

# The Implication of the BSE Crisis on the Demand for Beef in Ireland: An Econometric Investigation

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Since the spring of last year the media has been dominated by each new development on BSE. Consumers across Europe have stopped buying what had once been one of their staple foods and, consequently, the industry has been thrown into turmoil. Here, Suzanne O'Neill presents a model of the determinants of the change in demand for beef in Ireland.

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## Introduction

BSE in cattle was first confirmed in Ireland in 1989. At that time the Food Safety Advisory Committee reported that there was "no evidence to suggest that BSE or Scrapie is transmissible to humans" (FSAC, 1989). Today, despite not having conclusive scientific proof of human infection arising from the consumption of infected beef, the WHO has stated that "the most likely hypothesis for V-CJD<sup>1</sup> is the exposure ... to BSE" (Economic & Social Committee, 1996; Food Safety Advisory Board, 1996). It would appear that consumer confidence in the safety of beef has been damaged and that the consumption of beef has declined significantly (Burton & Young, 1996, Economic & Social Committee, 1996). This paper will analyse the impact of the BSE crisis on the demand for beef in Ireland.

The essay will focus on two main issues. Firstly, the paper concentrates on the retail market for beef and in particular focuses on the change in consumption of beef by Irish consumers. The evidence suggests that there has been a downward trend over time in consumption of beef and that the beef industry was in a state of turmoil before the BSE scare (Agra Europe, 1996). Hence the analysis will begin by examining the annual trend in the consumption of fresh meats including beef over a 16 year period, to determine whether this is the case in Ireland. The econometric techniques of ordinary least squares and error correction models are employed to demonstrate that the change in the consumption of beef can be attributed to price factors and the BSE crisis.

The second aspect of this paper is concerned with the way in which price signals are transmitted along the chain from farm to retail level. Starting from Marshall's hypothesis that retail prices fluctuate less than wholesale prices (Schein, 1996), the price of beef from the slaughter price to the average retail price will be traced to ascertain whether the well reported fall in beef prices (IFJ, 1996, E & S

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<sup>1</sup> V-CJD is considered to be the human variant of BSE.

Committee, 1996) at the farm level are being passed on to the consumer. This will involve analysing price in the period prior to the BSE crisis and the period since the start of the crisis, to gauge the size of the farmers' and wholesalers' margins.

### **Section 1: Placing the BSE Crisis in Context**

To begin, the paper outlines the sources of data used in the study and then proceeds to discuss the impact of BSE crisis on the market for beef in Ireland. Finally, this section concludes with an examination of the trends in the consumption of beef over the past fourteen years.

#### **The Data**

Data for this paper was collected from a number of sources, the primary source being the Central Statistics Office. The Consumer Price Index provided much of the retail price series. This data is collected quarterly and the intermediate time periods were estimated based on the average gross margins. The agricultural prices are a monthly series and were taken from the Statistical Abstract, while the annual meat consumption series was taken from Eurostat. The above data is as reliable as any government collected statistics can be. The retail sales of beef were provided on request by a leading national retail supermarket, the base period taken was November 1995, and a sales index was created based on the supermarkets estimated share of the beef market.

#### **The BSE Crisis**

BSE came to the fore in the late 1980s. The close proximity of Ireland to the UK and the easy accessibility to the UK media resulted in the British BSE scare impacting on Irish beef sales. Every time the media reported a rise in the number of cases of BSE there was a consumer reaction causing sales of beef to decline temporarily, adding to the already falling trend in the consumption of beef. However, it was not until March 1996 when the UK government acknowledged that BSE was transmissible to humans through the food chain that a serious crisis in consumer confidence in beef occurred (Dept. Food and Agriculture, 1996).

The decline in the consumption of beef did not recover in the period after March 1996, and it began to appear as if the change in the tastes of consumers was becoming permanent. The effect on domestic beef sales depends primarily on two factors. The first is how consumers respond to government and producers assurances concerning the safety of beef, and on how successful producers are in differentiating beef produced from infected and unaffected herds (The Economist, 1996). It appears that the response of consumers to lower prices is less important in the case of beef. Moreover, it can be argued that consumers are, in fact, willing to pay more for a product if this reduces the risk of adverse effects. The amount consumers are willing to pay "*increases as the severity of the adverse health*

*effects associated with the risk increases*" (Henson, 1996: 418). To fully explore the impact of the BSE crisis on the demand for beef, the overall trend in the consumption of red meat needs to be addressed.

