wise and the group-wise results were mixed for both May and December 2003 events.

The second essay used the techniques of vector error correction models along with historical decomposition techniques to analyze the impact of mad cow disease on the prices in the beef, pork, and poultry markets. To analyze the interdependence in the meat sector, this essay uses the technique of directed acyclic graphs (DAG). The results of the study indicate interdependencies in the beef, pork, and poultry markets in the United States. That is, a shock in one series has an impact on other series too. There is vertical as well spatial price transmission in the meat markets, though the transmission is not perfect. The different speeds of adjustment point to asymmetric price transmission. Also, the magnitude of the mad cow disease shock was different in different markets indicating asymmetry in terms of both speeds of adjustment and magnitude.

The focus of the third essay is to test for any structural change in the demand function for US beef in the major US beef importing countries – South Korea, Japan, Canada, and Mexico. This paper estimates a beef export demand function for the United States and conducts tests for structural changes using the Chow test and the CUSUM test.

(126 pages)

DEDICATION

This dissertation is dedicated to my grandmother & my parents

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INTRODUCTION

In today's globalized world where dissemination of information is fast and easy, news can travel to far away places with relative ease. Such dissemination of information can result in deep and widespread impacts within and across borders within a short period of time. For example, the East Asian economic crisis which started in Thailand spread to other neighboring countries through the financial contagion effect. Information carries economic value to individuals and governments. Economic agents can make or change their economic or social decisions by using the information available to them. For example, an announcement about a proposed increase in interest rates will effect investors' expectations and hence their investment behavior. Similarly, an announcement regarding a health risk associated with consuming a particular type of food leads to decreased demand for that type of food and, in some cases, leads to food recalls by the producers. The larger the media coverage regarding a health risk due to consuming some food, drug or using some gadget, the larger the impact felt in the society. In some cases, there is a shift in the demand for the product only in the short run but, in some cases, the consumers might shift their demand permanently to other products (substitutes) depending on the severity of the situation.

Information has always played a significant role in economic decision making. Information of interest is passed on to the concerned parties which in turn affect their economic behavior. This information whether true or not true, precise or imprecise, effects different sectors of the economy through direct or indirect channels. With advancement in information technology and rapid globalization, effects can be seen in international markets as well. The subject of information in economics has been a well researched one. In 2001, Akerlof, Spence, and Stiglitz received the Nobel Prize in Economics for their contribution to the study of information economics. Given the consensus in the literature that information does leave an impact, the past few decades of economic research have had the economics of information as their focus.

Background Information

The first documented case of the Bovine Spongiform Encephalopathy (BSE) was identified in the United Kingdom in 1986. Since then many more cases in different parts of the world have been identified and tested for BSE positive. Mad cow disease has caught the attention of the consumers, producers and the government through widespread media coverage. The disease has impacted many sectors of the different economies – some directly, others indirectly. There has been extensive research on the cause and, more importantly, the effects of BSE on both human and economic health of the nations.

To analyze the impact of the outbreak of BSE in specific countries, some researchers have focused on the beef industry alone while some have looked at the impact on related sectors also. The sectors that have been impacted by BSE are mainly cattle producers, ranch and dairy, retail businesses, food industry (food processing firms, meat producers), service industry (food wholesale and restaurants) and the food export businesses among others. This study is an attempt to focus on the impact of BSE on three different sectors in the United States.

BSE in North America

The first native-born case of BSE on the North American continent was reported on May 20, 2003 in central Alberta, Canada. After six months the first case of mad cow disease in the United States was announced on December 23, 2003 in the state of Washington. By May 2009, a total of 20 cases of BSE had been found in North America out of which 3 were identified in the United States and 17 in Canada (Source: www.cdc.gov).

Economics Theory Behind BSE Impact and the Research Objective

The demand for a commodity is a function of its own price and demand shifters. Negative health information can significantly affect the preferences of the consumers against the consumption of beef. As the demand for beef decreases, the demand for its substitute products would increase such as the demand for chicken and pork. As the demand for beef decreases (price falls) and the demand for its substitute products increases (price increases), one would expect that the companies or business involved in the production or processing of the beef products would suffer losses and the poultry and pork companies would gain.

As the demand for a product decreases (shifts down), the price falls and as the demand for a product increases (shifts up), the price increases. As the price of a product changes, it affects the profitability of the companies which in turn is reflected in the stock prices also. Negative health information not only affects the domestic demand for the commodity but also the international demand and thereby affects the international

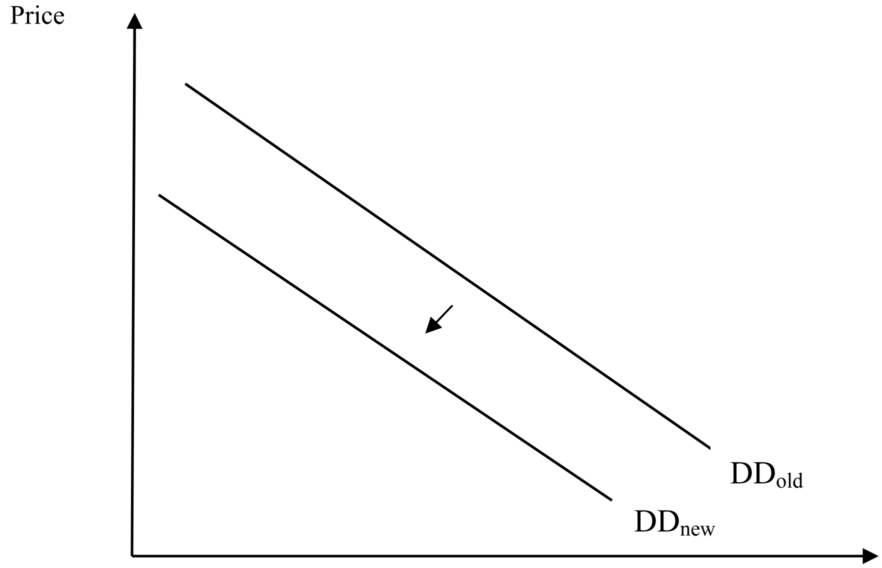

Figure I: Shift in demand for beef

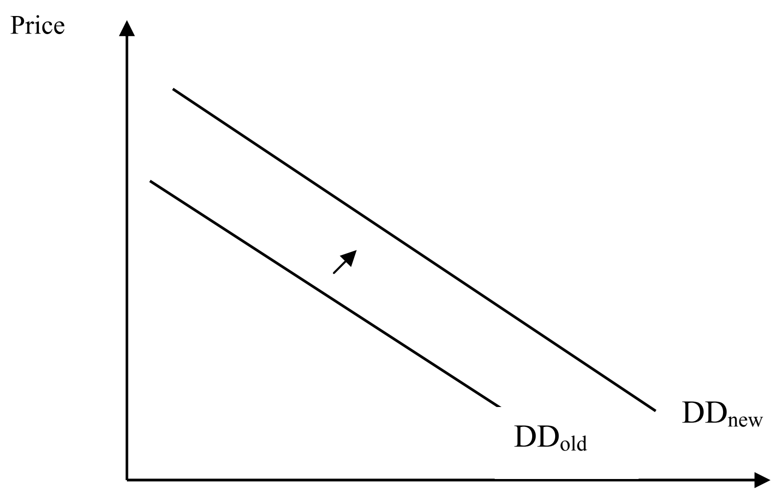

Figure II: Shift in demand for substitutes – pork and chicken

competitiveness of the exporting country in the world market.

My thesis is divided into three essays on the economic impact of the outbreak of Bovine Spongiform Encephalopathy (BSE) in the United States in December 2003. The first essay focuses on quantifying the impact of the outbreak of Bovine Spongiform Encephalopathy (commonly known as mad cow disease) in the United States on the stock returns of major publicly traded agribusiness firms and restaurant companies in the United States. Event study methodology has emerged to be the best way to analyze the impact of such events on the stock prices.

The second essay looks at the impact of BSE outbreak on the prices in vertically and spatially separated markets. This paper uses vector error correction methods along with historical decomposition techniques to analyze the impact of the mad cow disease on the prices in the beef, pork and poultry markets. To analyze the interdependence in the meat sector, this essay uses the technique of directed acyclic graphs (DAG).

The focus of the third essay is to test for any structural change in the demand function for the US beef in the major US beef importing countries – South Korea, Japan, Canada and Mexico. This paper estimates a beef export demand function for the United States and conducts tests for structural changes using the Chow test and the CUSUM test.

ESSAY 1: IMPACT OF THE BOVINE SPONGIFORM ENCEPHALOPATHY (BSE) ON THE STOCK PRICES OF PUBLICLY TRADED AGRIBUSINESS FIRMS AND RESTAURANT BUSINESSES IN THE UNITED STATES: AN EVENT STUDY APPROACH

Abstract

The first native-born case of Bovine Spongiform Encephalopathy (BSE or commonly known as mad cow disease) in North American continent was reported on 20 May 2003 in central Alberta, Canada. The first case of BSE in the United States was announced on 23 December 2003. The present paper analyzes the impact of BSE outbreak in North America on the stock prices of agribusiness firms and restaurant companies using an event study methodology. To calculate abnormal returns, the market equation is estimated using Ordinary Least Squares (OLS) as well Generalized Autoregressive Conditional Heteroskedasticity (GARCH) which accounts for heteroskedasticity and serial correlation of the financial data. Forty-eight companies (divided into seven groups) were selected for the analysis. The results showed that for the May 2003 event when the analysis was run taking all the companies together, the mean cumulative abnormal returns were not significant on the day of the announcement and post announcement. This could be because since January 2003 information was already present in the market that a cow was being tested for BSE. But the December event came as a surprise in the market and overall market showed negative abnormal return. The individual company-wise and the group-wise results were mixed for both May and December 2003 events.

1. Introduction

Food scares such as the Bovine Spongiform Encephalopathy (BSE), the Bird Flu, and the Foot and Mouth Disease (FMD) have been catching international attention due to globalized food market. Country of origin labeling through WTO regulations has changed the world food market in a significant manner. Recent years have seen a rising awareness in consumers through nutrition and other labeling aspects of the food commodities. Media coverage has also started playing an important role in consumer decision making. Negative health information significantly affects the demand for a commodity while positive information increases the demand for the commodity. Indirectly, media affects the profitability of the companies by changing the perceptions of the consumers. The first case of the outbreak of BSE in the United States also caught a lot of media attention and a number of articles focused on its link to a human disease variant Creutzfeldt-Jakob disease (vCJD). The media attention led to a decline in the sales of beef in the United States. This study is an attempt to focus on the impact of BSE on the security prices of publicly traded securities for agribusiness firms in the US including the impact on the major restaurant chains which have been overlooked in previous studies of the market impact of the BSE. The major contribution of this paper is in terms of the sensitivity analysis for the estimation period of normal returns. The first case of BSE, commonly known as the Mad Cow Disease in the United States was reported in December 2003. Earlier during the same year in May, the first case of the mad cow disease was reported in Canada which was also the first reported case in North America. Therefore, it is justified to hypothesize that the May 2003 outbreak in Canada had an impact on stock prices in the

United States also. If the efficient market hypothesis is to be believed then the stock prices in the United States would have already adjusted to the new information that arrived in May 2003. This paper therefore aims to first analyze the impact of the May event on the stock prices in the United States and conduct a sensitivity analysis by taking different estimation periods to analyze the impact of the December 2003 event on the stock prices in the United States. Another important contribution of this study is that the companies are grouped into different sectors and along with the aggregate results, group wise results are also reported. Individual company-wise results are also discussed under each group. We included an important sector in our analysis – the *restaurant sector* which has not been discussed in detail in the previous studies. Restaurant sector in 2008 has a total market capitalization of 92.4 billion dollar (Source: Yahoo! Finance). Due to the size of the market capitalization of this sector its inclusion in this study would provide a better picture of the effects of Bovine Spongiform Encephalopathy (BSE) on the security prices in the United States. The present study reports the results for both Ordinary Least Squares (OLS) and Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models.

2. Timeline of BSE and Literature Review

2.1. BSE in North America

The first native-born case of BSE on the North American continent was reported on May 20, 2003 in central Alberta, Canada. After six months the first case of mad cow disease in the United States was announced on December 23, 2003 in Washington State.

By May 2009, a total of 20 cases of BSE had been found in North America out of which three were identified in the United States and 17 in Canada (Source: www.cdc.gov).

2.2 Literature Review

Previous studies have looked into the impact of BSE on the consumer demand, cattle prices, stock prices and the international competitiveness of the affected countries. Peterson and Chen (2005) analyze the impact of BSE on Japanese meat demand by applying the Rotterdam model to retail meat demand in Japan. They found that Japanese meat demand underwent a transition period after the outbreak of BSE in Japan in 2001. Burton and Young (1996) analyzed the impact of BSE on demand for meat in Great Britain using an AIDS model and found that BSE outbreak had a significant short run as well long run impact on beef market share in Great Britain. Schlenker and Villas-Boas (2006) analyzed the impact of the actual outbreak of Mad Cow Disease and a report shown on television seven years before the outbreak that talked about the adverse impact of BSE on health; on consumer and financial markets in the United States. They used scanner data to examine the impact on the beef sales in the US and found significant reduction in the beef sales after the first native case. They found that the effects were not persistent. Peng, McCann-Hiltz, and Goddard (2004) studied the impact of BSE on meat demand in Alberta, Canada. They estimated an AIDS model using scanner data from 2001-2004. They included an index for media coverage and found that media coverage about mad cow disease had a negative impact on demand for beef while it led to a positive impact on the demand for pork. McCluskey, Grimsrud, Ouchi, and Wahl (2005) analyzed the factors that affect the consumers' willingness to pay price premiums for

BSE-tested beef by Japanese consumers. They found the three main factors that positively affect the consumers' WTP price premium for BSE tested beef are - reduced beef consumption after BSE announcement, food safety attitudes and being a female. They also found that consumers who were surveyed were willing to pay greater than 50% premium for BSE-tested beef. Ishida, Ishikawa, and Fukushige (2007) examined the impact of BSE and bird flu on Japanese meat demand using an almost ideal demand system and found that there was a decline in demand for beef (due to BSE) and chicken (due to bird flu) after the outbreaks whereas the markets for substitute products such pork and fish gained significantly. They also found that impact of BSE was more persistent and took longer time to stabilize than the impact of the bird flu. Impact of BSE is seen as having more long term impact, that is, the shift in the demand for beef was permanent. Henson and Mazzocchi (2002) analyzed the impact of BSE outbreak in the United Kingdom in 1996 on the equity prices of some selected 24 agribusiness firms. They used event study methodology (ESM) to estimate the impact of mad cow disease on stock returns in the food sector. They estimated the benchmark market model using three different methodologies, viz, ordinary least squares (OLS), Scholes -Williams approach and autoregressive distributed lag model (ARDL). Their results indicate that the processors of beef, dairy products, animal feed and pet food were negatively affected by BSE outbreak. Producers of other meat products seemed to have gained due to BSE crisis. Some of the sectors such as animal feed and pet food that were not directly associated with beef sector took time to react to the news. Jin and Kim (2008) analyzed the impact of BSE outbreak in the United States in 2003 on stock prices of agribusiness and food processing firms. They used data on 23 companies to estimate the impact using event study methodology. They estimated the benchmark model using OLS and ARDL approaches. They found that firms in the “other” meat sector had positive abnormal returns whereas firms under ranch and dairy sector did not react to the news. They found that the effects of BSE on returns extended beyond day 1 to day 2 and day 3 but the effects disappeared with time.

3. Methodology

3.1. Modeling of Abnormal Stock Returns

Event study methodology has emerged as an important way to measure the impact of an event or series of events on stock price returns. This methodology is widely used today in various fields of research mainly finance, economics and accounting to measure the economic impact of a specific event or series of events. The main idea behind event study methodology is to measure the abnormal returns of the securities due to the event. Event study methodology has particularly been useful in quantifying the effects of the events such as firm splits, mergers & acquisitions, dividend announcements, changes in government regulations, changes in the interest rates etc on the value of the firms using the available financial data. The first pioneering work using event study was done by Fama, Fisher, Jensen, and Roll (1969). Their study focused on using a market model to study how information about common stock splits effects the stock prices. Since then there has been lot of research using event study methodology to estimate abnormal returns of securities due to certain events. Brown and Warner (1980) found that the simple market model used in event studies to measure abnormal returns performs really well under varied conditions. Campbell, Lo, and Mackinlay (1997) give an excellent outline of the event study procedure by breaking it into seven steps. The first step is to identify the event and define the event window. Event window is defined as the period over which the behavior of the securities is examined. In the present study, the event is defined as the announcement of the first native case of the mad cow disease in the United States on December 23, 2003. Since the announcement was made after the markets closed on December 23, the first day of the event is taken as December 24, 2003. The event window includes pre-announcement and post-announcement days. If zero is treated as the day when the news came out, the present study included 5 days prior to the event and 10 days post announcement in the event window to study if the stocks had shown any unusual behavior in the pre-announcement days lest there was any information leakage. The second step in the event study analysis is to select the firms for analysis. The firms that are included in the present analysis are some of the major agribusiness firms and restaurants publicly listed in the United States. A detailed description of the data is given in section 6**.** The third step in event study is to calculate the normal and the abnormal returns of the securities chosen in step 2. The normal returns of the securities can be measured using a model like the constant-mean return model or the market model. The market model assumes a stable linear relationship between the market return and the security return (Mackinlay 1997). For the present analysis, market model was used to estimate the normal returns. Market model is defined as

$$R_{s,t} = \alpha_s + \beta_{s,t} R_{m,t} + \varepsilon_{s,t} \quad (1.1)$$

where $R_{s,t}$ is the return on security s on day t. $R_{m,t}$ shows the return on aggregate weighted securities in the market. The popular choices for market return are the indices provided by Center for Research in Security Prices (CRSP) such as CRSP value weighted index , CRSP equally weighted index and Standard and Poor's S&P (500) index (Mackinlay 1997). For the present analysis CRSP equally weighted market index was used. The estimation period for calculating the normal returns was a total of 255 days ending 10 days prior to the event. The next step is to calculate the abnormal return which is calculated as the difference between the actual returns and the expected normal returns. Abnormal returns is defined as

$$AR_{s,t} = R_{s,t} - (\alpha_s + \beta_{s,t} R_{m,t}) \tag{1.2}$$

where $AR_{s,t}$ is the abnormal return of stock *s* on day *t*. $R_{s,t}$ is the realized or the actual return on security *s* on day *t*. α and β are the parameters to be estimated. The parameters of the market model can be estimated using ordinary least squares technique (OLS) which assumes that $E(\varepsilon_{s,t}) = 0$ and $Var(\varepsilon_{s,t}) = \sigma^2$. The problem with OLS estimation is that it assumes that the error term is homoscedastic and there is no serial correlation which would be an invalid assumption for financial data. Therefore estimation of the market equation using OLS would be misleading. Therefore, to avoid this problem it is better to estimate equation (1.1) using a different approach which accounts for heteroskedasticity and serial correlation. General Autoregressive Conditional Heteroskedastic (GARCH, Bollerslev 1986) is a popular alternative method of estimating the model parameters to calculate abnormal returns of securities. This paper considers GARCH (1, 1) to estimate the market model. The GARCH (1, 1) can be expressed as:

$$R_{s,t} = \alpha_s + \beta_{s,t} R_{m,t} + \varepsilon_{s,t} \qquad (1.3)$$

where $\varepsilon_{s,t} \sim N(0, h_{i,t})$

and where $h_{i,t}$ the variance of the error term is is defined as:

$$h_{s,t} = \gamma_s + \nu_s h_{s,t-1} + \omega \varepsilon_{s,t-1}{}^2 \qquad (1.4)$$

3.2. Tests of Significance

The significance of the abnormal returns can be tested using either parametric tests or non-parametric tests. Serra (2002) gives a brief description of the event study tests. To test the significance of the abnormal returns this paper focuses on only parametric tests of significance though the non-parametric test results are also reported to check the robustness of the results. The most commonly reported parametric test using OLS is the Patell-Z test (Patell 1976) and Crude Dependence Adjustment (CDA) test with GARCH. The main idea of using non-parametric tests is these tests do not rely os12n any assumptions and therefore are more reliable. Since this paper also reports the GARCH results, which takes account of non-normality of the data, we can rely on parametric tests for our analysis. Campbell, Lo, and Mackinlay (2007) discuss that the non-parametric tests are generally used along with parametric tests and not in isolation. The non-parametric Generalized sign Z test is also reported in this paper.

4. Data Description

The data for the present paper has been taken from the Center for Research in Security Prices (CRSP) provided by Wharton Research Data Services (WRDS). The variable needed to run the EVENTUS software on WRDS is PERMNO which is a unique number that identifies an individual stock. Using the PERMNO and the event date the EVENTUS runs event study with the user defined specifications for methods, event window and estimation window. Forty-eight companies have been used for analyzing the impact of the mad cow disease on returns of stocks of major agribusiness firms and restaurants listed in the United States. These 48 publicly listed companies were chosen on the basis of market capitalization and data availability. All the 48 companies were classified into 7 major groups using Yahoo finance industry classification. The sectors included in the analysis are – *dairy* (group 1, 3 companies), *Farm Products* (group 2, 7 companies), *Food Major Diversified* (group 3, 4 companies), *Food Wholesale* (group 4, 4 companies), *Meat Products* (group 5, 7 companies), *Processed and Packaged Goods* (group 6, 9 companies) and *Restaurants* (group 7, 14 companies). A list of all the 48 companies included in the analysis along with the group classification and ticker symbol is given in table 1A in the appendix.

5. Results: Impact on Stock Returns

5.1. Impact of May 2003 Announcement of BSE in Canada on US Stock Price

5.1.1. Aggregate Impact

Event study analysis was done to analyze the impact of May 2003 event on the stock prices of selected agribusiness firms (48 companies) categorized into seven different groups. Event study results (table 1.1) showed no significant abnormal returns when the analysis was run for all the companies classified into groups using OLS and GARCH estimation methods. To check the robustness of the results, the event window was increased to (-14, +10) and (-14, +30) days. Increasing the event window brought about only a small change in the results. OLS results showed that there were negative abnormal returns for (-14, -2) days but GARCH results showed no significant abnormal returns. The mean cumulative abnormal returns were not significant on the day of the announcement and post announcement with all the three different event windows using both OLS and GARCH. This could be due to the fact that information was already present in the market before the day of the announcement that a cow was being tested for BSE in the labs. So when the actual announcement was made markets did not react much. It could also be due to the fact that the case was native to Canada though it was the first ever case of North America. The selected sample could also be such that the aggregate impact of the May event was not huge. The same analysis was run using GARCH and again no significant abnormal returns were found for the May event (table 1.2). Group and company-wise analysis shows that some companies gained while some showed negative abnormal returns and therefore, it is possible that the net effect of the announcement cancelled out and did not show any abnormal returns at an aggregate level. The group and company-wise analysis discussed below are for (-5, +10) event window.

5.1.2. Group Analysis

Event study analysis was run for all the seven groups using OLS as well as the GARCH market model estimation methods. Table 1.3 reports the results for May event using OLS and GARCH for all the seven sectors.

Table 1.1
Mean CAR values for May 2003 event (OLS) using equal group weights

Days	N	Mean CAR	Patell –Z (p-value)	Generalized Sign Z (p-value)
(-5,-2)	7	-0.53%	0.1392	0.1293
(-1,0)	7	0.46%	0.2051	0.3512
(+1, +10)	7	0.50%	0.3225	0.3512

The symbols >>, >, ^, * represent the significance level at 0.10, 0.05, 0.01 and 0.001 levels, respectively. N = number of groups (each group given equal weight).

Table 1.2
Mean CAR values for May 2003 event (GARCH) using equal group weights

Days	N	Mean CAR	CDA test (p-value)	*Generalized Sign Z (p-value)*
(-5,-2)	7	-0.54%	0.3514	*0.1356*
(-1,0)	7	0.43%	0.3349	*0.3403*
(+1, +10)	*7*	*0.56%*	*0.4007*	*0.3403*

The symbols >>, >, ^, * represent the significance level at 0.10, 0.05, 0.01 and 0.001 levels, respectively. N = number of groups (each group given equal weight).