### **Consumption of Beef 1980 to 1994**

For several years prior to the BSE scare the beef industry in Europe was in a state of turmoil (Agra Europe, 1996). Hence, I will begin by examining the trend in the consumption of fresh meat and beef over a 16 year period to determine whether this is the case in Ireland.

It is clear that per capita consumption of red meat, and in particular beef, has been declining over the past decade while poultry meat consumption has expanded. Consumption of poultry meat has risen steadily over the past decade from 14.4 kg/head in 1970 to 28 kg/head in 1994. Beef and veal consumption has fallen over the same period from 25.6 kg per head in 1970, to 16.0 kg per head in 1994. Both the consumption of sheepmeat and pig meat have remained fairly constant.

Although accepting the persistent decline in the annual consumption of beef, by examining in detail the months before and after the BSE crisis it is possible to gauge the effect of the crisis. The rationale for this analysis is to determine if the change in the consumption of beef can be attributed to price factors alone or if the BSE crisis is impacting on the demand for beef in Ireland.

## **Section 2: The Econometric Investigation**

### **The Choice of Variables**

The dependent variable (Y) chosen is the retail sales of beef from November 1994 to October 1996. Table 2.1 below gives a sample of the beef sales and shows that sales of beef<sup>2</sup> have declined since the major BSE crisis in March 1996, although there is some evidence to suggest that sales have started to recover again.

*Table 2.1, Beef Retail Sales*

1995		1996							
Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
113	123	120	103	80	87	91	92	97	130

*Source: Power Supermarket Ltd.*

Theory suggests that the demand for a food product is determined its own price, the price of substitutes, income and preferences (Tracy, 1993; Cortez & Senauer, 1996). Following on from this the choice of the independent X variables in this analysis includes the price of the meat in question, beef, and the price of other

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<sup>2</sup> Index of retail sales. Base Month November 1994=100.

meat substitutes, namely sheep meat and pork. The independent X variables used in the model are given below:

- $X_1$       The retail price of beef
- $X_2$       The retail price of lamb
- $X_3$       The retail price of pork
- $X_4$       Dummy variable representing the BSE crisis

It appears that consumer attitudes and preference issues are of growing importance in the demand for beef (Bansback, 1995). To allow for this the model includes a dummy variable to represent taste changes arising from the BSE crisis. It is envisaged that the use of a discrete step nature dummy variable would capture the immediate effect of the July 1995<sup>3</sup> BSE crisis, and the long term change in preferences resulting from the March 1996 BSE crisis. Accepting that a dummy variable will not pick up the intensity of the impact of the BSE crisis on consumer taste for beef or the fact that the crisis has evolved over time, it does nevertheless provide the best means to capture taste changes.

Ideally, the use of household survey data would have had the advantage of allowing the influence of socio-economic factors in determining consumer preferences for beef to be measured (Burton et al, 1996). However, although both income and socio-economic factors are considered to be important determinants of meat consumption (Cortez & Senauer, 1996; Bansback, 1995), they have not been included in the model. The rationale for excluding these variables in the model is that as the analysis is using monthly data collected over a short period of time changes in income would not have been significant.

### Specifying the Model

The testing of the model involved three stages. Given that in practice most time series data is non-stationary, the variables in the model were tested for non-stationarity. The rationale for this approach is that non-stationarity can lead to the production of spurious results (Lambert, 1995). The Dickey-Fuller test was applied to each of the variables in the model, and not surprisingly all the series were found to be non-stationary. However, the results of the Engle-Grainer test indicated that the estimated  $\epsilon_1$  was in fact stationary, and therefore the variables despite being individually non-stationary are co-integrated (Gujarati, 1995). The implication for the model is that in the long run there may exist a relationship between the variables, hence, two separate regression analyses were run.

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<sup>3</sup> Although there were reports of BSE prior to July 1995, it was in this month that the first restrictions on the export of British beef were imposed by the European commission.

The regression technique of ordinary least squares was applied to give estimates of the unknown parameters and their significance in the explanation of the dependent variable. The model used takes the form below:

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + \varepsilon_t$$

where  $\beta_0$  to  $\beta_4$  represent the unknown parameters, and  $\varepsilon_t$  is the error term. The results of the OLS regression give an indication of the long term relationship between the dependent variable and the independent variables. However, the results of the analysis need to be viewed with caution given the presence of non-stationary time series.

A second regression was undertaken using an Error Correction Model (ECM) and Engle-Granger methodology. The ECM takes the form:

$$\Delta Y_t = \alpha_0 + \alpha_1 \Delta X_{1t} + \alpha_2 \Delta X_{2t} + \alpha_3 \Delta X_{3t} + \alpha_4 \Delta X_{4t} + \alpha_5 v_{t-1} + \varepsilon_t$$

where  $\Delta$  denotes first difference,  $v_{t-1}$  the one period lagged value of the residual from the OLS regression above, and  $\alpha_0$  to  $\alpha_5$  represent the unknown parameters. The ECM is used to give an indication of the short run dynamics of the model.

### The Central Findings

In an attempt to explain the change in the retail sales of beef a multiple regression analysis was undertaken. The hypothesis tested is that there is no relationship between the X and Y variables ( $H_0: \beta_i = 0$ ). The estimation of the regression line and the correlation coefficients were obtained, and this yielded the line of best fit as follows:

$$Y = 265.53 - 49.24X_1 + 3.913X_2 - 12.27X_3 - 24.29X_4$$

Table 2.2

Independent Variable	Parameter Estimate	t-Statistic
Constant	265.53	
X <sub>1</sub> Beef Prices	-49.248	-6.978
X <sub>2</sub> Sheep Prices	3.913	.863
X <sub>3</sub> Pork Prices	-12.271	-2.416
X <sub>4</sub> BSE Dummy	-24.299	-5.946

$$R^2 = 0.86533 \quad F = 27.3074$$

An estimate of a parameter is said to be statistically significant if the t-statistic associated with it, at a particular significance level, causes us to reject the null

hypothesis that  $\beta$  is equal to zero. The hypothesis was tested at the 5% significance level<sup>4</sup>. These results suggest  $X_1$  (the retail beef price) is Table 2.2 below details the parameter estimates and the t-statistics: statistically significant in explaining the change in retail sales of beef since the t - statistic is -5.946. The negative sign of the parameter estimate for  $X_1$  suggests a negative relationship between the sales of beef and the price of beef.

One would expect the relationship between the sales of beef and the price of substitute meats to be positive, and this is the case for sheep meat. However, the price of sheep meat  $X_3$  is not statistically significant in explaining the change in retail sales of beef. It appears that pig meat is statistically significant in explaining the change in sales of beef. And even though the sign of the estimated coefficient for pig meat  $X_3$  is negative, this is not entirely unexpected. Evidence from studies by Burton & Young (1996) found that while most meats are found to be gross substitutes; not all were net substitutes. It does appear that  $X_4$ , the dummy variable representing the BSE crisis, is highly significant in explaining the change in the retail sale of beef.

The correlation coefficient ( $R^2$ ) implies that almost 87% of the variations in the Y variable (retail beef sales) are explained by the linear influence of the four X variables. The overall significance of the model was tested using the F - test and the results indicate that the model has significant explanatory power<sup>5</sup>. The variables in the model were all tested for the presence of collinearity using the variance-inflating factor (VIF) test, and were found not to be highly correlated<sup>6</sup>.

However, given that this is a cointegrating regression, the results of the OLS regression have to be interpreted as long term relationships rather than as a model estimating the short term impact of the independent variables on the dependent variable. For this reason a second Error Correction Model (ECM) was used in an attempt to reconcile the short-run behaviour of the variables with their long-run behaviour. The ECM resulted in the estimation of the regression line and the correlation coefficients as detailed below. The line of best fit was estimated to be:

<sup>4</sup> Reject the null hypothesis  $H_0=0$  if  $|t| > t_{\alpha, n-1}$ . In this case the t-statistic  $t = 2.11$

<sup>5</sup>  $H_0: \beta_2 = \beta_3 = \beta_4 = 0$ . If  $F > F_{\alpha}(k-1, n-k)$  then reject the null hypothesis. At a 5 percent significance level, the critical F value for 4 and 17 df,  $F_{0.05}(4, 17)$  is 2.96. Hence,  $H_0$  is rejected.