5.1.3. Dairy Sector Analysis (Group1)

Dairy sector (Group 1) which included three major dairy firms did not show any significant abnormal returns with both the methods. However, the apriori expectation was that BSE announcement would negatively affect the overall dairy sector. Lifeway Foods showed significant positive cumulative abnormal returns prior to the actual announcement of the outbreak of BSE using both OLS as well as GARCH. Wimm Bill showed positive cumulative abnormal returns after the day of the announcement for (+1, +10) days. Wimm Bill is Russia's largest dairy company and operates in Russia, Ukraine, Georgia and Central Asia. Its main products include juices, nectars and baby foods.

Wimm Bill's product diversification, production sites and the target markets could possibly explain the positive abnormal returns for the company. Tofutti did not show any significant results though one would expect that this company would have gained due to the announcement of the mad cow disease because Tofutti focuses only on Soya-based foods.

5.1.4. Farm Sector Analysis (Group 2)

The overall farm sector did not show any significant abnormal returns using OLS as well as GARCH. The individual company-wise results also showed no significant abnormal returns for any of the seven companies that were selected in the study.

5.1.5. Food Wholesale Sector Analysis (Group 3)

The overall food wholesale sector showed no significant abnormal returns either prior to the announcement or after BSE announcement. This could be due to the fact that all the four companies that were chosen are both into food and non-food distribution.

5.1.6. Food Major Diversified Sector Analysis (Group 4)

The overall food major diversified sector did not react to BSE news. Unilever PLC showed significant cumulative abnormal returns during (-5,-2) days and (-1, 0) days with OLS and GARCH methods of estimation. One of the reasons for the gain could be due to the fact that Unilever PLC is based in England and its products are diversified - includes food, personal care products, consumer products and beverages. The other three companies – Heinz (known for Ketchup and other processed foods), Lancaster Colony Corp (produces specialty foods such as salads and pastas) and Krafts Foods Inc (known for cheese and cookies and crackers) did not show any significant abnormal returns. The reason for no reaction could be because all the above three companies are not major dairy or beef producers or substitutes for dairy or beef.

5.1.7. Meat Products Sector Analysis (Group 5)

The overall meat products sector showed significant negative abnormal returns during (-5,-2) days and significant positive abnormal returns during (-1, 0) days. Tyson Foods Inc showed negative abnormal returns (-6.5% approx) for (-5,-2) days using both OLS and GARCH methods. Though Tyson is known as the largest chicken producer in the US the significant negative abnormal returns could be due to the fact there were talks going on to buy IBP Inc (major beef and pork producer) in 2001. The deal was finalized weeks after BSE announcement but the information about the potential deal between Tyson and IBP could have affected Tyson's returns significantly. Sanderson Farms which is mainly a poultry producer gained significantly after BSE test was confirmed. The mean cumulative abnormal return for Sanderson Farms was around 9% during (+1, +10) days. Pilgrims Pride Corporation, a chicken processing firm also gained significantly around the days of the announcement. The mean cumulative abnormal returns for Pilgrims Pride was around 8% around (-1, 0) days. The other firms in the meat products sector did not show any significant abnormal returns.

5.1.8. Processed and Packaged Foods Sector Analysis (Group 6)

Processed and Packaged Foods sector showed significant negative abnormal returns prior to the announcement (-5,-2) days and significant positive abnormal returns after the announcement (-1, 0) days using only OLS. GARCH results showed no significant abnormal returns for this group. Using OLS method we found that only one company reacted prior to the announcement. Unilever NV showed negative abnormal returns of -5.39% during (-5,-2) days but showed positive abnormal returns of 3.67% after the announcement was made (-1, 0) days. The fact that only one company showed reaction in terms of negative abnormal returns prior to the announcement explains why the overall processed and packaged foods sector showed negative abnormal returns around (-5,-2) days. Using OLS method of estimation we found that besides Unilever NV, two major companies namely, ConAgra Foods and Campbell Soup Company showed positive abnormal returns. ConAgra showed a positive abnormal return of 7.99% after the announcement was made (+1, +10) days. Campbell showed a positive abnormal return of 9.11% around (-1, 0) days. GARCH method of estimation showed that Unilever NV made positive abnormal returns around (-1, 0) days of about 3.64%, ConAgra gained 9.56% during (+1, +10) days after the announcement and Campbell showed positive abnormal returns of 9.22% around (-1, 0) days. All the above three companies that gained due to the announcement engage in diversified products. They are not into processing of only beef products.

5.1.9. Restaurants Sector Analysis (Group 7)

The OLS and GARCH results showed negative abnormal returns of around 2.6% for the overall restaurant sector during (-1, 0) days. Looking at the individual company-wise results, out of the fourteen restaurants that were selected in the sample, only three restaurants showed reaction to the news. OLS and GARCH results showed that only three restaurants – Wendy's International Inc, McDonald's Corporation and Bob Evans Farms Inc showed negative mean cumulative abnormal returns. Using OLS we found that only one company reacted to the news prior to the announcement. Bob Evans which is known for its meat and pork products showed a negative abnormal return of 5.29% during (-5, -2) days. Bob Evans also showed a negative abnormal return for (-1, 0) days using both OLS and GARCH. Wendy's and McDonald's showed significant negative abnormal returns of around 7% using both OLS and GARCH.

5.2. Impact of December 2003 Announcement of the First BSE Case in the United States on the US Stock Prices

5.2.1. Aggregate Impact

Event study analysis showed that December 2003 announcement of the first ever case of BSE in the United States had a negative impact on the overall agribusiness sector. OLS and GARCH results show that for (+1, +10) days after the announcement all the groups combined together showed abnormal returns of -3.79% (OLS) and -3.68% (GARCH).

The aggregate analysis was run for December 2003 event using new event windows of (-5, +15) and (-5, +30) to see if the cumulative abnormal returns persisted in the longer event window. It was found that as the event window was extended to (-5, +30) days, the mean CAR value for (+1, +30) window became insignificant. The mean CAR is plotted in figure (1A) and figure (1B) in the appendix for the above mentioned windows. We can see that there was initially less reaction (could be due to the fact that it was a holiday season) and then we see a sharp drop and after 15 days it starts gaining.

Table 1.3
Mean CAR values for May 2003 event using OLS and GARCH (1, 1) for all seven sectors

Sector	Days	N	Mean CAR with OLS	p-value	Gener-alized sign Z (p-value)	Mean CAR with GARCH	p-value	Gener-alized sign Z (p-value)
Dairy Sector	(-5,-2)	3	3.46%	0.2282	0.3090	3.42%	0.1852	*0.2095*
	(-1,0)	3	-0.46%	0.3575	0.3090	-0.80%	0.3834	*0.3609*
	(+1,+10)	3	2.49%	0.1463	0.2555	3.33%	0.2904	*0.3609*
Farm Sector	(-5,-2)	6	-0.33%	0.3997	0.1671	-0.25%	0.4548	*0.1655*
	(-1,0)	6	-0.82%	0.2786	0.4414	-0.83%	0.2971	*0.4388*
	(+1,+10)	6	3.32%	0.1422	0.0046^	3.64%	0.1481	*0.0046^*
Food Major Diversified	(-5,-2)	4	-2.34%	0.1051	0.0205>	-2.25%	0.1608	*0.0190>*
	(-1,0)	4	1.57%	0.1104	0.0252>	1.62%	0.1560	*0.0270>*
	(+1,+10)	4	-0.45%	0.4708	0.4828	-0.24%	0.4730	*0.4703*
Food Wholesale	(-5,-2)	4	2.21%	0.3730	0.1502	2.68%	0.2640>	*0.1625*
	(-1,0)	4	1.21%	0.3264	0.1502	1.40%	0.3207	*0.1625*
	(+1,+10)	4	-3.45%	0.1646	0.0247>	-2.11%	0.3766	*0.1549*
Meat Products	(-5,-2)	7	-3.49%	0.0241>	0.0322>	-3.40%	0.0521>.>	*0.0307>*
	(-1,0)	7	2.56%	0.0349>	0.0268>	2.57%	0.0417>	*0.0281>*
	(+1,+10)	7	-1.01%	0.4211	0.3380	-0.68%	0.4182	*0.3456*
Processed and Packaged goods	(-5,-2)	9	-2.66%	0.0078^	0.0016^	-2.60%	0.1122	*0.0017^*
	(-1,0)	9	1.85%	0.0080^	0.0432>	1.78%	0.1201	*0.3436*
	(+1,+10)	9	1.40%	0.2062	0.1472	1.87%	0.2904	*0.1424*
Restaurants	(-5,-2)	14	-0.46%	0.3157	0.3072	-0.42%	0.4396	*0.4998*
	(-1,0)	14	-2.65%	0.0014^	0.0175>	-2.66%	0.0891>>	*0.0163>*
	(+1,+10)	*14*	*1.26%*	*0.2251*	*0.4878*	*1.42%*	*0.3740*	0.1424

The symbols >>, >, ^, * represent the significance level at 0.10, 0.05, 0.01 and 0.001 levels, respectively.
N is the number of companies within each sector/group.

The markets adjust back showing there was initially over reaction in the market, hence implying that the effects of the mad cow disease were not persistent. The aggregate impact results for December 2003 event are in tables 1.4 and 1.5.

5.2.2. Dairy Sector Analysis (Group 1)

The dairy sector did not show any significant abnormal returns using OLS as well as GARCH. Company-wise analysis also showed no reaction to the announcement of the mad cow disease in the United States.

5.2.3. Farm Sector Analysis (Group 2)

All the farm sector firms taken together showed negative abnormal returns of 3.05% (OLS) and 3.44% (GARCH) prior to the announcement (-5,-2) days. Aggregate farm sector reacted positively during (-1, 0) days. It showed a positive abnormal return of 4.62% (OLS) and 4.43% (GARCH). Post announcement (+1, +10) days showed negative abnormal returns at 6.27% (OLS) and 7.49% (GARCH). Company-wise analysis shows mixed response to the news which explains the above numbers for the aggregate data. The Andersons, Inc showed positive abnormal returns 3.05% (OLS) and 2.89%

Table 1.4
Mean CAR values for Dec 2003 event (OLS) using equal group weights

Days	N	Mean CAR	Patell –Z (p-value)	Generalized Sign Z (p-value)
(-5,-2)	7	-0.25%	0.2848	*0.3166*
(-1,0)	7	0.27%	0.1715	*0.1502*
(+1, +10)	*7*	*-3.79%*	*0.0008**	*0.0054^*

The symbols >>, >, ^, * represent the significance level at 0.10, 0.05, 0.01 and 0.001 levels, respectively.N = number of groups (each group given equal weight).

Table 1.5
Mean CAR values for Dec 2003 event (GARCH) using equal group weights

Days	N	Mean CAR	CDA test (p-value)	Generalized Sign Z (p-value)
(-5,-2)	7	-0.21%	0.4139	*0.3198*
(-1,0)	7	0.29%	0.3382	*0.1481*
(+1, +10)	*7*	*-3.68%*	*0.0080^*	*0.0359>*

The symbols >>, >, ^, * represent the significance level at 0.10, 0.05, 0.01 and 0.001 levels, respectively. N = number of groups (each group given equal weight).

(GARCH) during (-1, 0) days. Andersons is not into meat production or processing which explains the gain. It is primarily into buying and reselling of corn, soybeans and wheat. Bunge Limited, an oilseed processing firm, also gained during (-1, 0) days, which showed a positive abnormal return of 3.9% (OLS) and 3.84% (GARCH). Cal-Maine Foods, a major poultry firm gained significantly at 14.71% (OLS) and 15.30% (GARCH) during (-1, 0) days. GARCH results showed that Cal-Maine had negative abnormal returns around (+1, +10) days at 19.73%.

5.2.4. Food Wholesale Sector (Group 3)

The food wholesale sector showed negative abnormal returns after the announcement during (+1, +10) days of about 6.04% (OLS). The GARCH output did not show any significant results. Performance Food Group showed significant abnormal returns after the announcement during (+1, +10) days of about 12% using OLS as well GARCH.

5.2.5. Food Major Diversified (Group 4)

All the major food diversified firms taken together did not show any significant abnormal returns for the selected event window. Heinz Company which produces processed foods such as soups and appetizers other than the sauces and ketchups that the company is known for showed a significant negative abnormal return during (+1, +10) days of about 5.14% (OLS) and 5.06% (GARCH). The other three companies – Kraft Foods, Lancaster Colony and Unilever PLC did not show any significant abnormal returns.

5.2.6. Meat Products (Group 5)

The overall meat products sector showed significant positive abnormal returns during (-1, 0) days of about 1.98 % (OLS) and 2.04% (GARCH). But this sector showed significant negative abnormal returns during the post announcement event window of (+1, +10) days at 4.39% (OLS) and 4.04% (GARCH). Within this group there was mixed reaction among the companies. Some companies gained significantly around the event date and therefore, the overall reaction of this sector can be seen as a positive abnormal return during (-1, 0) days. But once the announcement was made, some of the companies reacted adversely and the overall reaction of the meat sector showed negative abnormal returns during the post announcement period.

5.2.7. Processed and Packaged Foods Sector Analysis (Group 6)

All the nine companies taken together under processed and packaged foods sector showed negative abnormal returns of 1.22% during (-5,-2) days and about negative 1.5 % during (+1,+10) days using OLS. GARCH results did not show any significant results for the overall impact. Individual company wise analysis showed that Campbell Soup showed negative abnormal returns of 5.28% and 5.64% using OLS and GARCH respectively during (+1,+10) days after the announcement was made. General Mills showed negative abnormal returns before the actual announcement was made. Since General Mills is a major cereal producer in the United States, the reason for the negative abnormal returns could be due to some other factor other than the BSE effect. It could be something specific to the company or some other news that might have affected the returns for General Mills. McCormick & Company which is a major producer of spices, sauces and seasonings (including beef seasoning mixes and sauces) reacted negatively before the actual announcement was made. It showed negative abnormal returns of 2.8% approximately using both OLS and GARCH. Unilever NV showed positive abnormal returns of 6.54% during (+1, +10) days after the announcement was made using GARCH. This is could be due to the fact that Unilever has diversified products base. The rest of the companies under this group did not show any significant reaction.

5.2.8. Restaurants (Group 7)

All the fourteen companies taken together under the restaurants sector showed positive abnormal return of 1.67% during (-5,-2) days using OLS. Once the announcement was made this sector showed negative abnormal returns of about 1.43% using OLS during (-1, 0) days. After the announcement this sector showed negative abnormal returns during (+1, +10) days of about 5% using OLS and GARCH. Individual company wise analysis showed mixed response. Bob Evans Farms which sells mainly pork and meat products showed negative abnormal returns at about 9.5% during (+1, +10) days using OLS and GARCH. CBRL Group known for its roasted beef dishes showed negative abnormal returns of about 7% using OLS and GARCH during (+1, +10) days. Darden Restaurants which operates chain of restaurants - Red Lobster, Oliver Garden and LongHorn Steakhouse showed negative abnormal returns once the announcement was made. During (+1, +10) days after the announcement, Darden showed negative abnormal returns of about 10% using OLS and GARCH. Family restaurant IHOP (now known as DineEquity, Inc) showed negative abnormal returns at 6.25% using OLS and GARCH during (+1, +10) days. Jack in the Box known for its hamburgers and Mexican grill eateries showed negative abnormal returns of about 4% during (1,0) days of the announcement using OLS and GARCH. McDonald's Corporation also showed negative abnormal returns immediately after the announcement (-1, 0) days of about 5% using OLS and GARCH. P.F Chang's China Bistro showed negative abnormal returns of about 11% during (+1, +10) days of the announcement. Panera Bread Company known for its fresh bakery products showed positive abnormal returns of about 6% after the announcement (+1, +10) days. Red Robin Gourmet Burgers showed positive abnormal returns before the announcement. It showed positive abnormal returns of about 8% during (-5, -2) days. This could be due to factors specific to the company or some other economic news that might have affected the returns. It showed negative abnormal return of about 11% during (+1, +10) days after the announcement using OLS but GARCH results did not show any significant results. Sonic Corp – known for its drive through chains offering hamburgers and burritos showed negative abnormal returns immediately after the announcement was made. It showed negative abnormal returns of about 3.6% during (-1, 0) days of the announcement. Wendy's Group known for its specialty burgers

Table 1.6
Mean CAR values for Dec 2003 event using OLS and GARCH (1, 1) for all seven sectors

Sector	Days	Mean CAR with OLS	p-value	Generalized sign Z (p-value)	Mean CAR with GARCH	p-value	*Generalized sign Z (p-value)*
Dairy Sector	(-5,-2)	0.43%	0.3402	0.1837	0.85%	0.3959	*0.2012*
	(-1,0)	-1.27%	0.2793	0.0741	-1.07%	0.3204	*0.0672****
	(+1,+10)	-2.09%	0.4688	0.3928	-0.78%	0.4395	*0.3708*
Farm Sector	(-5,-2)	-3.99%	0.0413**	0.1670	-3.43%	0.0380**	*0.1366*
	(-1,0)	4.16%	0.0012*	0.0024*	4.43%	(0.0006)	*0.0269***
	(+1,+10)	-8.90%	0.0058*	0.0424**	-7.36%	0.0081*	*0.0320***
Food Major Diversified	(-5,-2)	0.93%	0.1844	0.0212**	1.00%	0.2066	*0.0220*
	(-1,0)	-0.18%	0.4198	0.4884	-0.14%	0.4357	*0.1552*
	(+1,+10)	0.43%	0.3817	0.4884	0.64%	0.3708	*0.4942*
Food Wholesale	(-5,-2)	1.03%	0.4652	0.1517	1.04%	0.2945	*0.1725*
	(-1,0)	-1.15%	0.3051	0.1517	-1.15%	0.0220**	*0.2838*
	(+1,+10)	-5.02%	0.0074*	0.1517	-5.02%	0.0242**	*0.0444***
Meat Products	(-5,-2)	-0.77%	0.2868	0.1725	-0.73%	0.2945	*0.1725*
	(-1,0)	1.92%	0.0253**	0.2838	1.94%	0.0220	*0.2838*
	(+1,+10)	-4.38%	0.0062*	0.0444**	-4.25%	0.0242	*0.0444*
Processed and Packaged goods	(-5,-2)	-1.13%	0.0263**	0.1610	-1.12%	0.1316	*0.1540*
	(-1,0)	-0.24%	0.3145	0.0488**	-0.23%	0.3727	*0.0459***
	(+1,+10)	-1.03%	0.1180	0.0488**	-1.00%	0.2638	*0.0459 ***
Restaurants	(-5,-2)	1.76%	0.0672***	0.1241	1.82%	0.1203	*0.1365*
	(-1,0)	-1.39%	0.0168**	0.0644***	-1.36%	0.1070	*0.0575 ****
	(+1,+10)	*-4.64%*	*0.0002**	*0.0048**	*-4.56%*	*0.0313***	*0.0041**

The symbols >>, >, ^, * represent the significance level at 0.10, 0.05, 0.01 and 0.001 levels, respectively. N is the number of companies within each sector/group.

and roast beef showed negative abnormal returns of about 3.7% once the announcement was made during (-1,0) days.

6. Sensitivity Analysis

The analysis was run for a new estimation window of 138 trading days after the May 2003 event occurred to check if including the May 2003 event in the estimation window led to some wrong conclusions. The results (Table 1.7) show that changing the estimation window did not change the previous findings significantly.

7. Policy Implications

These results would help businesses in formulating new strategies in case of future food scare events to mitigate any losses that might occur. For example, McDonald's can publish information on their website that they do not use parts of beef that can cause vCJD or if a company's major share of products do not contain beef or its products then they can promote their products to inform consumers.

8. Conclusion

The above analysis showed that the firms did not respond significantly to the announcement in May 2003 but the same firms did react to the news of BSE in the United States in December 2003. One of the possible reasons why the overall agribusiness sector did not react to the news about the outbreak of BSE in Canada in May 2003 is that information was already present in the market since January 2003 that a cow was being tested for BSE. But the December 2003 event was unexpected, and therefore companies reacted. Out of the seven groups chosen for the present study the farm

Table 1.7
Mean CAR values for December 2003 event with a new estimation window

Sector	Days	Mean CAR with OLS	p-value	Gener-alized sign Z (p-value)	Mean CAR with GARCH	p-value	Gener-alized sign Z (p-value)
Dairy Sector	(-5,-2)	0.43%	0.3402	0.1837	0.85%	0.3959	*0.2012*
	(-1,0)	-1.27%	0.2793	0.0741	-1.07%	0.3204	*0.0672****
	(+1,+10)	-2.09%	0.4688	0.3928	-0.78%	0.4395	*0.3708*
Farm Sector	(-5,-2)	-3.99%	0.0413 **	0.1670	-3.43%	0.0380**	*0.1366*
	(-1,0)	4.16%	0.0012*	0.0024*	4.43%	(0.0006)	*0.0269***
	(+1,+10)	-8.90%	0.0058*	0.0424**	-7.36%	0.0081*	*0.0320***
Food Major Diversified	(-5,-2)	0.93%	0.1844	0.0212**	1.00%	0.2066	*0.0220*
	(-1,0)	-0.18%	0.4198	0.4884	-0.14%	0.4357	*0.1552*
	(+1,+10)	0.43%	0.3817	0.4884	0.64%	0.3708	*0.4942*
Food Wholesale	(-5,-2)	1.03%	0.4652	0.1517	1.04%	0.2945	*0.1725*
	(-1,0)	-1.15%	0.3051	0.1517	-1.15%	0.0220**	*0.2838*
	(+1,+10)	-5.02%	0.0074*	0.1517	-5.02%	0.0242**	*0.0444***
Meat Products	(-5,-2)	-0.77%	0.2868	0.1725	-0.73%	0.2945	*0.1725*
	(-1,0)	1.92%	0.0253**	0.2838	1.94%	0.0220	*0.2838*
	(+1,+10)	-4.38%	0.0062*	0.0444**	-4.25%	0.0242	*0.0444*
Processed and Packaged goods	(-5,-2)	-1.13%	0.0263**	0.1610	-1.12%	0.1316	*0.1540*
	(-1,0)	-0.24%	0.3145	0.0488**	-0.23%	0.3727	*0.0459***
	(+1,+10)	-1.03%	0.1180	0.0488**	-1.00%	0.2638	*0.0459 ***
Restaurants	(-5,-2)	1.76%	0.0672***	0.1241	1.82%	0.1203	*0.1365*
	(-1,0)	-1.39%	0.0168**	0.0644***	-1.36%	0.1070	*0.0575 ****
	(+1,+10)	*-4.64%*	*0.0002**	*0.0048**	*-4.56%*	*0.0313***	*0.0041**

The symbols >>, >, ^, * represent the significance level at 0.10, 0.05, 0.01 and 0.001 levels, respectively.
N is the number of companies within each sector/group.

products, food wholesale, processed and packaged goods, meat products and restaurants showed negative reaction once the announcement was made.

Dairy and food major diversified did not show any reaction. Some of the sub sectors within the agribusiness sector reacted more than others. In order to single out the impact on stock returns due to the December event a different normal returns estimation window was taken. The new estimation window was taken as -10 days before the event till May 21, 2003 (a total of 138 trading days). This new estimation window calculated the normal returns for the stocks after the May event took place. The results showed that changing the estimation window did not change the results significantly. The results reported in this paper show both parametric and non-parametric tests of significance. Reporting the non-parametric tests helps in checking the robustness of the results.

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Appendix 1A

Table 1A
List of companies

Company	Sector	Ticker
Lifeway Foods Inc	Dairy	LWAY
Tofutti Brands Inc	Dairy	TOF
Wimm-Bill-Dann Foods OJSC	Dairy	WBD
Alico Inc	Farm Products	ALCO
The Andersons Inc	Farm Products	ANDE
Archer Daniels Midland	Farm Products	ADM
Bunge Limited	Farm Products	BG
Cal-Maine Foods Inc	Farm Products	CALM
Cresud S.A.C.I.F.yA	Farm Products	CRESY
Fresh Del Monte Produce Inc.	Farm Products	FDP
H.J.Heinz Company	Food Major Diversified	HNZ
Kraft Foods Inc	Food Major Diversified	KFT
Lancaster Colony Corporation	Food Major Diversified	LANC
Unilever PLC	Food Major Diversified	UL
Nash-Finch Company	Food Wholesale	NAFC
Performance Food Group (now private)	Food Wholesale	
SYSCO Corporation	Food Wholesale	SYY
United Natural Foods, Inc.	Food Wholesale	UNFI
Balchem Corporation	Meat Products	BCPC
Hormel Foods Corporation	Meat Products	HRL
Pilgrim's Pride Corporation	Meat Products	PGPDQ.PK
Sanderson Farms	Meat Products	SAFM
Seaboard Corporation	Meat Products	SEB
Smithfield Foods Inc.	Meat Products	SFD
Tyson Foods Inc.	Meat Products	TSN
Campbell Soup Company	Processed and Packaged Foods	CPB
ConAgra Foods Inc	Processed and Packaged Foods	CAG
Corn Products International Inc.	Processed and Packaged Foods	CPO
General Mills Inc.	Processed and Packaged Foods	GIS
Kellogg Company	Processed and Packaged Foods	K
McCormick & Company Incorporated	Processed and Packaged Foods	MKC
PepsiCo Inc.	Processed and Packaged Foods	PEP
Sara Lee Corporation	Processed and Packaged Foods	SLE
Unilever N.V.	Processed and Packaged Foods	UN
Bob Evans Farms Inc	Restaurant	BOBE
Brinker International Inc	Restaurant	EAT
CBRL Group Inc. (now known as Cracker Barrel Old Country Store, Inc)	Restaurant	CBRL
Darden Restaurants Inc	Restaurant	DRI
IHOP (now known as DineEquity, Inc)	Restaurant	DIN
Jack in the Box Inc.	Restaurant	JACK

McDonald’s Corporation	Restaurant	MCD
P.F.Chang’s China Bistro	Restaurant	PFCB
Panera Bread Company	Restaurant	PNRA
Papa John’s International Inc	Restaurant	PZZA
Red Robin Gourmet Burgers	Restaurant	RRGB
Sonic Corp	Restaurant	SONC
Wendy’s International Inc	Restaurant	WEN
Yum! Brands Inc.	Restaurant	YUM

Source: Yahoo! Finance Industry Index and Company Index

Appendix 1B

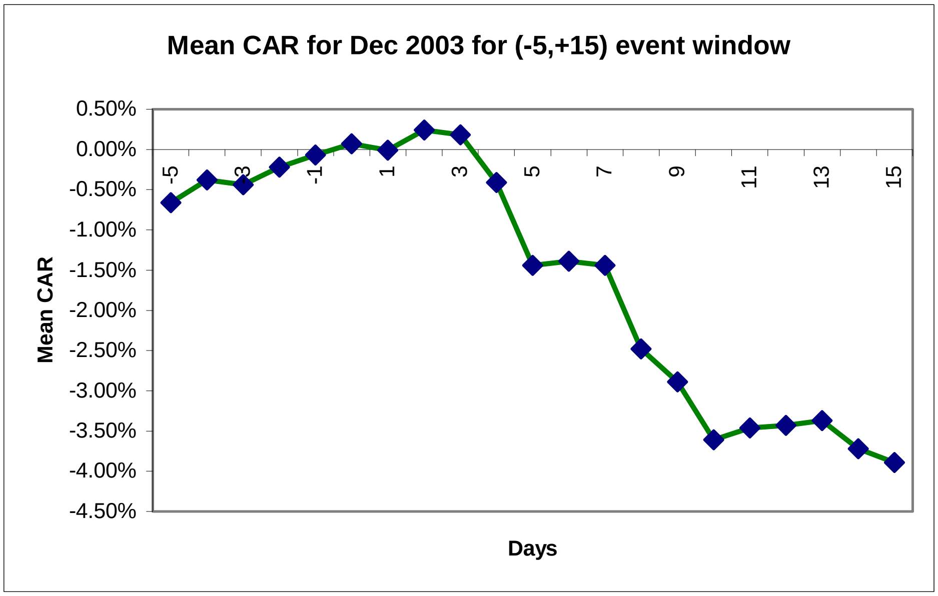

Figure 1A: Mean cumulative abnormal returns for Dec 2003 event with (-5, +15) event window

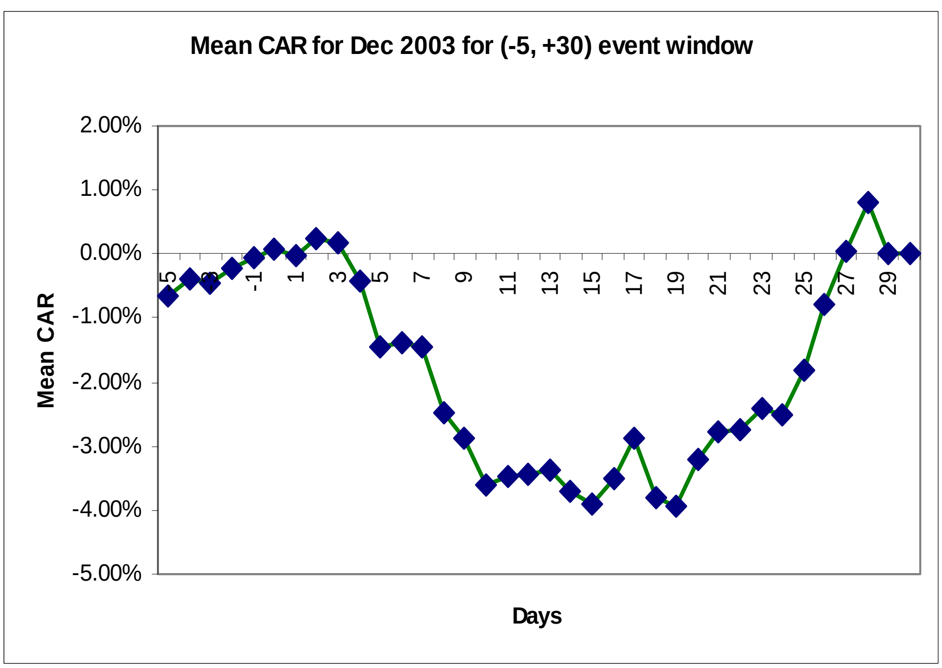

Figure 2A: Mean cumulative abnormal returns for Dec 2003 event with (-5, +15) event window.

ESSAY 2: VERTICAL AND SPATIAL PRICE TRANSMISSION IN BEEF AND RELATED SECTORS AND THE IMPACT OF THE BOVINE SPONGIFORM ENCEPHALOPATHY

Abstract

The objective of this essay is to study the interdependencies among the meat sectors in the United States and to analyze the impact of the first case of BSE outbreak in the United States in December 2003. This essay uses the vector error correction model (VECM) to study the short run dynamics along with long run equilibrium along with directed acyclic graphs (DAG) to study the interdependencies in the meat sectors and historical decomposition techniques to study the impact of BSE on beef, pork and poultry prices. The results of the study indicate interdependencies in the beef, pork and poultry markets in the United States. That is, a shock in one series has an impact on other series too. There is vertical as well spatial price transmission in the meat markets, though the transmission is not perfect. The different speeds of adjustment point to asymmetric price transmission. Also, the magnitude of the mad cow disease shock was different in different markets indicating asymmetry in terms of both speeds of adjustment and magnitude.

1. Introduction

The demand and supply phenomena play a crucial role in determining prices in the meat markets in the United States. Any demand side or supply side shock would lead to a change in the price of the commodity along with changes in the market for its substitutes as well. The first case of BSE in the United States created a widespread media coverage in the United States due to its link to a human disease new variant called Creutzfeldt-Jakob disease (vCJD). There was a sudden decrease in the demand for beef.

The objective of the present paper is to evaluate the effects of BSE on prices in the beef, pork and chicken markets. There is an extensive literature on the impact of food scares on different sectors in different countries. My research focuses on the first and unexpected outbreak of BSE in the United States on December 23, 2003. The current literature on the impact of December 2003 BSE on US economy looks at impacts on – domestic demand for beef and other meats, export demand for US beef, cattle prices, futures prices, price margins etc. This research aims to look at the impact of mad cow disease on price transmission in beef and related meat sectors. The current literature on the impact on farm-level, wholesale and retail prices looks at only the beef sector in the United States. My aim is to extend the research to look at the impact on farm-level, wholesale and retail prices of pork and chicken to look at the interdependence in meat sectors.

2. Literature Review

Jin, Power, and Elbakidze (2008) look at the impact of sixteen North American BSE cases on daily live cattle futures prices for six maturities. Their study looked at the size and persistence of the impact of BSE cases using data from January 4, 1998 to April 1, 2008 for six futures prices. They used recursive time varying cointegration methods to detect structural breaks and found that the structural break falls between the first BSE case in Canada and the first BSE case in the United States. Saghaian (2007) looks at the impact of the BSE discovery in the United States in 2003 on the US beef sector. He uses time series analysis and historical decomposition techniques on weekly price data of farm-level, wholesale and retail beef prices to quantify the impact of BSE along the beef marketing chain. The results in his paper show price transmission is bidirectional and price adjustment is asymmetric with respect to both speed and magnitude. He also found that the BSE had a differential impact on different levels of the marketing chain which further have an impact on the price margins. Saghaian, Maynard, and Reed (2007) analyze the impact of E. Coli (1996), FMD (2000), and BSE (2001) on Japanese beef prices. Their results showed that the Japanese consumers reacted differently to each of the food scares indicating that the Japanese consumers understood and differentiated among the risks. Hassouneh, Serra, and Gil (2009) study the impact of the outbreak of the BSE on the Spanish beef sector. They used a regime switching vector error correction model and found that the BSE affected producers and retailers differently. They found that producer prices are more responsive to shocks than retail prices indicating sticky prices at the retail level. Lloyd, McCorriston, Morgan, and Rayner (2003) studied the impact of the BSE outbreak in the UK on farm and retail prices. They found that the impact of the BSE was greater for farm prices than retail prices. Saghaian, Ozertan, and Spaulding (2008) study the impact of the 2005 outbreak of the H5N1 avian influenza on the Turkish poultry sector. Their results indicate differential impact of the food scare on farm-level and retail prices of poultry and also indicate asymmetric price adjustment in terms of speed and magnitude. Marsh, Brester, and Smith (2007) look at the impact of the BSE outbreak in Canada in May 2003 and the first case of the United States in December

2003 on the US fed and feeder cattle prices. Vavra and Goodwin (2005) provide a detailed description of price transmission theory and marketing margins. One of the most important early works by Gardner (1975) who examined the farm-retail price spreads due to supply and demand shocks. Since then there have been many papers examining the vertical price transmission and the causes of asymmetric transmission. In recent years, the literature has focused on modeling asymmetric price transmission (for example, Tiffin and Dawson (2000), Goodwin and Harper (2000)). In a perfectly competitive market, the price should equal the marginal cost of production. Therefore, if there is no market power, the wholesale price should equal the farm price plus a constant marginal cost. If there is indeed market power the wholesale price should equal the farm price plus a constant (marginal cost) and a percentage of the farm price (Jumah 2004).

3. Theoretical Model on Demand and Vertical Price Transmission

The demand function for beef can be expressed as a function of its own price and other demand shifters like the price of its substitute goods (such as pork and chicken), income of the consumer, and the tastes and preferences of the consumers. If there is negative media coverage about consumption of beef, it would enter the demand equation through the tastes and preferences shifter.

$$demand_{Beef} = f(price_{Beef}, price_{Pork}, price_{Chicken}, income, tastes\ \&\ preferences, othershifters)$$

Other things being constant, if there was a sudden increase in the demand for pork and chicken due to the discovery of mad cow disease then one would assume that the prices of these commodities would have gone up too. The aim of the present paper is to look at the impact (if any) of the mad cow disease outbreak on the prices of beef, pork

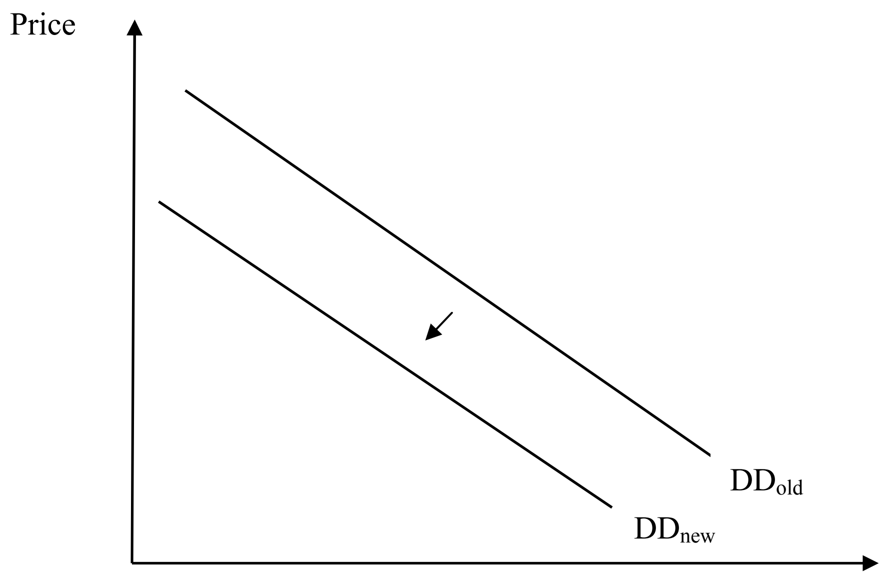

Figure 2.1: Shift in demand for beef

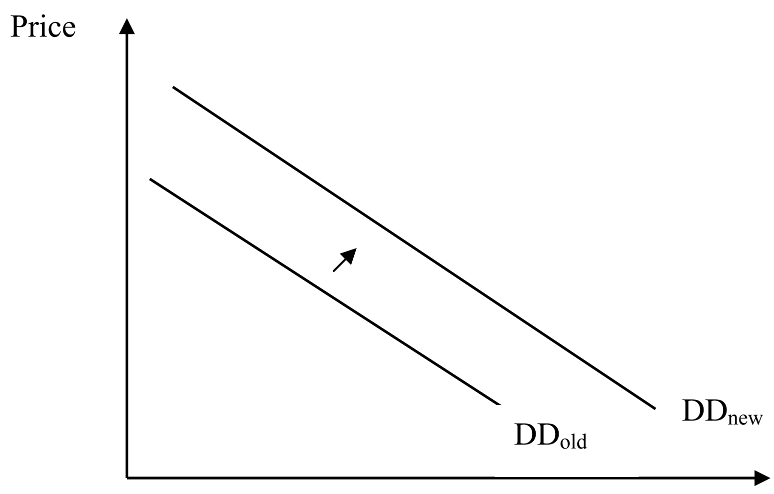

Figure 2.2: Shift in demand for substitutes – pork and chicken

and chicken and also to analyze if there had been any impact on the marketing margins of these commodities.

In a perfectly competitive environment, any change in the farm-level price is shown immediately on the wholesale and retail prices of the commodity. The seminal work of Gardner (1975) led to a number of articles on price transmission. Earlier works focused on unidirectional flow of price changes, that is, any change in the farm-level price would be reflected in the wholesale prices and then on the retail prices (Saghaian 2008). Earlier works therefore focused on a linear equilibrium model such as

$$P_w = P_f + C \tag{2.1}$$

$$P_r = P_w + M \tag{2.2}$$

where P_f, P_w and P_r are farm-level price, wholesale price and retail price, respectively and where C and M are the marketing margins (Bojnec 2002). The above equations describe the theoretical relationship between prices of a commodity in two different marketing channels. The first equation shows that the wholesale price of a commodity is a linear function of the farm-level price of the commodity and the marketing margin. Similarly, retail price is a linear function of the wholesale price and the marketing margin. The marketing margins are also seen as a linear combination of a constant and a mark-up such as

$$C = a + bP_w \tag{2.3}$$

$$M = c + dP_r \tag{2.4}$$

where a and c are constant and b and d are percentage mark-ups of wholesale and retail prices, respectively. In a perfectively competitive market there is no mark-up therefore, the marketing margins are just constants where $C = a$ and $M = c$ representing constant marginal costs.

Empirical work has shown that such linear symmetric vertical price adjustment does not always holds true. Market power leads to positive mark-ups and also leads to asymmetric price adjustments. Asymmetric price adjustment in the vertical chain can be defined in terms of magnitude and speed. Vavra and Goodwin (2005) describe the theory of asymmetric price adjustment in terms of magnitude and speed. They define asymmetry in terms of magnitude as how big (small) the response is at each level of the chain in response to a given size of shock at a different level of the chain. There is asymmetry in price transmission in terms of speed if there are lags in adjustment to the shock. Consequently, price asymmetry in vertical price transmission can exist with respect to magnitude or speed or a combination of both (Saghaian 2007). The evidence on asymmetric price transmission is mixed and depends on the commodities in questions and the countries for which the time series are taken (Vavra and Goodwin 2005).

4. Econometric Modeling

4.1. Vector Error Correction Model

To investigate the impact of BSE on beef and related markets (poultry and pork), this paper uses monthly time series data on the farm value, wholesale value and retail value of beef and pork and the retail and wholesale value for poultry. Because the poultry industry is highly integrated in the United States, the farm value for pork is not reported (USDA, Agricultural Outlook, December 1997). Weekly retail prices of poultry are also not reported therefore, this study uses monthly data to study the impact on prices. This study uses the data reported by Economic Research Service (ERS) on monthly historical price spreads. Because time series data are used, the first step is to test for the stationary of the data series. The series can be tested for stationarity using the Augmented Dickey-Fuller (ADF) test. The monthly series for three meat categories can be written in a vector form

$P_t^{'} = [P_{1t}, P_{2t}, P_{3t}, P_{4t}, P_{5t}, P_{6t}, P_{7t}, P_{8t}]$ where the subscript t represents time and $i = 1,...,8$ is for farm price of beef, wholesale price of beef, retail price of beef, farm price of pork, wholesale price of pork, retail price of pork, wholesale price of poultry and retail price of poultry, respectively. If the series are non-stationary (tested using ADF), the vector P_t can be modeled using an error correction model:

$$\Delta P_t = \prod P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \mu + e_t \tag{2.5}$$

where $\prod$ and Γ are the parameter matrices that we need to estimate. If the rank of the matrix $\prod$ is positive $r < p$ ($p = 8$, the number of series in the model), then there exists a long run information between the series. Consequently the matrix $\prod$ may be written as $\prod = \alpha\beta^{'}$ where the matrix α is the speed of adjustment and matrix β is the cointegrating vector. The long run equilibrium relationship can be tested using Johansen's cointegration test (Johansen 1988, Johansen 1995) which determines the number of cointegrating vectors or the cointegrating rank r. The cointegrating vectors are useful in analyzing short-run reactions and the speeds of the adjustments, trends and long-run equilibria (Saghaian 2007).

4.2. Directed Acyclic Graphs

Historical decomposition is the method to analyze the impact of a shock on a time series. Historical decomposition is derived from the moving average representation of equation (1) (Chopra and Bessler 2005, Park, Jin, and Bessler 2008).

$$x_t = \sum_{i=0}^{\infty} \Theta_i \varepsilon_{t-i} \tag{2.6}$$

The matrix Θ_i is the covariance matrix which summarizes the contemporaneous causal patterns between orthogonal innovations (Park, Jin, and Bessler 2008). The e_t estimated from the ECM may exhibit off-orthogonal contemporaneous correlations, therefore e_t must be converted to orthogonal price innovations (Chopra and Bessler 2005, Park et al. 2008), such that

$$\varepsilon_t = Ae_t \tag{2.7}$$

Directed acyclic graphs are used widely today to determine the causal structure of the correlations in innovations. Earlier techniques such as the Choleski decomposition are recursive in nature (Bessler and Akleman 1998). The other technique is the structural factorization method as proposed by Bernanke (1986) which requires the knowledge of the structural information in order to specify a contemporaneous causal pattern between innovations. Directed graph algorithms place zeros on the A vector to orthogonalize the price innovations (Chopra and Bessler 2005).

A directed acyclic graph is a pictorial representation of the causal flows among variables. The variables are called nodes and vectors are used to represent causal flow from one node to the other (Saghaian, Ozertan, and Spaulding 2008, Chopra and Bessler

2005). If a vector is shown as $A \rightarrow B$ implies causal relationship flows from A to B (A causes B). If $A - B$, indicates that node A and node B are connected with some information flow but one cannot determine if A causes B or B causes A.

4.3. Historical Decomposition

To determine the impact of a shock on the price series, an historical decomposition technique is used (Park, Jin, and Bessler 2008, Saghaian 2007) which decomposes the price series into moving average parts based on causal patterns:

$$P_{t+j} = \sum_{s=0}^{j-1} \psi_s \varepsilon_{t+j-s} + \sum_{s=j}^{\infty} \psi_s \varepsilon_{t+j-s} \qquad (2.9)$$

where $\sum_{s=j}^{\infty} \psi_s \varepsilon_{t+j-s}$ is the base price projection i.e. how the series would have evolved if there had been no shocks (Saghaian, Ozertan, and Spaulding 2008) and P_{t+j} is the actual price. The difference between the projected price and the actual price is a linear function of innovations (Park, Jin, and Bessler 2008).

5. Data Description

The data are available from USDA, ERS for monthly farm, wholesale and retail values for beef and pork only wholesale and retail values are available for poultry. The farm-level data for broilers is not available since the market is very integrated. The data is collected from January 1990 to December 2009. All the series are expressed as retail equivalent values (cents per pound). All eight price series are converted to their real values using the CPI food and beverage index compiled by the Bureau of Labor Statistics. The descriptive statistics for the price series is in table 2.2.

Table 2.1
Descriptive statistics of the price series

Stat	Beef Farm	Beef Wholesale	Retail Beef	Pork Farm	Pork Wholesale	Pork Retail	Broiler Wholesale	Broiler Retail
Mean	141.56	148.38	255.87	67.77	88.79	193.67	49.37	121.59
Median	137.76	145.57	258.39	65.27	86.49	192.82	49.15	121.66
Max	190.53	193.7	306.85	122.17	132.56	233.1	67.16	147.24
Min	111.74	119.36	219.89	24.84	63.4	168.12	32.64	99.67
St. Dev	19.71	17.53	18.53	18	14.42	11.69	7.18	10.64
Obs	240	240	240	240	240	240	240	240

6. Results

6.1. Unit Root Tests

All eight price series were tested for stationarity using the Augmented Dickey Fuller test. The null hypothesis that the series have unit roots (non-stationary series) is tested against the alternate hypothesis that the series are stationary at their levels. All the price series were tested for unit roots at levels using two specifications – a) constant, no trend and b) constant and a trend. The series were then tested for stationarity using the first difference of the series using only a constant (no trend). Differencing of the series removes any trend effects therefore, we use only the constant. The lags for the ADF test were determined using the SIC criterion. The results of the unit root tests are given in the table 2.2. The results indicate that out of the eight price series all the series are non-stationary at levels except for the pork farm and broiler wholesale using only constant and no trend. The results are similar when a trend component was included in the test specification, except for the pork wholesale price and retail price of broilers also which rejected the null hypothesis of a unit root. The first difference of all the series is stationary. Given that the series are I (1) with first differences, we can test if the series

Table 2.2
Unit root test results using ADF test

	Levels				First Difference	
Series	Constant, No trend		Constant and Trend		Constant, No trend	
	ADF Test Statistic	p-value	ADF Test Statistic	p-value	ADF Test Statistic	p-value
Beef Farm	-2.656 [3]	0.083	-3.181[2]	0.090	-10.756 [2]	0.000
Beef Wholesale	-2.550 [3]	0.104	-2.575[3]	0.292	-12.309 [2]	0.000
Beef Retail	-2.085 [1]	0.250	-2.104[1]	0.540	-11.927 [1]	0.000
Pork Farm	-2.969 [1]	0.039	-4.045[1]	0.008	-13.144 [0]	0.000
Pork Wholesale	-2.177 [1]	0.215	-3.697[1]	0.024	-13.694 [0]	0.000
Pork Retail	-1.241 [0]	0.656	-1.955[0]	0.622	-13.450 [0]	0.000
Broiler Wholesale	-3.626 [1]	0.005	-4.494[1]	0.001	-14.965 [0]	0.000
Broiler Retail	-1.653 [0]	0.453	-4.017[1]	0.009	-14.266[1]	0.000
The values in the bracket ( ) are p-values based on Mackinnon (1996) one sided p-values and the values in [ ] are the ADF lags by SIC criterion.						

have any long-run relationship between them using Johansen's cointegrating test.