<sup>6</sup> If the VIF of a variable exceeds 10 that variable is said to be highly collinear (Gujarati, 1995). All the variables in the model had VIF values of between 1.4 and 2.599.

$$\Delta Y_t = .036647 - 52.768\Delta X_{1t} + 5.412 \Delta X_{2t} - 7.393 \Delta X_{3t} - 23.126\Delta X_{4t} - 1.2692 \upsilon_{t-1}$$

The parameter estimates and the t-statistics are detailed in Table 2.3.

*Table 2.3*

Independent Variable	Parameter Estimate	t-Statistic
Constant	.036647	
$\Delta X_1$ Beef Prices	-52.768	-3.685
$\Delta X_2$ Sheep Prices	5.4124	.804
$\Delta X_3$ Pork Prices	-7.3933	-.882
$\Delta X_4$ BSE Dummy	-23.558	-7.794
$\upsilon_{t-1}$ Error Correction Term	-1.2692	-4.767

$$R^2 = .88957 \quad F = 24.166$$

The statistical significance of the co-efficient of the error correction term  $\upsilon_{t-1}$  implies that the  $\upsilon_{t-1}$  term is capturing the adjustment toward long term equilibrium. The results of the ECM indicate that the short run changes in beef prices and the BSE dummy variable have a negative effect on the sales of beef (Y), and that about 1.2 of the discrepancy between the actual and long run value of beef sales is eliminated each month (Gujarati, 1995). The BSE variable is also highly statistically significant<sup>7</sup>, with a t-statistic of -7.794. Neither the price of pig meat or sheep meat is significant at a 5% or 10% significance level. The F-statistic of 24.16 implies that the estimated regression has significant explanatory power<sup>8</sup>. The  $R^2$  suggests that almost 89% of the variation in the sale of beef can be attributed to the explanatory X variables. As with the OLS model each of the variables in the ECM were checked for the presence of collinearity using Tolerance and VIF tests, and none of the variables were found to be collinear<sup>9</sup>.

### **The Implications of the Findings**

The econometric investigations strongly suggest that the BSE crisis has had an impact on the sale of beef in Ireland. It appears that there has been a marked change in tastes

<sup>7</sup> Reject the null hypothesis  $H_0=0$  if  $|t| > t_{\alpha, n-1}$ . In this case the t-statistic  $t_{.05, 15} = 2.571$

<sup>8</sup> At a 5 percent significance level, the critical F value for 5 and 15 df,  $F_{0.05}(5,15)$  is 2.90.

<sup>9</sup> All the variables in the model had VIF values of between 1.05 and 2.18.

away from beef by consumers, and that this change has become permanent. Even if retail prices were to fall significantly it is questionable whether sales would increase. Farmers' groups have stated that price decreases are pointless without increased consumer confidence in beef (IFJ, 1996). Furthermore, studies have shown that consumers are willing to pay more to reduce the likelihood of infection from the consumption of contaminated food (Baker et al, 1994; Henson, 1996). The effect of aggressive beef advertising may not increase fresh beef consumption given that consumers are constantly reminded of the possible risks of BSE by the media (Fausti et al, 1995). Part of the notoriety of the BSE saga has been the conflicting information provided by the industry and the government regarding the safety of Irish beef. This raises questions about the ability of An Bord Bia, or the government, to influence the consumers perceptions of the quality of beef, and thereby increase demand for beef. It would seem that beef sales may never recover to the pre - BSE scare levels.

### **Section 3: Producer Margins and the BSE Crisis**

In many countries meat is among the most important items in the consumers food budget, and increasing attention is being given to the spread between the price paid by the consumer and that received at other stages in the marketing chain (Hall et al, 1979). This section of the paper ascertains whether the well reported fall in beef prices at the farm level are being passed on to the consumer. This will be explored through analysis of the farm price of beef in the period prior to the major BSE scare in March 1996, and also in the period after the scare. However, to begin it is first necessary to detail the theoretical explanations available to explain the price transmission mechanism in food markets. Therefore, this section begins by reviewing the literature on price margins. The results of this study are then presented, and finally these results are discussed in relation to the theoretical explanations outlined earlier.