6.2. Cointegration tests

When the series are non-stationary I (0) but their first difference is stationary I (1), one can test for cointegration to check if there exists any cointegrating relationship between the variables. A linear combination of non-stationary variables can be stationary if there exists a linear relationship between the variables. To check for cointegration, Johansen proposed two tests:

6.2.1. Trace Test (λ_{trace})

The null hypothesis for the trace test is that the number of unique cointegrating vectors is less than or equal to r against a general alternative (Enders 1995)

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i) \tag{2.10}$$

6.2.2. Maximum Eigen Value Test (λ_{max})

The null hypothesis for this test is that the number of cointegrating vectors is r against the alternative of $r+1$ cointegrating vectors.

$$\lambda_{max}(r, r+1) = -T \ln(1-\hat{\lambda}_{r+1}) \tag{2.11}$$

The cointegration test was done using both the above tests. To determine the lag length for the cointegrating vectors, an unrestricted vector autoregressive (VAR) model is estimated and then the lag length is determined using the lag length criterion which gives values for the final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SIC), and Hannan-Quinn information criterion (HQ).

Whenever there is a difference in the lag order selection given by the above criteria, HQ is used as the final selection method (Park, Jin, and Bessler 2008). On the basis of the HQ criterion 2 lags were chosen to conduct the cointegration tests (table 2.2)

Table 2.3
VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-6139.545	NA	3.63e+13	53.92584	54.04617	53.97439
1	-4472.390	3202.693	28356918	39.86307	40.94602*	40.30001
2	-4358.872	210.1071	18400832*	39.42870	41.47428	40.25403*
3	-4294.353	114.8893	18406540	39.42415	42.43235	40.63787
4	-4229.695	110.6000	18471435	39.41838*	43.38920	41.02048
5	-4190.435	64.40029	23300951	39.63539	44.56884	41.62589
6	-4148.506	65.83533	28931487	39.82900	45.72507	42.20789
7	-4101.605	70.35164	34711422	39.97899	46.83768	42.74627
8	-4036.422	93.19990	35875857	39.96862	47.78993	43.12428
9	-3986.159	68.34014	42831007	40.08912	48.87305	43.63317
10	-3917.656	88.33239*	44263041	40.04962	49.79618	43.98206
11	-3870.197	57.86742	56035804	40.19471	50.90389	44.51554
12	-3806.686	72.98234	62958380	40.19900	51.87080	44.90822

* indicates lag order selected by the criterion

Table 2.4
Unrestricted cointegration rank test (trace test)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.321796	247.4802	159.5297	0.0000
At most 1 *	0.183167	155.4514	125.6154	0.0002
At most 2 *	0.158839	107.5013	95.75366	0.0061
At most 3	0.131115	66.50684	69.81889	0.0893
At most 4	0.057825	33.19767	47.85613	0.5459
At most 5	0.037747	19.08105	29.79707	0.4871
At most 6	0.024115	9.961687	15.49471	0.2837
At most 7 *	0.017468	4.176448	3.841466	0.0410

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 2.5
Unrestricted cointegration rank test (maximum eigen value)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.321796	92.02882	52.36261	0.0000
At most 1 *	0.183167	47.95010	46.23142	0.0324
At most 2 *	0.158839	40.99447	40.07757	0.0393
At most 3	0.131115	33.30916	33.87687	0.0583
At most 4	0.057825	14.11662	27.58434	0.8145
At most 5	0.037747	9.119361	21.13162	0.8227
At most 6	0.024115	5.785239	14.26460	0.6409
At most 7 *	0.017468	4.176448	3.841466	0.0410

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

6.3. Vector Error Correction Model (VECM)

The above cointegration tests indicate the presence of three cointegrating vectors.

When there exists a long run relationship between the variables, a VECM is the best way to analyze the short run and long run dynamics of the variables.

The differing speeds of adjustments (in absolute terms) in the meat markets at different levels of the marketing channel point to asymmetric price transmission in these meat markets. For example, the first cointegrating equation shows that the speed of adjustment of wholesale beef (0.17) is higher than absolute speeds of adjustment for retail (0.007) and farm level beef (0.04) prices. This indicates the wholesale beef prices adjust more quickly than retail beef and farm beef to restore long run equilibrium. This result is also consistent with the results discussed in Saghaian (2007).

The impulse response graphs (appendix) show the response of each price series to a one unit shock in each of the price series. The gross farm value of beef responds positively to a shock in wholesale value of poultry and wholesale value of pork. It responds negatively to the farm value of pork, the retail value of beef and the retail value of pork. There is little response to a shock in retail value of poultry. Wholesale value of beef responds positively to the farm value of beef, the wholesale value of pork and the retail value of poultry. It responds negatively to retail value of pork and farm value of pork. Retail value of beef responds positively to farm value and wholesale values of beef. It also responds positively to the wholesale value of chicken. The retail value of beef responds negatively to the farm value of pork, but has is no response to the retail values of poultry and pork.

The farm value of pork responds positively to the farm value of beef and the wholesale value of pork. It responds negatively to the wholesale value of poultry and the

Table 2.6
Speeds of adjustment from VECM

Equation	$\Delta FBeef$	$\Delta FPork$	$\Delta RBeef$	$\Delta Rchk$	$\Delta RPork$	$\Delta Wbeef$	$\Delta Wchk$	$\Delta Wpork$
Cointegrating Eq 1	-0.047096 (0.05547) [-0.84903]	0.169804 (0.06771) [2.50787]	-0.007825 (0.04253) [-0.18398]	-0.067820 (0.02758) [-2.45891]	-0.105179 (0.02760) [-3.81086]	0.173976 (0.06494) [2.67897]	0.114245 (0.03356) [3.40450]	0.014503 (0.04774) [0.30382]
Cointegrating Eq 2	-0.196952 (0.12684) [-1.55270]	-0.169075 (0.15483) [-1.09201]	0.003528 (0.09726) [0.03628]	-0.012424 (0.06307) [-0.19699]	0.135756 (0.06311) [2.15099]	-0.095749 (0.14850) [-0.64476]	0.001950 (0.07674) [0.02542]	0.237254 (0.10916) [2.17352]
Cointegrating Eq 3	0.023537 (0.03082) [0.76379]	-0.011343 (0.03761) [-0.30156]	-0.096750 (0.02363) [-4.09470]	-0.020710 (0.01532) [-1.35160]	-0.011869 (0.01533) [-0.77412]	0.102313 (0.03608) [2.83594]	0.015703 (0.01864) [0.84234]	-0.046026 (0.02652) [-1.73559]
R^2	0.3177	0.1717	0.4352	0.2500	0.4222	0.2892	0.1686	0.1597

Standard errors in ( ) & t-statistics in [ ]

retail value of pork. The wholesale value of pork responds positively to the farm value of beef but responds negatively to the wholesale poultry, the retail pork and the retail beef. The retail value of pork positively responds to farm value of pork and wholesale value of beef. It responds negatively to the wholesale pork.

The wholesale poultry responds positively to the farm value of beef and responds negatively to the wholesale beef, the farm pork, wholesale pork and retail beef. The retail poultry responds positively to wholesale poultry, wholesale beef and farm value of pork. There is no response of retail poultry prices to a shock in retail beef or retail pork.

The residual correlation matrix of the VECM model is given below. The variables are in the order gross farm value pork (GFVP), wholesale value pork(WVP), retail value pork (RVP), gross farm value beef (GFVB), wholesale value beef (WVB), retail value beef (RVB), wholesale value poultry (WVC) and retail value poultry(RVC).

GFVP	WVP	RVP	GFVB	WVB	RVB	WVC	RVC
1.000000							
0.905758	1.000000						
0.162365	0.250893	1.000000					
0.075750	0.092741	0.050038	1.000000				
0.140534	0.226267	0.127913	0.748527	1.000000			
- 0.031086	- 0.025065	0.024053	0.234224	0.247315	1.000000		
0.195007	0.127657	0.053731	0.039904	0.038999	0.090063	1.000000	
- 0.034713	- 0.051648	0.003083	- 0.028383	0.021308	0.044927	0.066516	1.000000

There is a high correlation between the farm and wholesale prices of beef and pork but low correlation between the farm and retail prices and also between wholesale and the retail prices. There is a low correlation between wholesale value (price) of chicken and retail value of chicken. GES algorithm was applied to the above correlation matrix in Tetrad 4.3 to understand the causal patterns in the meat sector.

6.4. Directed Acyclic Graphs and Causality

Using the Greedy Equivalence Search (GES) algorithm in the Tetrad IV software, directed acyclic graphs (DAG) were created which shows the direction of causal relationship between the eight price series. Tetrad 4.3 software uses the correlation or the covariance matrix of the innovations from the VECM model to create the graphs (Spirtes, Glymour, and Scheines 2000). The directed acyclic graph created by Tetrad IV is given in Figure 2.3.

The DAG generated by Tetrad 4.3 shows the interdependencies between the different meat sectors. The wholesale price of beef affects the farm value prices of beef and the retail value of beef affects the wholesale value of beef. There exists a relationship

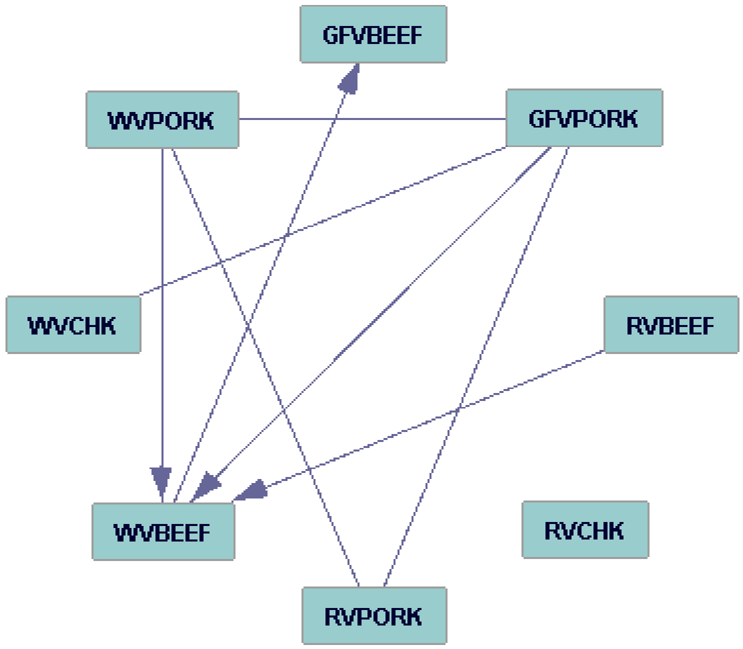

Figure 2.3: Directed Acyclic Graph (DAG) on innovations from the eight meat price series

between wholesale value of pork and retail value of pork and also between wholesale value of pork and gross farm value of pork, though the direction of causality is not known. The wholesale value of pork directly affects the wholesale value of beef. The wholesale value of beef affects the gross farm value of beef. There also exists a flow of information between gross farm value of pork and wholesale value of chicken but the direction of causality is unknown. The retail value of chicken is not linked to any other price in the model. This could be specific to the sample or the data that is collected. Since the data used for the present study are only on a monthly basis and the observations are defined as retail value equivalents (cents per pound).

6.5 Impact of BSE on Meat Prices

The impact of BSE on the eight price series is analyzed using historical decompositions. By comparing the actual values with the forecasted values one can analyze the impact of the external event of the price series. Tables 2.5-2.12 show the actual values along with forecasted values and the deviations of the actual from the forecasted values. If the deviation is positive it implies that the actual value in the period was above the forecasted value and vice-versa. The event date was December 2003 which is highlighted in the tables below. January 2003 is also highlighted because there might be a lag in the reaction since the mad cow disease was announced on December 23, 2003 around the holiday season. Farm-level beef values showed negative deviation (actual prices declined) in January 2004 implying that the actual values were lower than the forecasted values. The farm beef values continued to show negative deviations till April 2004. The wholesale beef values also showed negative deviations and continued to show negative deviations through March 2004 but started gaining in by April 2004. Surprisingly, the retail beef did not show any negative deviation. Farm, wholesale and retail values of pork showed negative deviations. Wholesale poultry showed positive deviations (actual prices increased) whereas there was not much deviation in retail poultry prices. The historical decomposition graphs are shown in the appendix.

7. Conclusion

The objective of this essay was to study the interdependencies among the meat sectors in the United States and to analyze the impact of the first case of the mad cow

Table 2.7
Impact of BSE (Dec 2003) on farm beef values

Date	Actual Values	Forecasted Values	Deviations = Actual-Forecasted
Oct-03	169.46	155.91	13.55
Nov-03	171.73	156.68	15.05
Dec-03	155.86	153.21	2.65
Jan-04	136.18	150.22	-14.04
Feb-04	133.37	149.57	-16.20
Mar-04	144.53	149.72	-5.19
Apr-04	144.75	149.39	-4.64

Table 2.8
Impact of BSE (Dec 2003) on wholesale beef values

Date	Actual Values	Forecasted Values	Deviations = Actual-Forecasted
Oct-03	193.70	173.76	19.94
Nov-03	182.98	168.77	14.21
Dec-03	167.33	164.25	3.08
Jan-04	150.11	161.75	-11.64
Feb-04	139.87	160.85	-20.98
Mar-04	153.44	160.82	-7.38
Apr-04	171.55	160.68	10.87

Table 2.9
Impact of BSE (Dec 2003) on retail beef values

Date	Actual Values	Forecasted Values	Deviations = Actual-Forecasted
Oct-03	280.63	274.85	5.78
Nov-03	306.86	281.23	25.63
Dec-03	299.62	279.97	19.65
Jan-04	282.51	278.06	4.45
Feb-04	281.06	278.04	3.02
Mar-04	279.18	278.60	0.58
Apr-04	285.07	278.98	6.09

Table 2.10
Impact of BSE (Dec 2003) on farm pork values

Date	Actual	Forecasted	Actual - Forecasted
Oct-03	51.54	54.45	-2.91
Nov-03	47.87	52.57	-4.70
Dec-03	47.56	53.64	-6.08
Jan-04	51.47	55.64	-4.17
Feb-04	59.56	57.54	2.02
Mar-04	63.50	59.04	4.46
Apr-04	63.52	60.20	3.32

Table 2.11
Impact of BSE (Dec 2003) on wholesale pork values

Date	Actual	Forecasted	Actual - Forecasted
Oct-03	77.12	81.73	-4.61
Nov-03	72.70	78.86	-6.16
Dec-03	71.90	79.44	-7.54
Jan-04	76.14	80.35	-4.21
Feb-04	80.26	80.75	-0.49
Mar-04	83.54	81.18	2.36
Apr-04	85.39	81.75	3.64

Table 2.12
Impact of BSE (Dec 2003) on retail pork values

Date	Actual	Forecasted	Actual - Forecasted
Oct-03	192.97	194.77	-1.80
Nov-03	193.45	193.92	-0.47
Dec-03	189.26	193.55	-4.29
Jan-04	189.95	192.92	-2.97
Feb-04	189.57	192.33	-2.76
Mar-04	189.55	191.73	-2.18
Apr-04	190.67	191.33	-0.66

Table 2.13
Impact of BSE (Dec 2003) on wholesale poultry values

Date	Actual	Forecasted	Actual - Forecasted
Oct-03	49.13	48.79	0.34
Nov-03	49.36	47.22	2.14
Dec-03	49.63	46.30	3.33
Jan-04	52.22	46.34	5.88
Feb-04	56.07	46.75	9.32
Mar-04	58.53	47.27	11.26
Apr-04	59.55	47.60	11.95

Table 2.14
Impact of BSE (Dec 2003) on retail poultry values

Date	Actual	Forecasted	Actual - Forecasted
Oct-03	117.48	115.48	2.00
Nov-03	116.02	116.32	-0.30
Dec-03	116.23	115.73	0.50
Jan-04	116.79	115.80	0.99
Feb-04	117.37	115.92	1.45
Mar-04	117.33	115.70	1.63
Apr-04	117.43	115.57	1.86

disease outbreak in the United States in December 2003. The results of the study indicate interdependencies in the beef, pork and poultry markets in the United States. That is, a shock in one series has an impact on other series too. There is vertical as well spatial price transmission in the meat markets, though the transmission is not perfect. The different speeds of adjustment point to asymmetric price transmission. Also, the magnitude of the mad cow disease shock was different in different markets indicating asymmetry in terms of both speeds of adjustment and magnitude. The first case of the mad cow disease led to a decrease in the price of farm and wholesale of both beef and pork, though the decrease in the prices continued beyond January only for beef. The retail prices of beef did not show any negative effect. Wholesale values of poultry gained through April 2004 whereas the gains in retail values of poultry were not substantial.

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Appendix

Stability of the VECM Model

If there are n series in the model and k cointegrating vectors, then the VECM imposes $n-k$ unit roots. If the model has to be stable, the moduli of the other roots should lie within the unit circle.

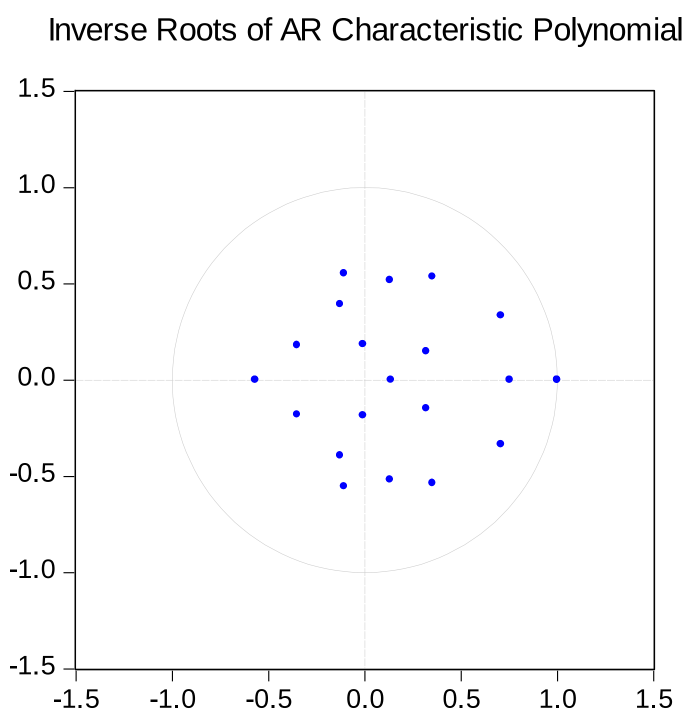


Figure 2A: Inverse roots of AR characteristic polynomial

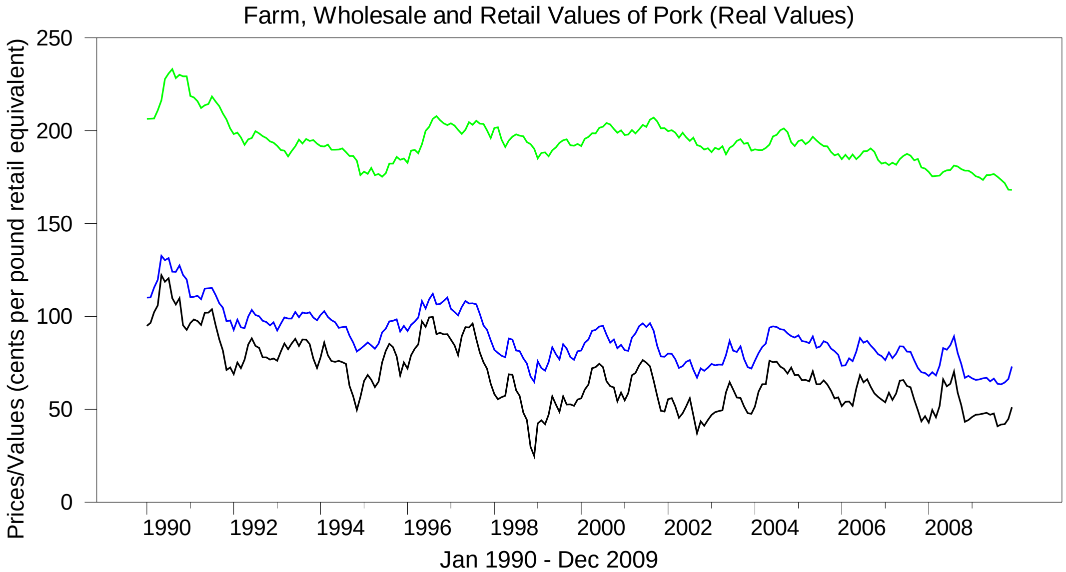


Figure 2B: Farm, wholesale and retail values of pork (real values)

Green – Retail Values Blue – Wholesale Values Black- Farm values

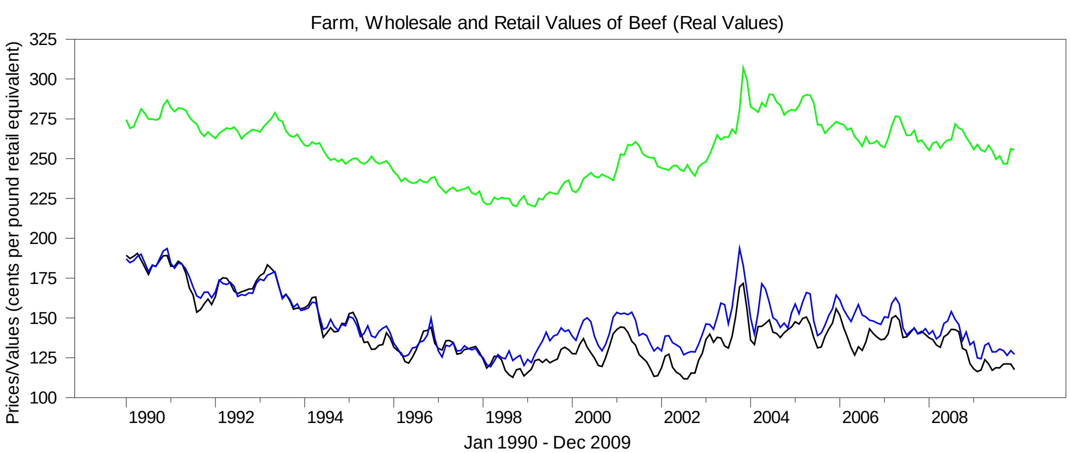


Figure 2C: Farm, wholesale and retail values of beef (real values)

Green – Retail Values Blue – Wholesale Values Black- Farm values

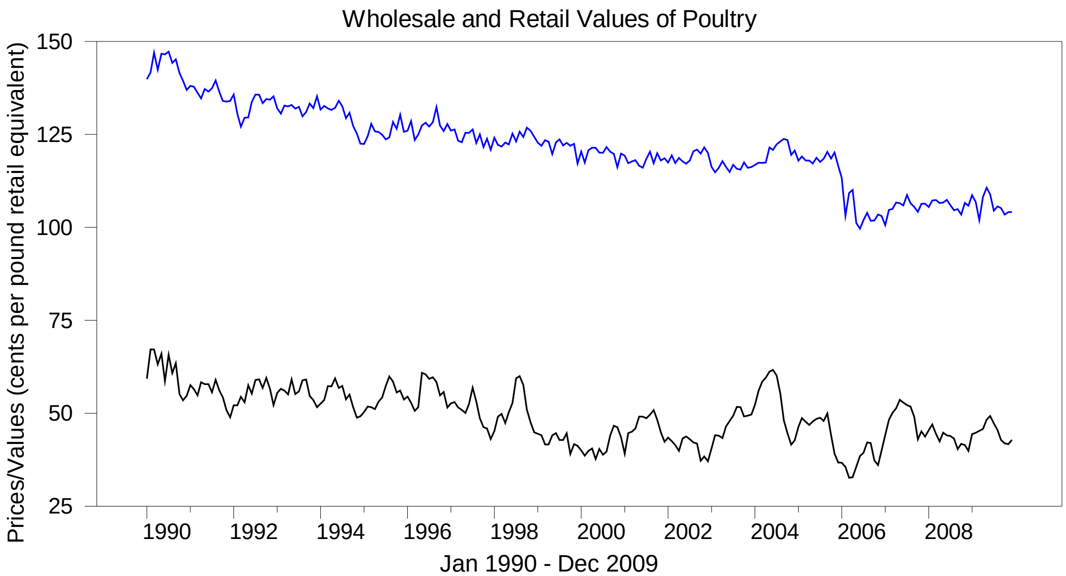
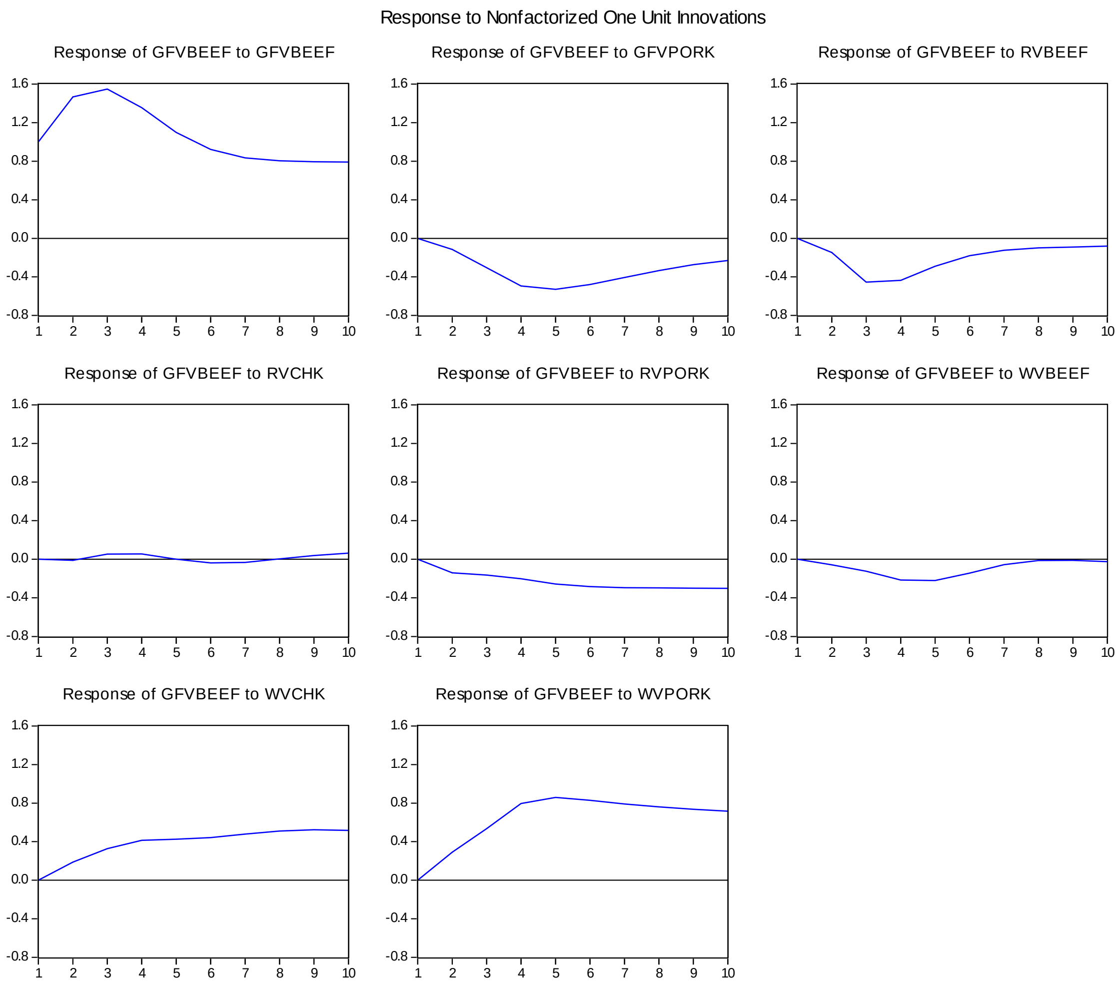
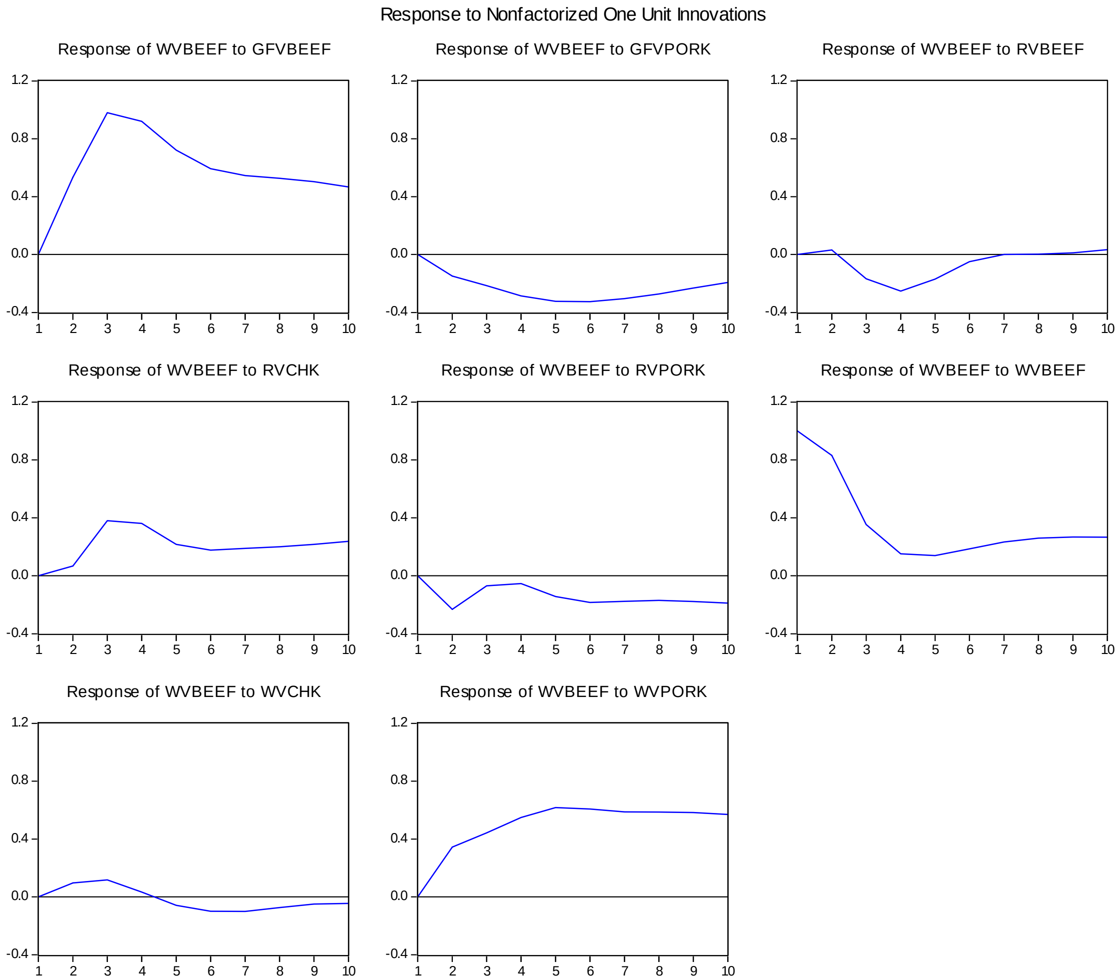


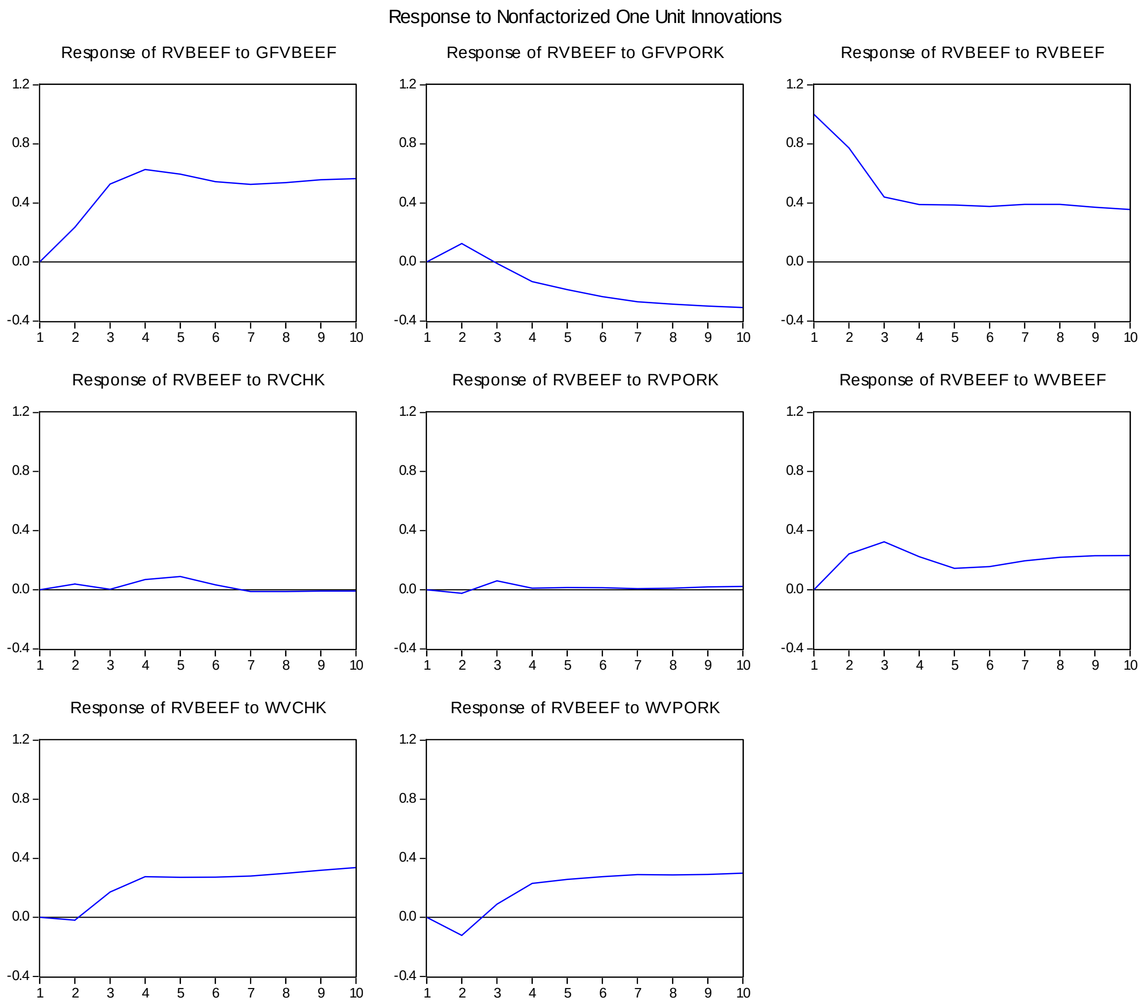
Figure 2D: Wholesale and retail values of poultry (real values)

Blue – Retail Values
Black – Wholesale Values

The Impulse Response Functions: Dynamic response of each meat price series to a one unit shock in each series.




Response to Nonfactorized One Unit Innovations
Response of WVBEEF to GFVBEEF
Response of WVBEEF to GFVPORK
Response of WVBEEF to RVBEEF
Response of WVBEEF to RVCHK
Response of WVBEEF to RVPORK
Response of WVBEEF to WVBEEF
Response of WVBEEF to WVCHK
Response of WVBEEF to WVPORK
1.2
0.8
0.4
0.0
-0.4
1 2 3 4 5 6 7 8 9 10


Response to Nonfactorized One Unit Innovations
Response of RVBEEF to GFVBEEF
Response of RVBEEF to GFVPORK
Response of RVBEEF to RVBEEF
Response of RVBEEF to RVCHK
Response of RVBEEF to RVPORK
Response of RVBEEF to WVBEEF
Response of RVBEEF to WVCHK
Response of RVBEEF to WVPORK
1.2
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0.0
-0.4
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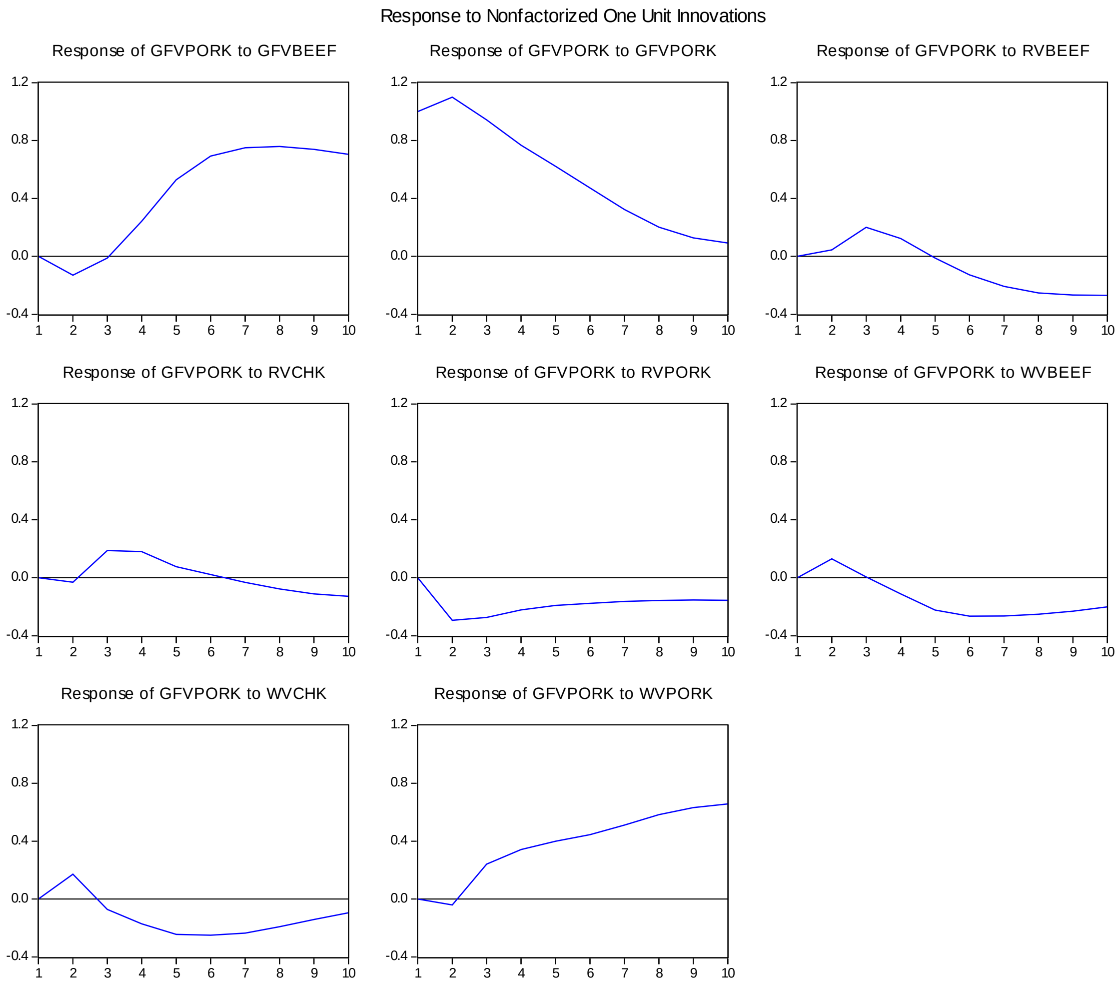
Response to Nonfactorized One Unit Innovations
Response of GFVPORK to GFVBEEF
Response of GFVPORK to GFVPORK
Response of GFVPORK to RVBEEF
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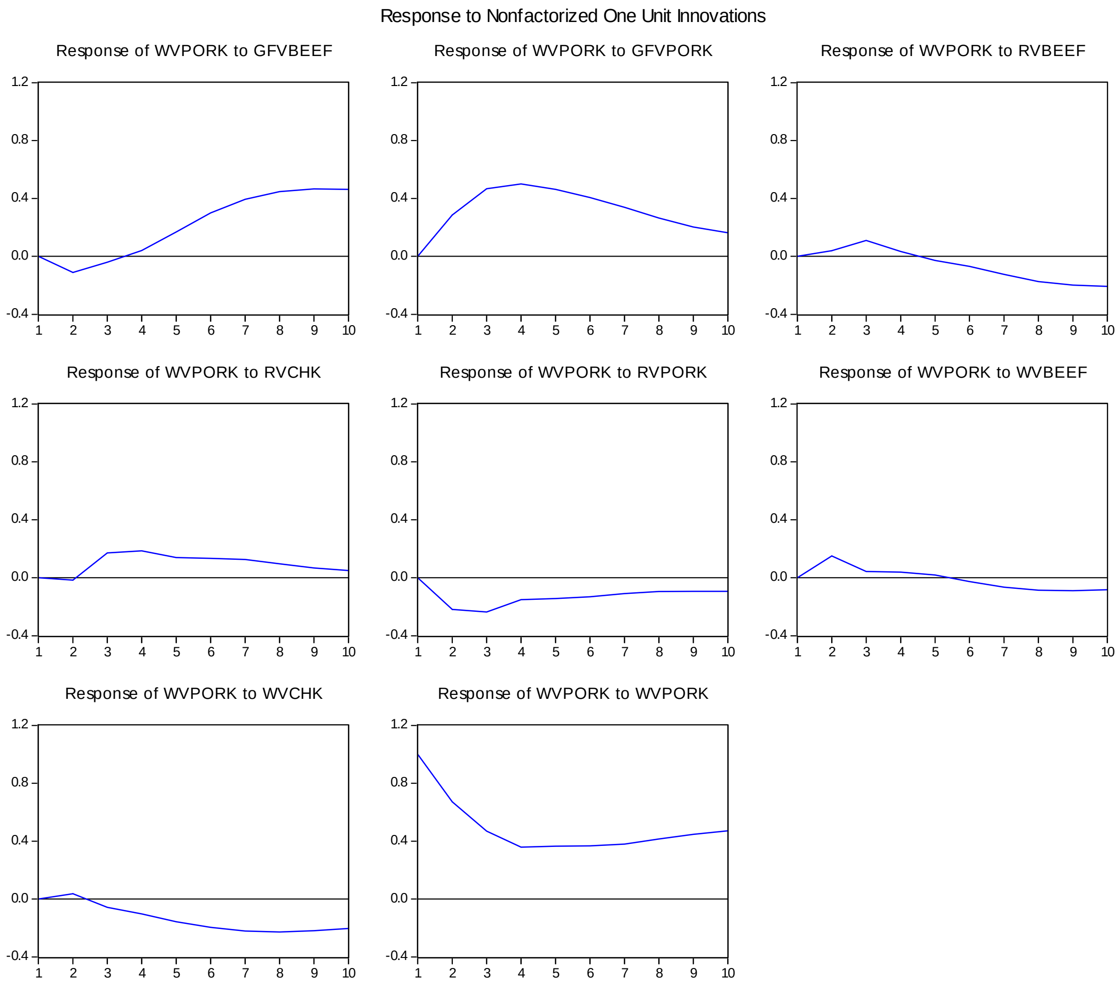
Response of GFVPORK to RVPORK
Response of GFVPORK to WVBEEF
Response of GFVPORK to WVCHK
Response of GFVPORK to WVPORK


Response to Nonfactorized One Unit Innovations
Response of WVPORK to GFVBEEF
Response of WVPORK to GFVPORK
Response of WVPORK to RVBEEF
Response of WVPORK to RVCHK
Response of WVPORK to RVPORK
Response of WVPORK to WVBEEF
Response of WVPORK to WVCHK
Response of WVPORK to WVPORK
1.2
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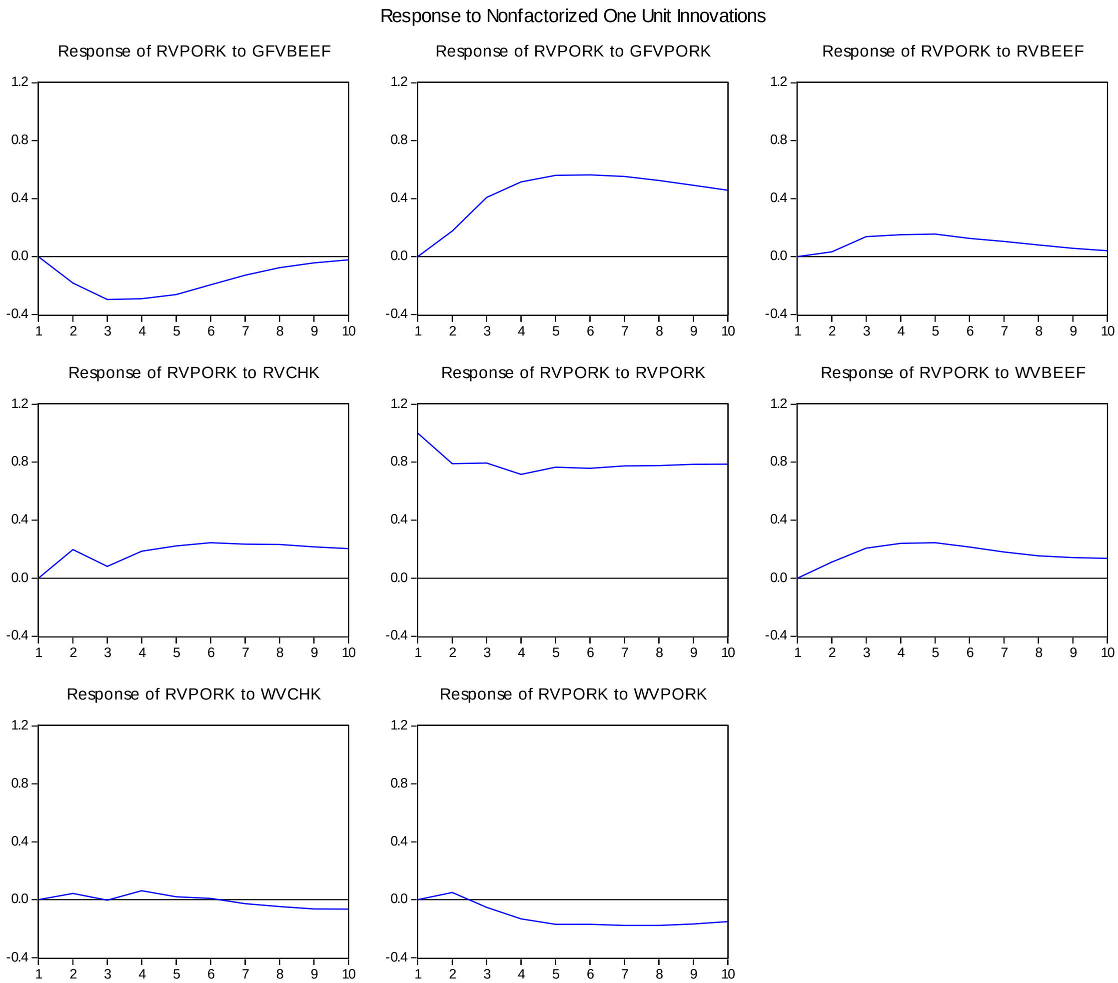
1 2 3 4 5 6 7 8 9 10