#### **The Price Transmission Mechanism**

Central to the study of food price determination is Alfred Marshall's hypothesis that retail prices fluctuate less than wholesale prices. As the consumer seldom has access vis-à-vis changes in wholesale prices they rarely expect price reductions, hence the retailer, unless for some special reason, is slow to pass on a fall in wholesale prices. Schein (1996) tested Marshall's hypothesis on a variety of products including meat and concluded that the evidence strongly supports Marshall's theory. The key implications of Schein's results are firstly that the retail price of many goods are sticky, in the sense that the retail prices do not immediately change in response to wholesale prices fluctuations. Secondly, it is not possible to make simple assumptions about future variations in consumer prices when wholesale prices change (Schein, 1996). The BSE crisis exemplifies such a 'special circumstance' resulting in the lowering of retail prices, despite

evidence that consumers do not expect retail prices to fall as a result of a decline in wholesale prices.

A further essential point in the study of price determination for the farm, wholesale and retail sector, is the belief that variations in consumer prices are caused by changes in prices at lower levels, such as a reduction of prices in the marketing chain. Palaskas (1995) examined the dynamic transmission of agricultural producer prices through the food marketing system in seven EU countries. Using monthly data the analysis looked at the price chain mechanism from heifer to beef. The estimates from the co-integrated systems approach indicated that in most cases the percentage change in the consumer price is greater than the percentage change in the producer price.

It was also noted that while farm-level prices exert an influence on the consumer price, the length of the transmission lag has a bearing on the rate of the price increase. The results of the empirical work suggest that the responsiveness of consumer price to shifts in producer prices is not instantaneous but instead distributed over a period of time. In addition to the speed of transmission, given that the difference between consumer and producer prices consists of the aggregate margins within processing and distribution, it is the behaviour of the processing and marketing sector that often are the crucial factor affecting the nature of the transmission. Palaskas (1995) asserts that as the cost of off-farm activity often accounts for approximately one half of the consumer price of food, the study of price transmission is of particular importance.

Other studies including that by Heien (1980) indicate that, given the presence of auction markets at farm level and price competition at retail levels, agricultural markets clear quickly. However, as the time periods under consideration become shorter, disequilibrium becomes more of a factor in these markets. The model presented by Heien relies on the notion that changes in prices at the retail level are caused by changes in prices at the wholesale level. This theory is centred around the notion that changes in retail food prices are caused by price variations at lower levels in the marketing chain. These cost changes are transmitted via mark-up-type pricing rules which are shown to be consistent with firm's optimisation behaviour under assumptions of constant returns to scale. Empirical tests undertaken by Heien show that "*unidirectional causality from wholesale to retail is the rule*" (Heien, 1980:16). Using these theoretical considerations as a framework the paper goes on to analyse the linkage between producer and retail prices.

### **Measuring the Change in Prices**

While it is acknowledged that the price chain from farm to retail consists of a wholesale link this study concentrates on the gross margins, that is the difference

between the price farmers receive for beef at market, and the retail price paid by consumers.

The time frame for analysis is the period from January 1995 to April 1996. This time frame covers the two main BSE scares, the first in July 1995 and the second and more serious scare, in March 1996.

Statistics show that producer prices have fallen in the period of time after both of the BSE crises. Prices fell from approximately 56 pence per pound of beef in June 1995 to 50 pence in September of the same year. Although prices did increase again, the major BSE scare in March 1996 led to a marked decline in beef prices at the producer level. By July 1996 beef prices had fallen to 46 pence per pound of beef. The retail price of beef also fluctuated during the time of the BSE crisis. The retail price of beef continued to fall in the period after the initial BSE scare in July 1995. The price stabilised until the March 1996 BSE crisis when prices fell again from £2.81 per pound to £2.31 in July 1996. The retail price of beef in August at £2.58 seems to suggest that retail beef prices are starting to rise again, however, it is too early to say whether prices will return to their pre BSE scare level.

The analysis of prices indicates that retail prices are following the trend in producer prices. Although both producer and retail prices are changing as a result of the BSE crisis, the variance in the producer prices is less than the variance in consumer prices. These results are consistent with Palaskas (1995) findings that the percentage change in retail price is greater than the percentage change in producer prices.