Response to Nonfactorized One Unit Innovations
Response of RVPORK to GFVBEEF
Response of RVPORK to GFVPORK
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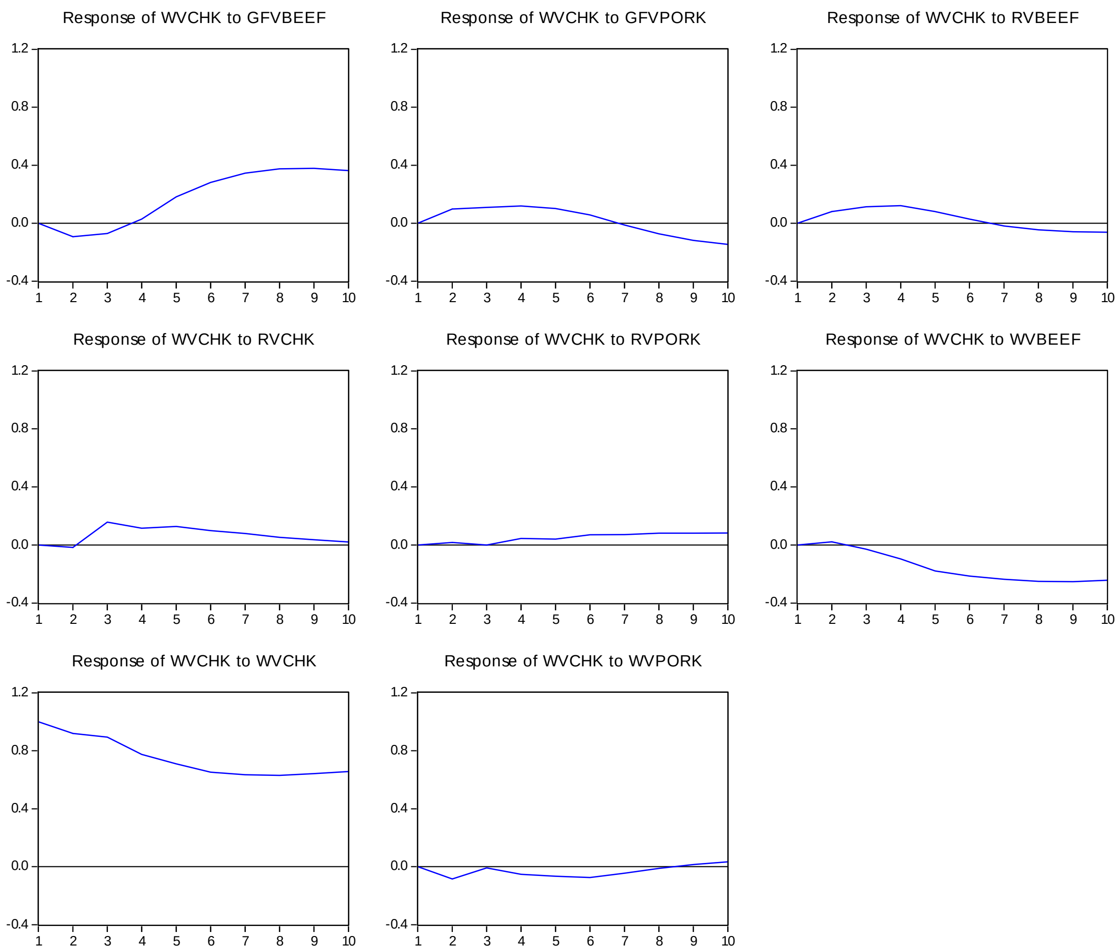
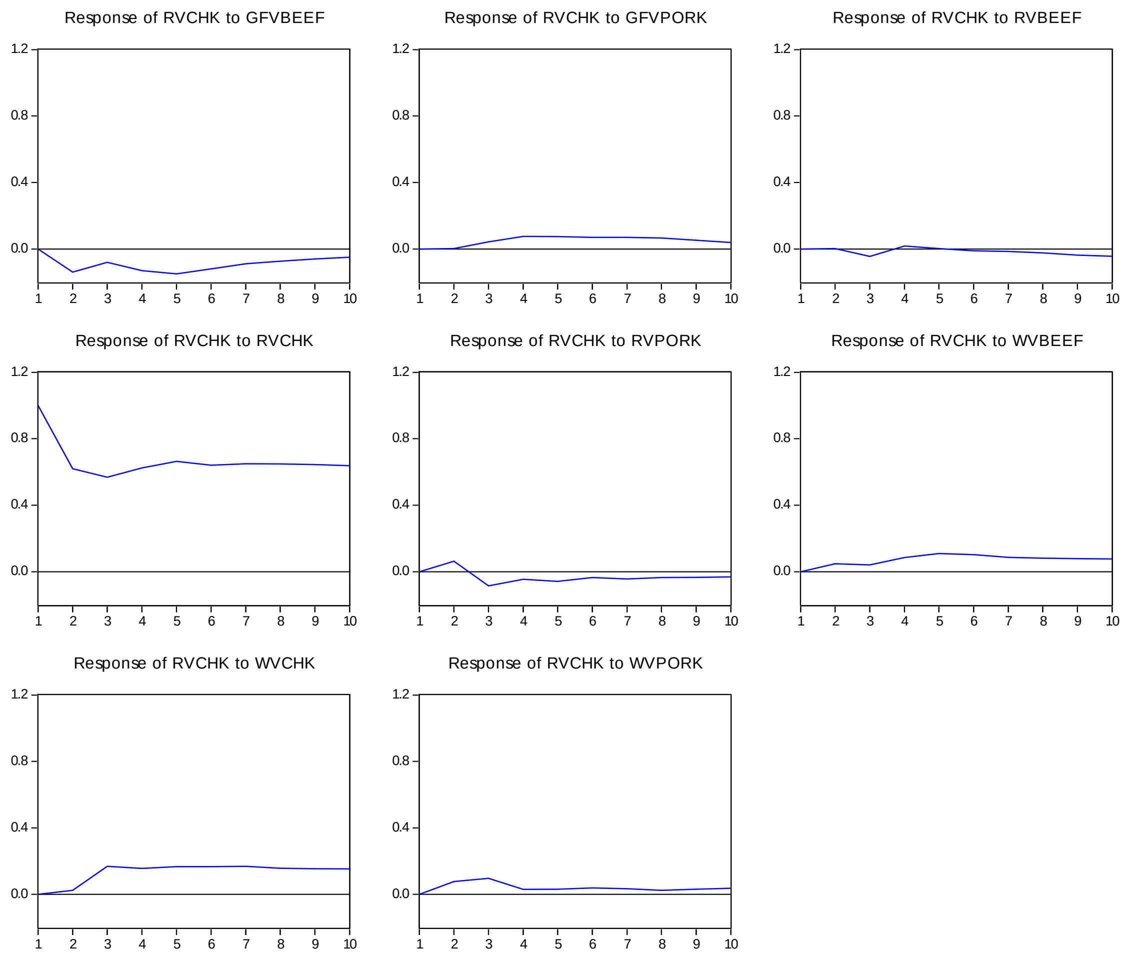
Response of RVPORK to WVBEEF
Response of RVPORK to WVCHK
Response of RVPORK to WVPORK

Response to Nonfactorized One Unit Innovations



Response to Nonfactorized One Unit Innovations



Historical decomposition graphs for the eight price series

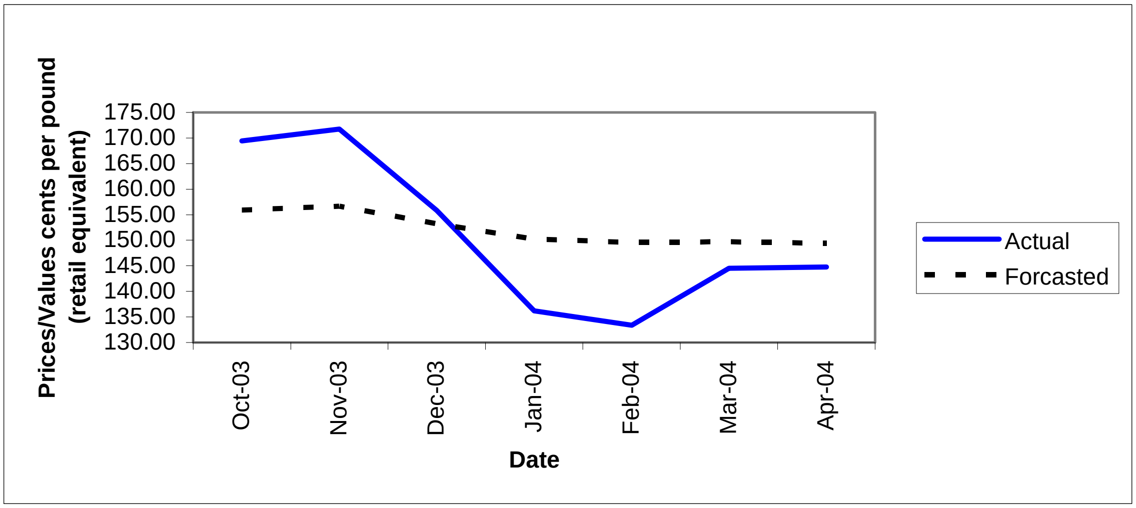


Figure 2E: Historical Decomposition - Farm Value Beef

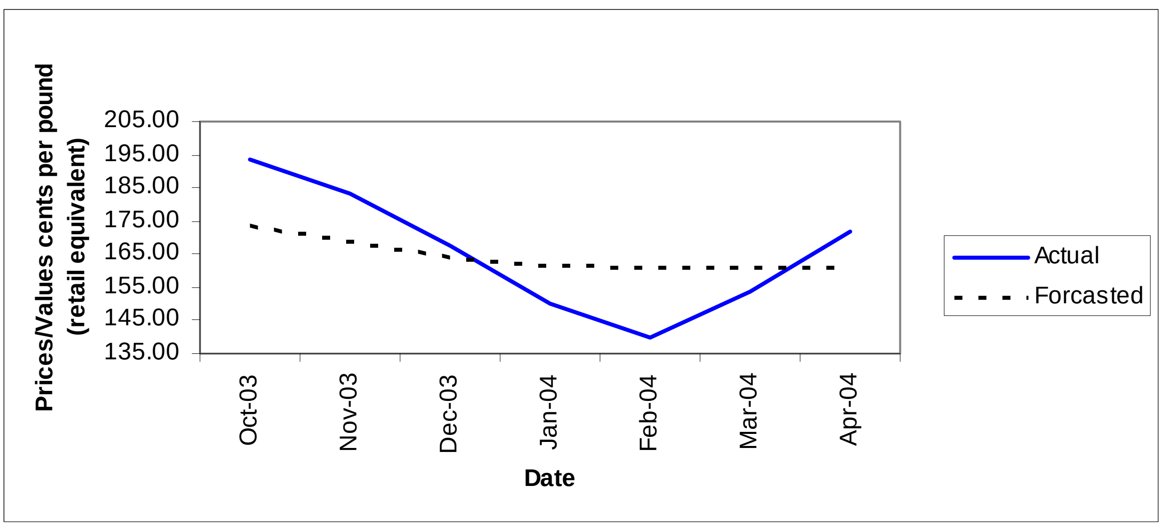


Figure 2F: Historical decomposition of Wholesale Beef Values

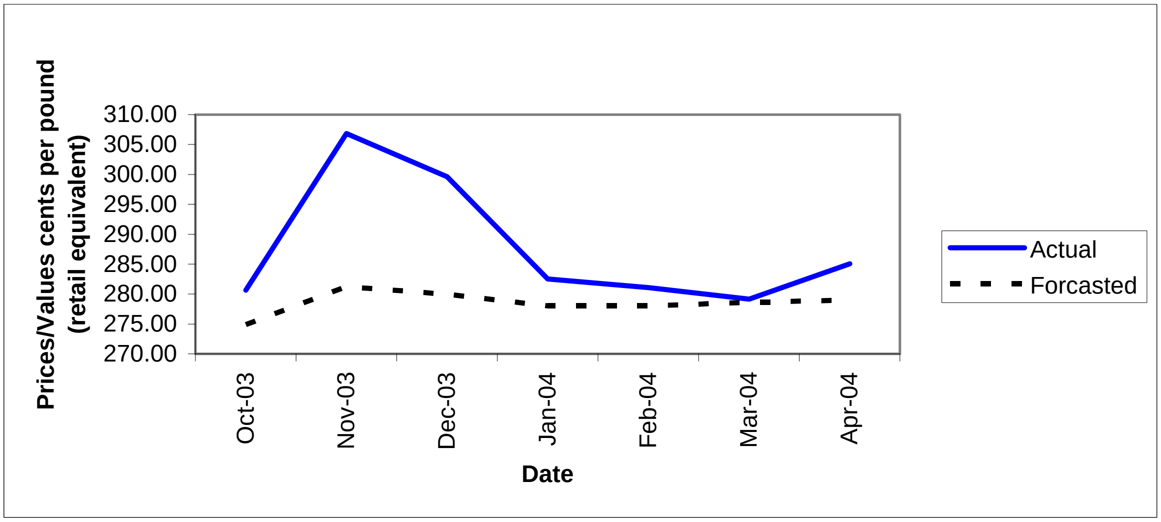


Figure 2G: Historical decomposition of Retail Beef Values

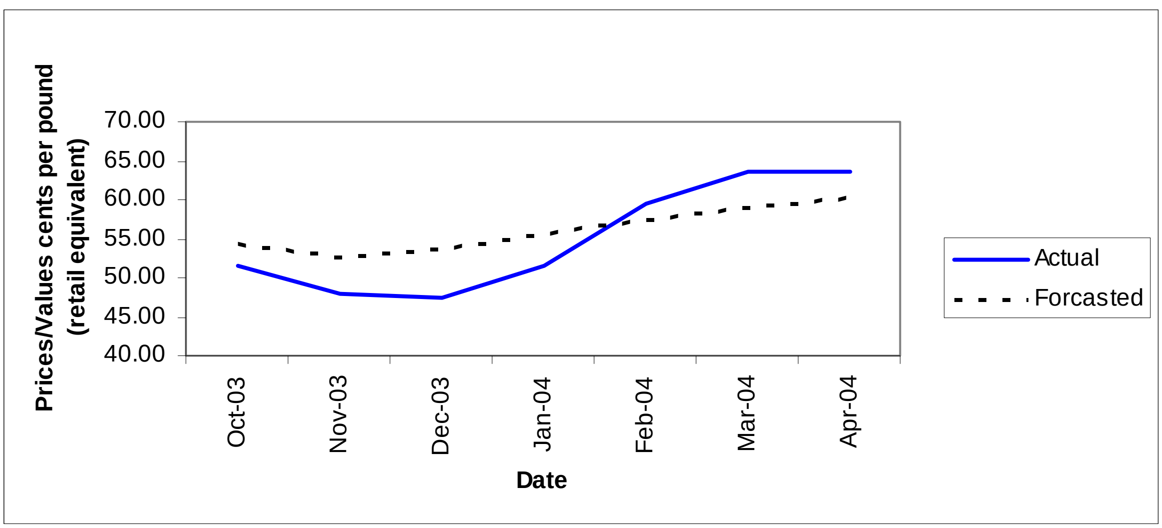


Figure 2H: Historical decomposition of Farm Pork Values

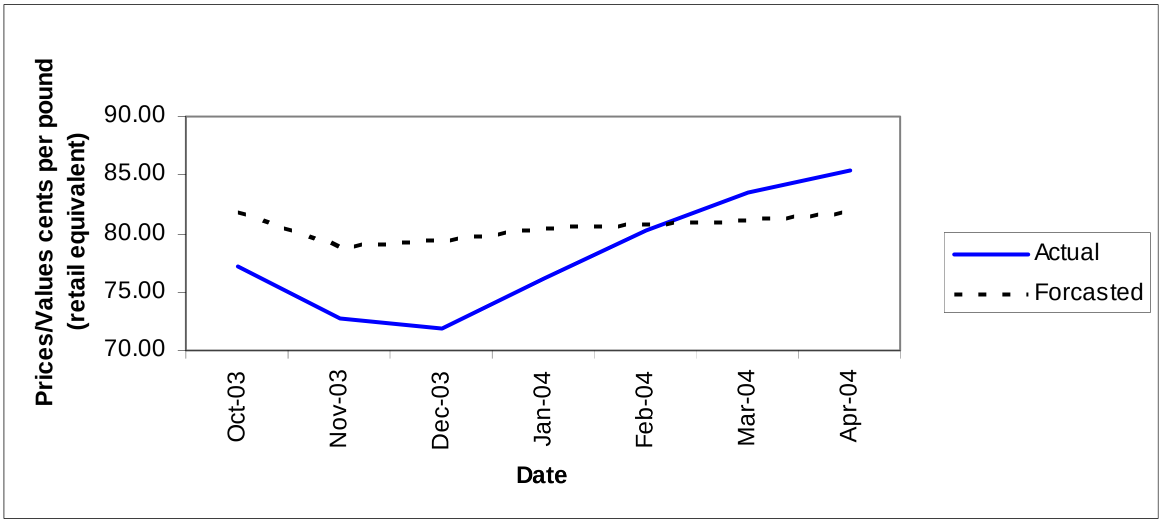


Figure 2I: Historical decomposition of Wholesale Pork Values

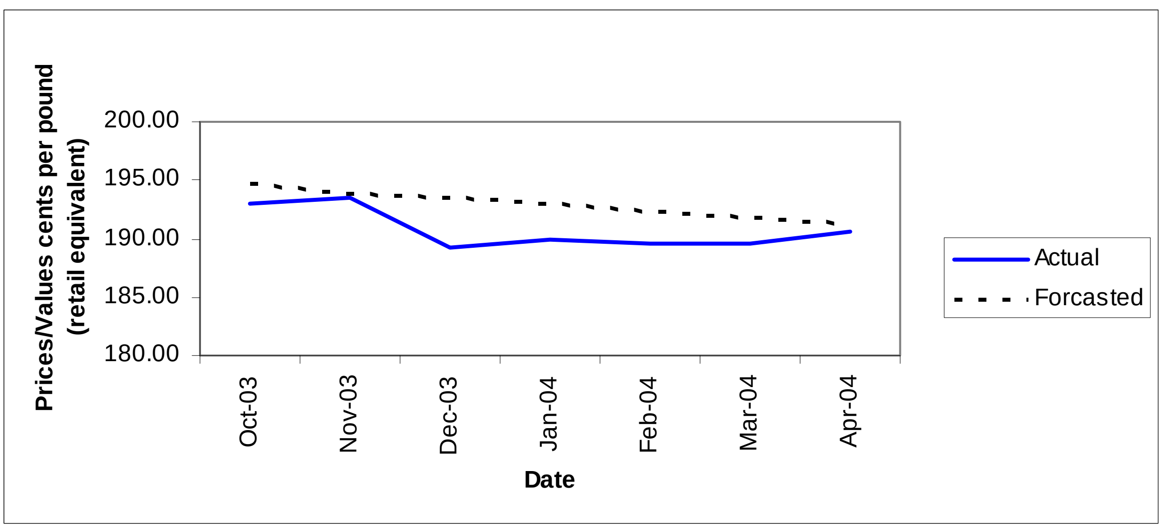


Figure 2J: Historical decomposition of Retail Pork Values

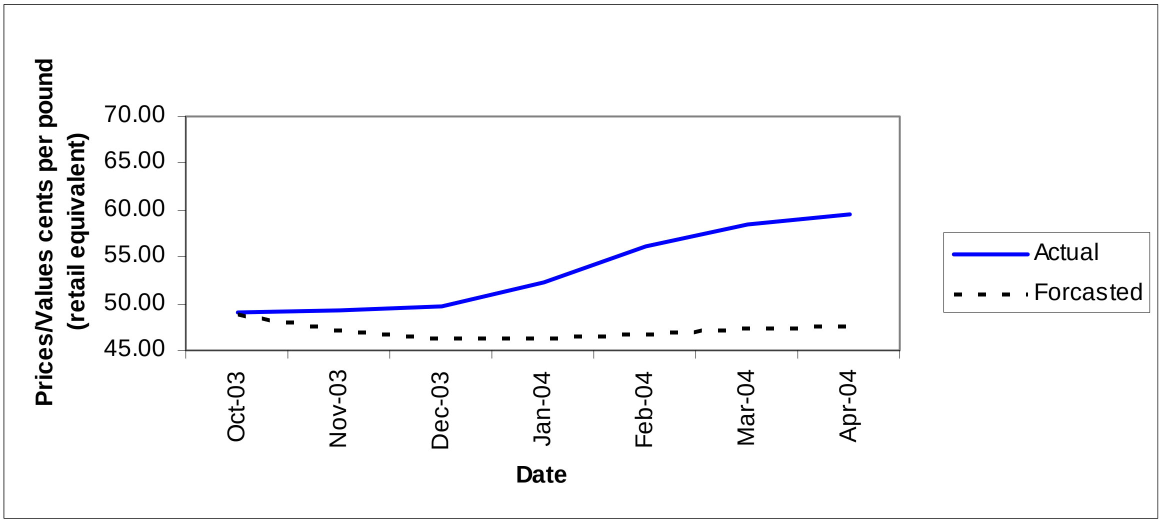


Figure 2K: Historical decomposition of Wholesale Poultry Values

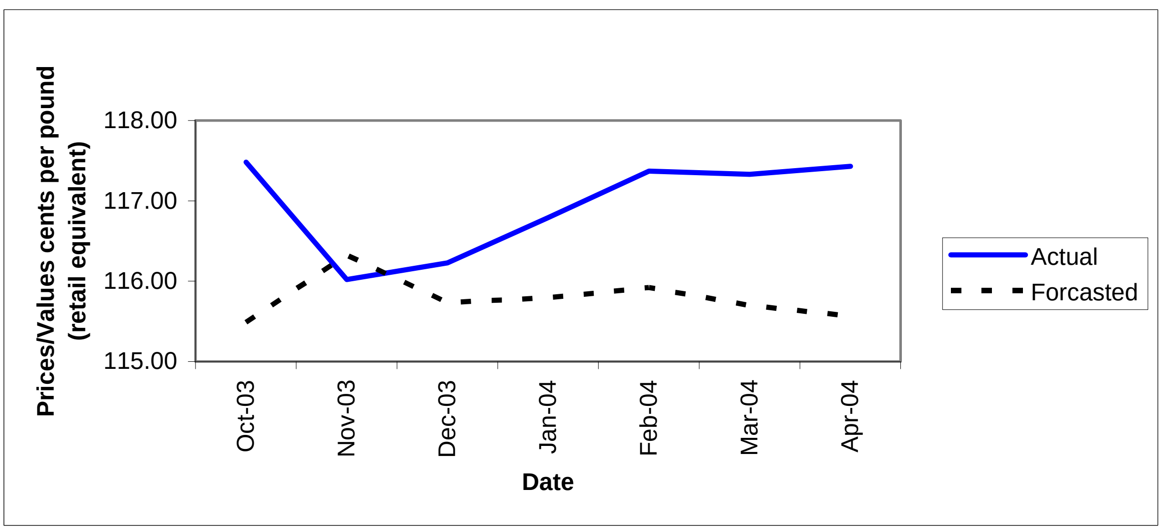


Figure 2L: Historical decomposition of Retail Poultry Values

ESSAY 3: IMPACT OF THE OUTBREAK OF THE BOVINE SPONGIFORM ENCEPHALOPATHY ON THE EXPORT DEMAND FOR THE US BEEF: TESTING FOR STRUCTURAL STABILITY

Abstract

This essay analyzes the impact of the outbreak of the Bovine Spongiform Encephalopathy (BSE) on the demand for US beef in Canada, Mexico, South Korea and Japan. These four countries together accounted for more than 90% of the US beef export market share before the BSE announcement in the US in December 2003. To analyze the impact of BSE on US beef exports, an export demand function is estimated and the parameter stability of the model is analyzed using various structural stability tests. The results indicate that the parameters have not been stable for Mexico, Canada and South Korea in the entire estimated sample. These results have important policy implications for export promotion and bilateral trade between countries.

1. Introduction

Following the discovery of the first case of the Bovine spongiform encephalopathy (BSE) in the United States, the largest beef importers of the US beef mainly; South Korea, Japan, Canada and Mexico; placed an immediate ban on the imported beef the United States. Before the discovery of BSE, the United States was one of the largest exporters of beef in the world (Table 3.1). These four major importing countries accounted for more than 90% of the US beef exports during 2003 (Hanrahan and Becker 2006). Following the first case of the BSE in the United States, about 20

Table 3.1
US beef exports as a percentage of production

Year	US beef exports as a percentage of production
2002	9.0
2003	9.6
2004	1.9
2005	2.8
2006	4.4
2007	5.4
2008	7.1

Source: Economic Research Service, USDA

countries placed a ban on US beef imports. This includes United States' four major trading partners – Japan, South Korea, Canada, and Mexico.

The ban placed by the major trading partners of the US resulted in substantial losses in the US beef export sector. Canada and Mexico lifted the ban relatively more quickly compared to Japan and South Korea which were more strict with their regulations and did not reopen their markets quickly. Japan was the largest importer of US beef until the BSE announcement in the United States in December 2003. Japan put a ban on all imports of US beef from December 2003 till December 2005. Japan removed their restrictions on imported US beef in December 2005. The Japanese ban was lifted on the US export beef to Japan only from cattle less than 21 months of age. But Japan placed a ban on the US beef again in January 2006 after it found some banned material in the imported beef from the US. The Japanese ban was lifted in June 2006 on cattle below 20 months of age. US beef exports suffered significant losses due to BSE and the subsequent ban on US beef by importing countries. South Korea also immediately placed a ban on imported US beef and did not reopen its markets until September 2006 when it started importing only boneless beef cuts only from cattle under thirty months of age (UTM). In July 2008 Korea relaxed its restrictions on US beef imports which allowed bone-in cuts of beef only from cattle under than thirty months of age. South Korea's imports of US beef have expanded significantly in 2010 and during 2010 South Korea became the largest importer of US beef in Asia for the first time. Mexico banned imports of US beef after the announcement of the first case of BSE in the United States. But by March 2004, Mexico reopened its market to US beef but allowing imported boneless beef only from cattle less than thirty months of age. Though Mexico has relaxed some restrictions it continues to import only boneless and bone-in beef from cattle under thirty months (UTM). Mexico continues to the largest export market for US beef. Canada lifted the ban on US beef in March 2005 which allowed import of feeder cattle UTM. In June 2006, Canada started importing live cattle born after 1999 all beef and beef products (Source: USDA (ERS), www.thebeefsite.com, www.meattradenewsdaily.co.uk. The objective of the present study is to estimate an export demand function for US beef by its four major trading partners and examine if there was a structural change in export demand for US beef due to BSE in the United States.

2. Literature Review

The literature on the estimation of export and import demand functions is vast. Researchers have estimated import and export demand functions for different commodities and for different countries. The objective of estimating import or export demand functions is different for different papers, with some researchers focusing on the impact of trade liberalization or policy changes on the demand for imports or exports while some have focused on how the elasticities (price and income) for demand for a commodity vary with different commodity groups and with countries. The earliest works on export function estimation can be found in Goldstein and Khan (1978) and Leamer and Stern (1970). Their works describe traditional export demand as a function of the relative price of the commodity and the income of the importing country. Stern, Baum, and Greene (1978) estimate aggregate import demand and export demand functions for the US to test for structural change in export demand since 1950s. They found that there was structural change for imports around 1972 and found no evidence of change for exports. Hooper (1978) used data between 1957 and 1977 to study the stability of income and price elasticities in US trade. He found that the price elasticities of imports were more volatile in the selected sample than were the income elasticity. Uri and Jones (1988) estimated the export demand function for three US commodities – soybeans, corn and wheat. They found that the export demand for soybeans and corn destabilized over the sample period of 1971-1986. Tang and Ward (1978) estimated an export demand function for US grapefruit in the presence of Japanese trade restrictions. They used seemingly unrelated regression equations to estimate the export demand function. They found that the elasticities differed among US, Canada and Japanese markets. Le, Kaiser, and Tomek (1998) estimated the demand for US red meat in four Pacific-Rim countries – Hong Kong, Taiwan, Singapore, and South Korea to address the effectiveness of the export promotional expenditure. They found that export promotion expenditure had a positive impact on the demand for US red meat only in South Korea and not in the other three countries. Hossain (2008) analyzed the structural change for export demand function for Indonesia using annual data. To investigate aggregate export demand behavior of Indonesian exports, he used recursive and rolling regressions and the Hansen-Johansen stability test and found that the export demand function has undergone significant structural change since the late 1990s. Nur, Wijeweera, and Dollery (2007) estimated an export demand function for Bangladesh using bilateral trade. They used data from 1973-2004 to study the impact of trade liberalization on the disaggregated export demand function for Bangladesh. They also tested if the elasticities were different between major trading partners. They found that there are different elasticities with different trading partners and also found that trade liberalization had a positive impact on the export demand for Bangladesh. Onunkwo and Epperson (2000) estimated an export demand equation for US pecan exports to evaluate the impact of federal promotional programs on the US pecan exports. Their findings showed a significant increase in the demand for US pecans due to the promotional programs. Panagiotou and Azzam (2010) studied welfare effects of the outbreak of the BSE on the US beef industry in the presence of overlapping trade restrictions between Canada and the US and in the presence of imperfect competition. They address the issue of disentangling the welfare effect using theoretical and empirical models. They found that the consumers were better off under the partial ban on US beef exports and worse off under the total ban. The cattle feeders were better off with partial ban on US exports than when the cattle imports from Canada were either totally or partially banned. Devadoss, Holland, Stodick, and Ghosh (2006) used a general equilibrium analysis to study the impact of the mad cow disease outbreak on beef and cattle industry in the US. They used different scenarios for foreign demand shock and domestic demand shock and study the impact on the beef industry. They found that the impact of the mad cow disease even in the worst scenario (25% decline in domestic demand and 90% decline in foreign demand) was not as damaging as the BSE outbreak in Canada because of the difference in their export dependency. Jin and Koo (2004) used simulation techniques to analyze the impact of BSE outbreak on domestic prices of beef and slaughter prices and feeder cattle prices. Their simulation results showed that if the domestic consumption fell by 10% and exports decreased by 75% then the price of beef would decrease by 15% and the prices of substitutes – pork and chicken would increase by 3%. Mattson, Jin, and Koo (2006) studied the effect of the decrease in the US exports due to the bans put by its trading partners after the discovery of BSE on beef and cattle prices. They used a simultaneous equations model to study the impact of exports and other supply and demand factors, on the beef prices. Their results indicate that the loss in US beef exports led to a decline in the price of the US beef. They also found that the cattle prices would have been higher by $0.04 per pound if there had not been a drop in the US beef exports due to BSE.

3. Theory and Methodology

The traditional export demand function that has been used in the literature (Khan 1974, Goldstein and Khan 1978, Leamer and Stern 1970) is used to estimate the export demand function for the US with each of the four trading partners.

The export demand function can be written with a log linear specification

$$\log(X_{it}) = \alpha_0 + \alpha_{1i}\log(Y_{it}) + \alpha_{2i}\log(P_{it}) + \alpha_{3i}\log(X_{it-1}) + \varepsilon_{it} \quad (3.1)$$

where X_{it} is the real exports of the US beef to its trading partners ($i = 1,\ldots4$); X_{it-1} is the lagged value of US beef exports to country i which takes into account the dynamic adjustment of the exports to meet the demands in the importing country, Y_{it} is the real GDP of the importing country and P_{it} relative price of US beef. Because the demand function is estimated in the logarithmic form, the estimated parameters will be the partial elasticities. α_{1i}'s are the income elasticities and α_{2i}'s are the price elasticities. This kind of model was used by Eenoo, Petersen, and Purcell (2000) to estimate the export demand function for US beef. The model will be estimated for the period 1990-2009 using monthly data for beef exports. This paper reports of the ordinary least squares results (OLS) for individual country equation estimations and also reports the two structural break tests - Chow test (1960) and the CUSUM test by Brown, Durbin, and Evans (1975) - to check for parameter stability of the export demand function. When the errors are correlated across equations, estimating (1) separately for each trading partner as a single equation would give rise to inefficient results. Therefore, it becomes useful to use seemingly unrelated regressions (SUR) model (Zellner 1962) which takes into account the correlations of errors across equations. The SUR system of equations is estimated by Feasible Generalized Least Squares (FGLS). To test the parameter stability of the model using SUR one can use the Wald Coefficient Restrictions test.

4. Tests for Structural Change

To test for any structural change in the parameters of the export demand function, we use two widely used test statistics – the Chow test and the CUSUM test. The chow test is based on the assumption that the structural breaking point is known and that variances are constant (Maddala and Kim 1998). The CUSUM test is useful when the structural break point is unknown and the variances are not necessarily constant. This paper tests for the null hypothesis of constant parameters against the alternative of a structural change due to the announcement of BSE. The BSE announcement happened in December 2003 so one can assume that if there is any structural change it could be right after 2003. If this is the case, then the Chow test can be used. But it is also justified to assume that there could have been some kind of lagged effects too. If there was indeed any lagged effect, to find the actual break point, the CUSUM test would be more appropriate to test for parameter stability of the export demand function.

4.1. Chow Test

Structural change means that the values of the parameters do not remain constant through the entire time period (Gujarati 2003). It is important to test for structural change in when there is a shock to the demand for the US exports because of a food scare. When the exact date of an event is known, the common test for testing structural change is the Chow test (1960). The null hypothesis is that there is no structural change which is tested against the alternative that there is a structural change. In the present paper, the null hypothesis is that the parameters of the export demand function did not change due to the outbreak of the BSE in the United States. The two sub-samples are assumed to be independent so that the unrestricted residual sum of squares can be added. If the null hypothesis is true then the residual sum of squares of the restricted model and the unrestricted models should not be statistically different. The Chow test follows an F distribution

$$F = \frac{(RSS_R - RSS_{UR})/k}{(RSS_{UR})/(n_1 + n_2 - 2k)} \sim F_{k,(n_1+n_2-2k)} \tag{3.2}$$

We do not reject the null hypothesis of no structural change if the calculated F value does not exceed the F table value at the chosen level of significance.

4.2. CUSUM Test

The cumulative sum of squares (CUSUM) test as proposed by Brown, Durbin, and Evans (1975) is based on recursive residuals. This test is useful when the actual structural break point is unknown. The null hypothesis is that the regression coefficient vector α is constant in every time period which is tested against the alternative hypothesis that the vector is not constant in every time period.

The recursive residuals are defined as the ex post prediction error for y_t when the regression is estimated using only the first t-1 observations (Greene 2003).

$$e_t = y_t - x_t^{'}\alpha_{t-1} \tag{3.3}$$

where x_t is the vector of explanatory variables for each y_t and α_{t-1} is the OLS coefficients computed using the first t-1 observations (Greene 2003). The CUSUM test requires calculating scaled recursive residuals and plotting the quantity W_m against time t where

$$W_m = \sum_{t=k+1}^{m} \frac{w_r}{\hat{\sigma}} \quad m = k+1,...,T \tag{3.4}$$

where $\hat{\sigma}^2 = (T-K-1)^{-1}\sum_{r=k+1}^{T}(w_r - \overline{w})^2$ and $\overline{w} = (T-K)^{-1}\sum_{r=k+1}^{T} w_r$. The probabilistic bounds for W_m are determined and the null hypothesis is rejected if W_m crosses the boundary for some level of m (Maddala and Kim 1998).

4.3. Dummy Variable for Structural Stability with Seemingly Unrelated Regression Estimation

The Chow test and the CUSUM test are valid only with OLS estimation methods. When using Seemingly Unrelated Regression Estimation (SURE), one can use dummy variables to test for the parameter stability of the model. To conduct the test, a dummy variable is created which takes a value (=0) for the sample period before the BSE announcement and takes a value (=1) for the post announcement sample period. That is, the equation (1) is rewritten as:

$$\begin{aligned} \log(X_{it}) &= \alpha_0 + \alpha_{1i}\log(Y_{it}) + \alpha_{2i}\log(P_{it}) + \alpha_{3i}\log(X_{it-1}) + \alpha_{4i}(Dum) \\ &+ \alpha_{5i}(Y_{it} * Dum) + \alpha_{6i}(P_{it} * Dum) + \varepsilon_{it} \end{aligned} \tag{3.5}$$

where $Dum = 0$ for the period January 1990 : November 2003 and $Dum = 1$ for the period December 2003: December 2009. The above equation would test for any change in the intercepts as well as the slope coefficients. The Wald coefficient restriction test can also be done to check whether the coefficients of the dummy and the dummy-interaction variables are significantly different from zero.

5. Data

The data for the present study were collected from January 1990 – December 2009. The data on quantity of exports to the individual trading partners of the US were obtained from the Foreign Agricultural Service (USDA). The quantity of exports is measured in metric tonnes (MT). Data on gross domestic product (GDP) of each country was not available on a monthly basis and therefore, industrial production index from OECD Stat was used as a proxy for the GDP. The industrial production index covers production in mining, manufacturing and public utilities but excludes construction. The industrial production indices are useful in measuring increases or decreases in production output. They are used as short-term economic indicators because they show a strong relationship between industrial production and overall economic behavior (OECD Economic Outlook). Due to unavailability of the relative price data, this paper used bilateral agricultural exchange rates data provided by Economic Research Services, USDA. The rationale for using bilateral agricultural exchange rate is that the response of each country to the outbreak of BSE in the US was unique and also US exports different kinds of beef to the four countries that are being analyzed. Hence, in this situation, bilateral agricultural exchange rate provided by the ERS, USDA seems to be more appropriate compared to other exchange rates. This is because it helps to capture the changing relative price dynamics between the US and each of its beef export market individually. The changes in bilateral exchange rates help in understanding the changes in the trade between two countries. Any change in the bilateral exchange rate would change the price of imported commodities in the importing country and therefore, the import demand would change. An appreciation of the currency of the exporting country makes its exports less competitive in the world market. On the other hand, depreciation of the currency makes exports more competitive in the world market. That is, if the exporting country's currency appreciates then the price being faced in the importing country increases and therefore, the demand for imports from that country decreases. For example, if the dollar's value increases against South Korea's won, then the price being faced in South Korea for US beef would increase and hence demand for US beef would decrease (ERS, USDA).

6. Results

The export demand equation for US beef was estimated using OLS for individual countries. The estimated equations were tested for serial correlation and heteroskedasticity (White 1980) and the parameters of the equations were tested for stability using the Chow test and the CUSUM test.

6.1. Canada Equation OLS Results

The results for the estimated export demand for US beef in Canada are shown below in tables 3.2(a) through 3.2(d). The signs of the coefficients are consistent with the expected signs and are significant. The coefficients can be interpreted as price and income elasticities, respectively. The results show that the elasticity of demand for US beef with respect to the exchange rate (price) was 0.14 in absolute terms i.e. a one percent increase in the value of the US dollar against the Canadian dollar decreased the demand for US beef in Canada by 0.14 %. The elasticity of demand for US beef with respect to the industrial production index proxy for the (GDP of Canada) was 0.20 indicating that for every 1% increase in the index (GDP) of Canada increased the demand for the US beef in Canada by 0.20%. Including lagged values of the dependent variables takes care of the serial correlation problem. Therefore, lagged values of the exports of the US beef to Canada were included in the export demand equation. We fail to reject the null hypothesis of no serial correlation at the 1% level of significance. The residual test for heteroskedasticity was also carried out. I failed to reject the null hypothesis of no heteroskedasticity.

6.1.1. Structural Stability of the Canada Model

The Chow test and the CUSUM test were carried out to check for the stability of the parameter estimates (elasticities). The null hypothesis for the Chow test is that there are no breaks at the specified breakpoints. In this case, the breakpoint was defined as December 2003 when the first case of the BSE in the United States was announced. The

Table 3.2(a)
Dependent Variable: LOGCEXPORTS
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.276157	0.215312	1.282593	0.2009
LOGCRATE	-0.147949	0.059289	-2.495383	0.0133
LOGCINDEX	0.200178	0.072548	2.759249	0.0062
LOGCEXPORTS(-1)	0.879575	0.031482	27.93900	0.0000

R-squared	0.874892	Mean dependent var	9.362334
Adjusted R-squared	0.873295	S.D. dependent var	0.317898
S.E. of regression	0.113158	Akaike info criterion	-1.503474
Sum squared residuals	3.009097	Schwarz criterion	-1.445290
Log likelihood	183.6651	Hannan-Quinn criter.	-1.480027
F-statistic	547.7939	Durbin-Watson stat	2.305664
Prob(F-statistic)	0.000000		

Table 3.2(b)
Test for Serial Correlation for export demand equation for Canada : Breusch-Godfrey serial correlation LM test

F-statistic	3.811256	Prob. F(2,233)	0.0235
Obs*R-squared	7.571114	Prob. Chi-Square(2)	0.0227

Table 3.2 (c)
Test for Heteroskedasticity for export demand equation for Canada : Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.693014	Prob. F(3,235)	0.5571
Obs*R-squared	2.095888	Prob. Chi-Square(3)	0.5527
Scaled explained SS	1.976795	Prob. Chi-Square(3)	0.5772

Table 3.2. (d)
Chow Test for Structural Stability:
Breakpoint (=Dec 2003)

Log likelihood ratio	31.43349	Prob. Chi-Square(4)	0.0000

results of the Chow test indicate the parameter estimates have not been stable.

The results of the CUSUM test (Figure 3.1) also indicate parameter instability for the entire sample. The first change in the parameters can be seen around 1993-94. This could be due to the implementation of the North American Free Trade Agreement (NAFTA). The parameters were stable from 1999 till 2007 but again changed around 2008. The December 2003 event did not specifically have any effect on the stability of the parameters but there could be some lagged effect on the parameters on the model due to BSE (as seen in the CUSUM test).

6.2. Mexico Equation OLS Results

The results of the Mexico export demand equation are reported below in tables 3.3(a) through 3.3(d). The signs of the coefficients have the expected signs. The coefficient of the log of the exchange rate (price elasticity of demand) is significant at 10% level of significance and the coefficient of the log of the industrial production index is significant at 1%. The coefficient of the log of the exchange rate indicates that for every 1% increase in the value of the US dollar against the Mexican Peso, the demand for US beef in Mexico decreased by 0.27%. The elasticity of the demand for US beef with respect to Mexican industrial production index indicates that for every 1% increase in the index (GDP) of Mexico, the demand for the US beef increased by 0.86%. The equation was tested for serial correlation and heteroskedasticity. We failed to reject the null of

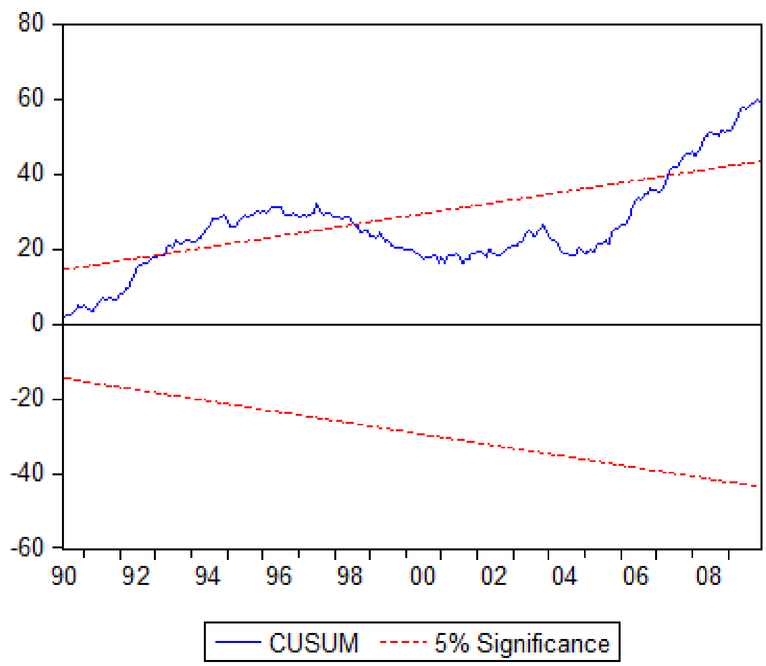


Figure 3.1: CUSUM test for Canada model

Table 3.3(a)
Dependent Variable: LOGMEXPORTS
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.237128	0.459737	-0.515792	0.6065
LOGMRATE	-0.278393	0.154139	-1.806116	0.0722
LOGMINDEX	0.866076	0.179999	4.811570	0.0000
LOGMEPXPORTS(-1)	0.713009	0.062345	11.43652	0.0000

R-squared	0.940305	Mean dependent var	10.26980
Adjusted R-squared	0.939543	S.D. dependent var	0.577274
S.E. of regression	0.141940	Akaike info criterion	-1.050230
Sum squared resid	4.734536	Schwarz criterion	-0.992047
Log likelihood	129.5025	Hannan-Quinn criter.	-1.026784
F-statistic	1233.897	Durbin-Watson stat	2.228913
Prob(F-statistic)	0.000000		

Table 3.3(b)
Test for Serial Correlation for export demand equation
for Canada : Breusch-Godfrey serial correlation LM test

F-statistic	3.326167	Prob. F(2,233)	0.0376
Obs*R-squared	6.634226	Prob. Chi-Square(2)	0.0363

Table 3.3(c)
Test for Heteroskedasticity for export demand equation for Canada:
Heteroskedasticity Test: Breusch-Pagan

F-statistic	3.525797	Prob. F(3,235)	0.0157
Obs*R-squared	10.29409	Prob. Chi-Square(3)	0.0162
Scaled explained SS	25.76119	Prob. Chi-Square(3)	0.0000

Table 3.3(d)
Chow Breakpoint Test: 2003M12
Null Hypothesis: No breaks at specified breakpoints

Log likelihood ratio	25.58595	Prob. Chi-Square(4)	0.0000

both no serial correlation and no heteroskedasticity. The tests for serial correlation and heteroskedasticity are reported below.

6.2.1. Structural Stability of the Mexico Model

The results of the parameter stability tests using the Chow test and CUSUM test are reported below. The Chow test and the CUSUM test results clearly give different results for parameter stability of the model. The Chow test rejects the null hypothesis of no break point whereas the CUSUM test (figure 3.2) indicates no break point in the parameter stability of the Mexico model. The difference is because of the difference in the assumptions of the two test statistics.

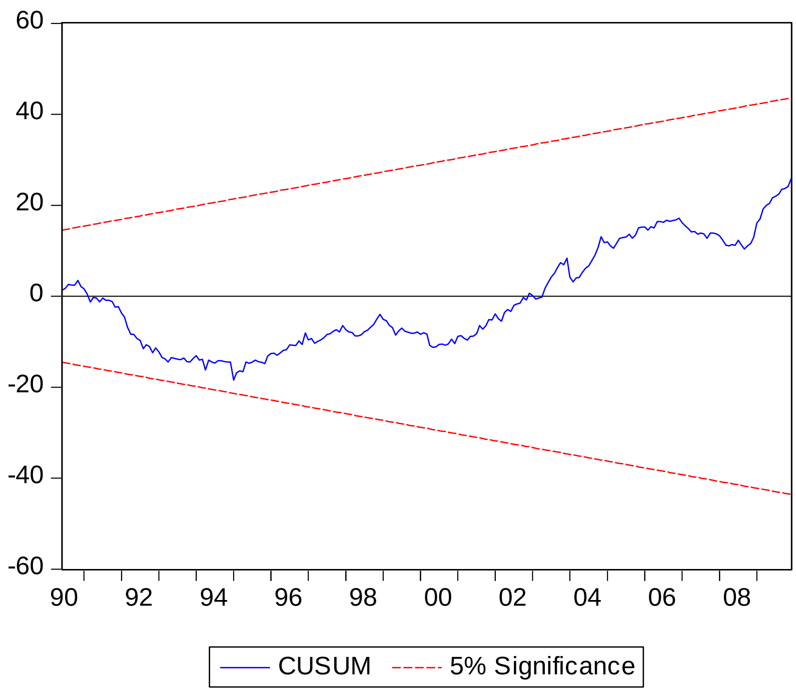


Figure 3.2: CUSUM test for Mexico model

6.3. Japan Equation OLS Results

The coefficient estimates have the expected sign for the export demand equation, but the coefficients are not significant for either the exchange rate or the industrial production index. The results are reported in tables 3.4(a) through 3.4(c). Because the coefficients are not significant, we did not test for the parameter stability of the model. The tests for no serial correlation and homoskedasticity showed no serial correlation or heteroskedasticity in the model. The insignificant results could be due to the fact that Japan imports specific types of beef from the US and Australia (which is a major competitor for the US beef in the export market). The United States' major exports to Japan are comprised of frozen boneless cuts to beef while Australia exports primarily chilled beef. The lack of major competition for US type beef in Japan can explain these results. Also, Japan has not yet completely lifted the entire ban put in place due to BSE on US beef exports to Japan. The United States can only export beef from cattle of less than 21 months of age which can explain why there is not a significant relationship between the explanatory variables of the model, namely, exchange rate and the industrial production index. The coefficient of the lagged value for exports is significant implying a dynamic adjustment of US beef exports to meet the demand for US beef in Japan. As Almas, Colette, and Amosson (2005) point out, Australia and New Zealand cannot completely meet the import demand for beef by Japan and Brazil cannot export to Japan due to its FMD status thus indicating a highly inelastic demand in Japan for US beef.