When producer prices are compared to retail prices, it appears that farm prices in the period after the BSE crisis are continuing to fall, while the retail price is starting to recover. If this trend continues there are serious consequences for beef producers.

### **The Change in Producer Margins**

By examining the change in the absolute size of producer margins, that is the difference between the producer price and the retail price, it can be seen that producer margins did fall significantly in the period after the March 1996 BSE crisis.

It is evident that producer margins have fallen due to the BSE crisis and this is most noticeable in the period June to August 1996. There is some indication that margins are increasing again.

In the period from May to June 1996 producer margins fell sharply this can be attributed to the impact of the March 1996 BSE crisis. However they subsequently recovered, with the increase in the period from June 1996 more than compensating for the fall in the previous three months. This increase can be linked to the increase in retail prices combining with the continual decrease in farmer prices. Thus, it seems possible that wholesalers and dominant retailers are gaining from the increased margins, while the producers and consumers are both losing out. This effect of the BSE crisis, although significant, is not focused on in detail in this paper. As indicated earlier there is possibly a time lag in the price transmission mechanism, and this would help to explain why the change in producer margins is not occurring in the month directly following the BSE crisis.

### **Comment on Results**

There are several other possible explanations as to why margins change in the meat industry. The first is that when there is an outbreak of serious livestock disease such as BSE, the economic loss in output to the farmer is dependant not only on the forced slaughter of cattle, but also the effects at the market level (McInerney, 1996). In the case of BSE the number of cattle slaughtered for market was not only reduced, but the demand and price fell due to the decreased consumer confidence in the safety of beef.

The second possible reason is that the degree of uncertainty in the market enables the wholesalers and dominant retailers to exploit the position of farmers who may be heavily burdened with beef they cannot afford not to sell (Hall, 1979). In essence, there are two type of risk associated with the buying and selling of slaughtered cattle. Firstly, there is a general price risk inherent in a competitive market, and secondly an informational risk associated with the uncertainty over the quality of the saleable beef products from individual cattle. Risk aversion may explain why buyers offer lower prices when buying cattle (Fausti, 1995), and hence the dominant retailer can raise prices even when costs have not increased, thus achieving higher price cost margins without any beneficial price gain accruing to the consumer.

Finally, retail outlets in Ireland often practice price averaging and price levelling in the face of unbalanced demand for types of beef. This allows them to minimise the level of waste from each carcass (Meat Prices Advisory Board, 1974). The need to price average arises from the notion that individual parts of the beef carcass may have a significantly different price elasticity from the aggregate carcass, and so retailers are rational in operating differentiated pricing for cuts of beef (Brester, 1991). Hence, if there is a significant fall in the demand for certain poor quality cuts of beef the retailer will adjust the overall beef prices to minimise any loss.

In conclusion the data indicates that both consumers and producers are negatively affected by the price effects of the BSE crisis, while other players in the wholesale and retail sectors have maintained, and in some cases improved, their margins.

### Conclusion

The analysis presented in this paper concentrates on two aspects of the BSE crisis. Firstly, through the use of econometric techniques the link is confirmed between the BSE crisis and the decline in beef consumption. The results of the OLS regression indicate that, as expected, there exists a statistically significant relationship between the sale of beef and the price of beef. The BSE variable was also found to be highly significant. The short term analysis, confirmed by the ECM, shows that BSE is impacting on the retail sale of beef in Ireland. These results indicate the growing influence of tastes and preferences in determining consumer choice. So, although price factors remain important, consumers are more concerned with the safety and quality of Irish beef. Reducing beef prices at the retail level will not increase sales of beef unless the government and farm organisations can alter consumers negative perception of beef. Consumers need reliable information to assess the risks associated with the consumption of beef. This has been highlighted in other studies of food products with potential ill health effects. Thus, the beef industry and government agencies need to carefully consider strategies, such as quality control, to counteract consumer exposure to negative information (Chang et al 1991).

Secondly, the paper examines the change in margins in the beef industry as a result of the BSE crisis. The data demonstrates that both producer and retail prices decreased at the time of the crisis, however, only retail prices have recovered. The implication of this is that wholesale margins have grown as a result of the variations in producer and retail prices. It appears that dominant retailers and wholesalers are consolidating their profit margins at the expense of others in the beef industry. Further analysis of the marketing chain is required to confirm these initial findings.

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