6.4. South Korea Equation OLS Results

The coefficient of the log of the industrial production index satisfies our a priori

Table 3.4(a)
Dependent Variable: LOGJEXPORTS
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.135299	0.488378	2.324630	0.0209
LOGJRATE	-0.065271	0.040081	-1.628495	0.1048
LOGJINDEX	0.012253	0.083901	0.146044	0.8840
LOGJEXPORTS(-1)	0.916306	0.019716	46.47634	0.0000

R-squared	0.855096	Mean dependent var	10.63023
Adjusted R-squared	0.853247	S.D. dependent var	0.321042
S.E. of regression	0.122986	Akaike info criterion	-1.336898
Sum squared resid	3.554503	Schwarz criterion	-1.278715
Log likelihood	163.7594	Hannan-Quinn criter.	-1.313452
F-statistic	462.2560	Durbin-Watson stat	2.279189
Prob(F-statistic)	0.000000		

Table 3.4(b)
Test for Serial Correlation for export demand equation for Japan :
Breusch-Godfrey serial correlation LM test

F-statistic	3.562092	Prob. F(2,233)	0.0299
Obs*R-squared	7.090832	Prob. Chi-Square(2)	0.0289

Table 3.4(c)
Test for Heteroskedasticity for export demand equation for Japan :
Heteroskedasticity Test: Breusch-Pagan

F-statistic	0.351448	Prob. F(3,235)	0.7881
Obs*R-squared	1.067500	Prob. Chi-Square(3)	0.7849
Scaled explained SS	2.749687	Prob. Chi-Square(3)	0.4318

expectations regarding the sign. The results are reported in tables 3.5(a) through 3.5(d). The coefficient for the log of the exchange rate is positive which does not satisfy our sign expectation but it is statistically insignificant. The elasticity of demand for US beef demand with respect to industrial production index (GDP) of South Korea indicates that for every 1% increase in the index (GDP) of South Korea, the demand for the US beef increased by 0.13%. The null hypothesis of no serial correlation could not be rejected in the case of South Korea model but the null hypothesis of no heteroskedasticity was rejected.

6.4.1. Structural Stability of the South Korea Model

The Chow test indicates that there has been a change in the parameter values of the South Korea model following the announcement of the BSE in December 2003. The

Table 3.5(a)
Dependent Variable: LOGSKEXPORTS
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.111061	1.107626	1.003102	0.3168
LOGSKRATE	0.035286	0.178890	0.197250	0.8438
LOGSKINDEX	0.135734	0.067443	2.012577	0.0453
LOGSKEXPORTS(-1)	0.786287	0.061491	12.78697	0.0000

R-squared	0.711498	Mean dependent var	8.959364
Adjusted R-squared	0.707815	S.D. dependent var	0.724147
S.E. of regression	0.391431	Akaike info criterion	0.978580
Sum squared resid	36.00630	Schwarz criterion	1.036764
Log likelihood	-112.9403	Hannan-Quinn criter.	1.002027
F-statistic	193.1845	Durbin-Watson stat	2.204927
Prob(F-statistic)	0.000000		

Table 3.5(b)
Test for Serial Correlation for export demand equation for South Korea : Breusch-Godfrey serial correlation LM

F-statistic	4.711409	Prob. F(2,233)	0.0099
Obs*R-squared	9.289776	Prob. Chi-Square(2)	0.0096

Table 3.5 (c)
Test for Heteroskedasticity for export demand equation for Japan : Heteroskedasticity Test: Breusch-Pagan

F-statistic	2.351739	Prob. F(3,235)	0.0730
Obs*R-squared	6.966167	Prob. Chi-Square(3)	0.0730
Scaled explained SS	55.79015	Prob. Chi-Square(3)	0.0000

Table 3.5(c)
Chow Breakpoint Test: 2003M12
Equation Sample: 1990M02 2009M12

Log likelihood ratio	55.86459	Prob. Chi-Square(4)	0.0000

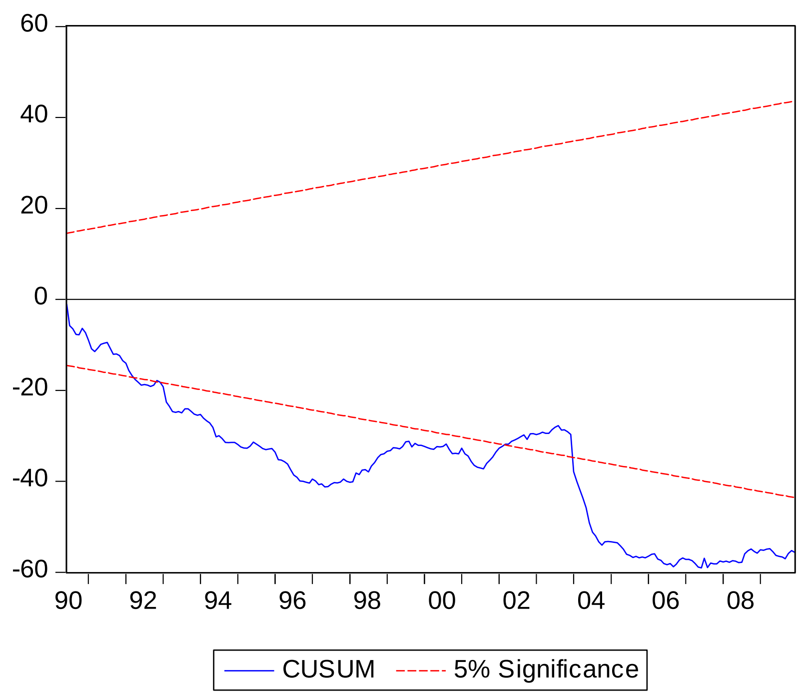


Figure 3.3 CUSUM test for South Korea model

CUSUM test (figure 3.3) also indicates parameter instability. The results indicate that parameter instability of the model started around 1991 and remained unstable till 2001. The parameters remained stable from 2001 till 2003, but again became unstable. This result could be an indication of the impact of the outbreak of the BSE on the structural stability of the South Korea model.

6.5. Seemingly Unrelated Regression Estimators (SURE)

The four export demand equations were estimated as a system using SUR. A dummy variable was introduced to take into account the BSE announcement. The dummy variable took the value (=0) in the pre-announcement period from January 1990-Novemeber 2003 and it took a value (=1) in the post-announcement period from December 2003-December 2009. The results of the SUR estimation are given in table 3.6. The results indicate that for Japan, other than the coefficient of the log of the lagged value of the exports, all coefficients were not significant.

Mexico had the expected signs for the coefficients for the log of the industrial production index and the log of the exchange rate and both were significant. The dummy coefficient for Mexico was not significant indicating there is no change in the intercept of the demand function due to the BSE outbreak. The interaction of the dummy variable with the log of the exchange rate is significant whereas the interaction of the dummy variable with the log of the industrial production index was not significant. This is indicative of a change in the price elasticity of the US beef demand in Mexico due to the BSE announcement. For South Korea, all the coefficients were significant at the 5% other than the dummy interaction with exchange rate and had the expected signs. This indicates

Table 3.6
Estimation Method: Seemingly Unrelated Regression
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
Constant Japan	0.768864	1.206799	0.637110	0.5242
Log-J-Rate	-0.017215	0.067262	-0.255935	0.7981
Log-J-Index	0.102711	0.248971	0.412540	0.6800
Dummy-J	0.177996	1.425742	0.124844	0.9007
Dum*Log-J-Rate	0.029252	0.245717	0.119046	0.9053
Dum*Log-J-Index	-0.078036	0.314440	-0.248175	0.8041
Log-J-Lag-Imports	0.892387	0.027518	32.42917	0.0000
Constant Mexico	0.775326	0.486128	1.594900	0.1111
Log-M-Rate	-0.557659	0.098649	-5.652981	0.0000
Log-M-Index	1.053618	0.145024	7.265123	0.0000
Dummy-M	-1.938401	2.455099	-0.789541	0.4300
Dum*Log-M-Rate	1.263447	0.322061	3.923007	0.0001
Dum*Log-M-Index	-0.225328	0.427954	-0.526524	0.5987
Log-M-Lag-Imports	0.597047	0.044145	13.52468	0.0000
Constant S Korea	4.278891	1.264242	3.384552	0.0007
Log-SK-Rate	-0.607331	0.219118	-2.771710	0.0057
Log-SK-Index	1.038473	0.167008	6.218096	0.0000
Dummy-SK	-11.81161	3.817170	-3.094338	0.0020
Dum*Log-SK-Rate	0.727579	0.434792	1.673395	0.0946
Dum*Log-SK-Index	1.270262	0.413872	3.069212	0.0022
Log-SK-Lag-Imports	0.537587	0.049269	10.91135	0.0000
Constant Canada	2.267891	0.632148	3.587596	0.0004
Log-C-Rate	0.138328	0.152248	0.908567	0.3638
Log-C-Index	0.197190	0.140659	1.401904	0.1613
Dummy-C	4.564605	1.223160	3.731814	0.0002
Dum*Log-C-Rate	-1.330927	0.270401	-4.922042	0.0000
Dum*Log-C-Index	-0.928966	0.270166	-3.438495	0.0006
Log-C-Lag-Imports	0.656822	0.044495	14.76161	0.0000

that there has been a structural change due to the outbreak of the BSE in the US in 2003. For Canada, coefficients of the log of the exchange rate and industrial production index were not statistically significant but the coefficients of the dummy interaction terms were significant indicating that exchange rate and industrial production index became important in explaining changes in demand for US beef by Canada after 2003. The above results can be written as the following equations each of the trading partners.

Japan

$$Log\_EX_J = 0.8923(LLEX_J) \qquad (3.6.a)$$

Mexico

$$Log\_EX_M = -0.55(LEXRATE_M) + 1.05(LIPINDEX_M) + 1.26(Dum * LEXRATE_M) + 0.59(LLEX_M) \qquad (3.6.b)$$

South Korea

$$Log\_EX_{SK} = 4.27 + (-0.60)(LEXRATE_{SK}) + 1.03(LIPINDEX_{SK}) + (-11.81)(Dum) + 1.27(Dum * LIPINDEX_{SK}) + 0.53(LLEX_{SK}) \qquad (3.6.c)$$

Canada

$$Log\_EX_C = 2.26 + 4.56(Dum) + (-1.33)(Dum * LEXRATE_C) + (-0.92)(Dum * LIPINDEX_C) + 0.65(LLEX_C) \qquad (3.6.d)$$

where EX_i = Log of the quantity of US beef exports of US beef to country i

$LLEX_i$ = Log of lagged value of exports to country i

$LEXRATE_i$ = Log of the bilateral exchange rate between the US and country i

$LIPINDEX_i$ = Log of industrial production index in country i

$LLEX_i$ = Log of the lagged value of US beef exports to country i

Dum = Dummy variable defined as $Dum = 0$ for January 1990-November 2003 (pre-BSE period) and $Dum = 1$ for December 2003-December 2009.

The above results indicate that for Mexico, the elasticity of demand for US beef with respect to the exchange rate (price) changed in the post-BSE period (became more elastic) whereas there was no change in the elasticity of demand for US beef with respect to industrial production index due to the BSE outbreak. In the case of South Korea, there was a change in the elasticity of demand for US beef with respect to the industrial production index (GDP) in the post-BSE period. Before the announcement of the BSE, the income elasticity for US beef in South Korea was 1.03 indicating that for every 1% increase in the income of South Korea, the demand for US beef increased by 1.03%. In the post-BSE period, the income elasticity is 2.30 indicating that for every 1% increase in the income of South Korea leads to an increase in the demand for the US beef by 2.3%. In the case of Canada, results indicated there was no statistically significant relationship between the dependent variable and the independent variables other than the lagged value of the exports of US beef to Canada. But the dummy and the dummy interaction coefficients are significant indicating that bilateral exchange rate and industrial production index play a significant role in determining the demand for US beef in Canada. The results are mostly consistent with stability test results with OLS.

7. Policy Implications

As Uri and Jones (1988) point that the right agricultural policy is a function of the magnitude of the elasticities, these results might have significant policy implications for increasing bilateral trade between countries. For example, South Korea's income elasticity is positive and elastic in the post-BSE period. This implies that there is a positive relationship between income of South Korea and the demand for US beef. Therefore, analyzing and monitoring South Korea's economic condition and identifying opportunities for export promotion consistent with the economic well-being of South Korea would help in increasing US beef exports. Similarly, US beef into Japan is not affected by exchange rate changes or output in Japan. This implies that there are other factors that affect the demand for US beef in Japan, most importantly are the quality standards. United States should focus on US beef export promotion and marketing strategies in Japan by focusing on the quality standard requirements set by Japan.

8. Conclusion

The objective of the present paper is to analyze the impact of the announcement of the BSE on the demand for US beef in Canada, Mexico, South Korea and Japan. These four countries together accounted for more than 90% of US beef exports before the BSE announcement in December 2003. To analyze the impact of BSE on the demand for US beef an export demand function is estimated and the parameter stability of the model is analyzed using various structural stability tests. Four individual country equations are estimated first using OLS and two tests for structural stability – the Chow test and the CUSUM test are carried out. The export demand equation is then estimated using Seemingly Unrelated Regression to account for contemporaneous correlation between the error terms of the different equations. The results indicate that the parameters have not been stable for Mexico, Canada and South Korea in the entire estimated sample. In the case of Japan, the exchange rate and the industrial production index do not explain changes in the demand for US beef. Identifying the factors that affect the demand for the US beef in its export markets, and estimating the price and income elasticities are important in formulating policies for export promotion in the right direction.

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Appendix

Table 3A
Top markets for US beef

Beef and Veal Exports Carcass weights (in thousands of pounds)				
Year	Canada	Japan	Mexico	South Korea
1987	30929	396967	10703	687
1988	52639	503465	37361	16055
1989	98152	821121	74700	57747
1990	191065	574446	72922	97742
1991	258916	534123	172755	149849
1992	249415	629127	194896	164524
1993	243548	719768	120016	116162
1994	285715	832429	223021	177287
1995	311982	1004451	92302	272176
1996	295424	1015779	172246	203796
1997	282725	1053553	312583	261673
1998	261211	1118488	418855	153808
1999	249629	1095309	465988	307847
2000	253759	1112417	516355	384888
2001	233291	1004062	531972	345518
2002	240550	771074	629252	597301
2003	226681	918014	586390	586617
2004	56457	11609	333454	648
2005	105895	17496	464024	1077
2006	238556	51639	660454	1283
2007	339106	159411	586434	77919
2008	389250	231070	649239	152095
2009	362330	274578	562966	140553

Source: USDA (ERS) Data provided by Livestock Marketing Information Center

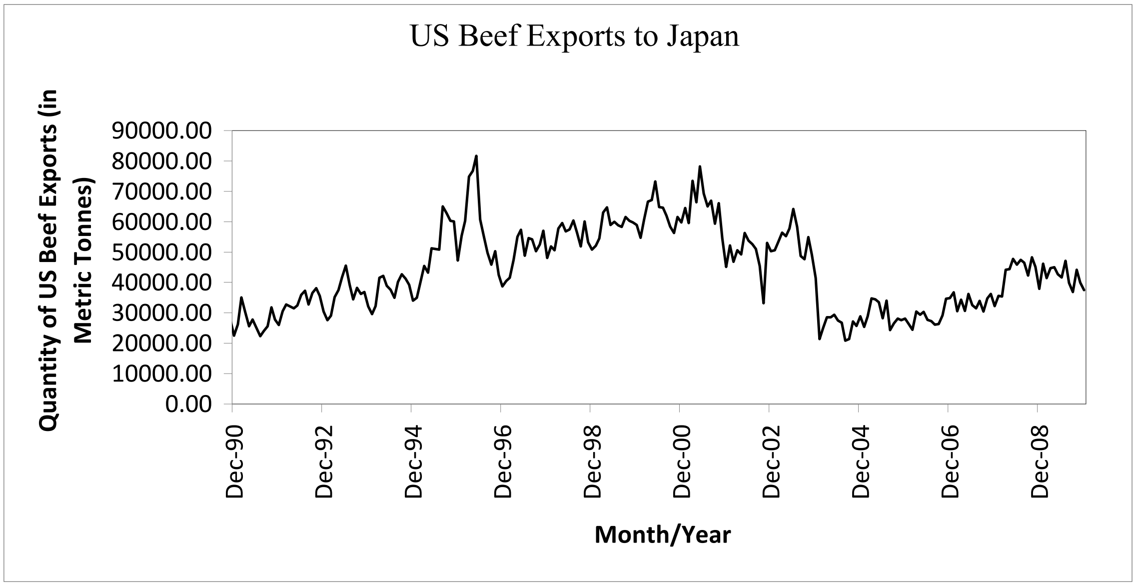

Figure 3A: US beef exports to Japan

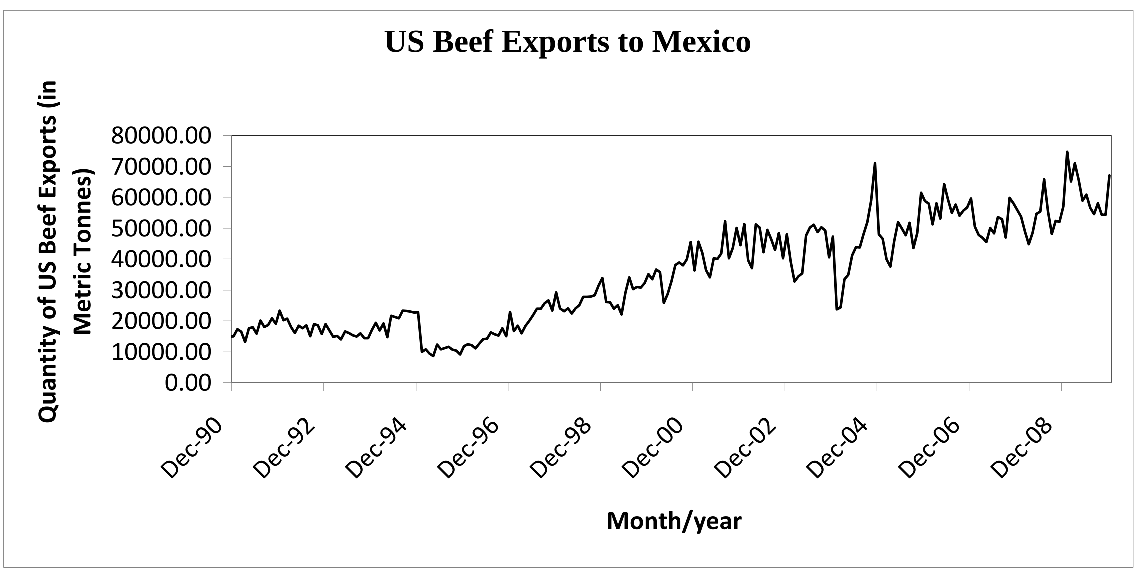

Figure 3B: US beef exports to Mexico

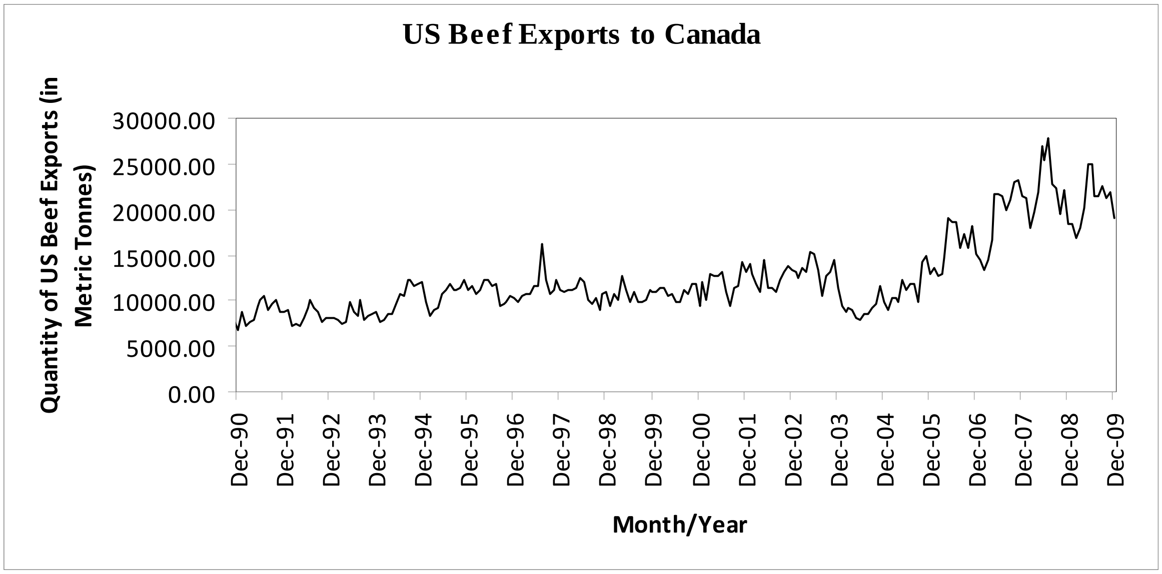

Figure 3C: US beef exports to Canada

Figure 3D: US beef exports to South Korea

CONCLUSION

In this three essay dissertation, the impact of the outbreak of Bovine Spongiform Encephalopathy (BSE) in the United States in December 2003 on three different sectors is examined. The first essay examined the impact of the announcement of the first case of BSE in North America (May 2003 in Canada) and the first case of BSE in the United States in December 2003 on security prices of publicly listed agribusiness firms and restaurant companies in the United States. The analysis showed that the firms did not respond significantly to the announcement in May 2003 but the same firms did react to the news of BSE in the United States in December 2003. One of the possible reasons why the overall agribusiness sector did not react to the news of BSE in Canada in May 2003 is that information was already present in the market since January 2003 that a cow was being tested for BSE. But the December 2003 event was unexpected, and therefore companies reacted. Out of the seven groups chosen for the present study the farm products, food wholesale, processed and packaged goods, meat products and restaurants showed negative reaction once the announcement was made.

The objective of the second essay was to study the interdependencies among the meat sectors in the United States and to analyze the impact of the first case of the mad cow disease outbreak in the United States in December 2003. The results of the study indicate interdependencies in the beef, pork and poultry markets in the United States. That is, a shock in one series has an impact on other series too. There is vertical as well spatial price transmission in the meat markets, though the transmission is not perfect. The different speeds of adjustment point to asymmetric price transmission. Also, the magnitude of the mad cow disease shock was different in different markets indicating asymmetry in terms of both speeds of adjustment and magnitude. The first case of the mad cow disease led to a decrease in the price of farm and wholesale of both beef and pork, though the decrease in the prices continued beyond January only for beef. The retail prices of beef did not show any negative effect. Wholesale values of poultry gained through April 2004 whereas the gains in retail values of poultry were not substantial.

The objective of the present paper is to analyze the impact of BSE on the demand for US beef an export demand function is estimated and the parameter stability of the model is analyzed using various structural stability tests. Four individual country equations are estimated first using OLS and two tests for structural stability – the Chow test and the CUSUM test are carried out. The export demand equation is then estimated using Seemingly Unrelated Regression to account for contemporaneous correlation between the error terms of the different equations. The results indicate that the parameters have not been stable for Mexico, Canada and South Korea in the entire estimated sample. In the case of Japan, the exchange rate and the industrial production index do not explain changes in the demand for US beef. Identifying the factors that affect the demand for the US beef in its export markets, and estimating the price and income elasticities are important in formulating policies for export promotion in the right direction.

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Worked on "The impact of nutrition labeling on the demand for certain varieties of meat in the US market."
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