The Impact of Food Scares on Beef and Inter-Related Meat Markets

T. Lloyd[†], S. McCorriston[*], C.W. Morgan[†] and A.J. Rayner[†]

[†] School of Economics, University of Nottingham, UK.
[*] School of Business and Economics, University of Exeter, UK.

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Abstract

In this paper we investigate the impacts of food scares in the UK on the prices and spreads of beef, pork and lamb using a decade of monthly price data (1990-99). Results underline the importance of food scares on prices and price spreads and the strong inter-relationships between meats, typically ignored in such studies.

Keywords: Food scares, food publicity index, BSE, price adjustment.

Corresponding author:
Dr. Tim Lloyd
School of Economics
University of Nottingham
NOTTINGHAM
NG7 2RD
UK

Tel. 44(0)115 951 5474
Fax. 44(0)115 951 4159
Email tim.lloyd@nottingham.ac.uk

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1. Introduction

The debate over the impact of the recent outbreak of foot and mouth disease on British farmers represented the latest manifestation of concern being expressed over the safety of food and food production generally. Such concerns are not unique to Britain; other European countries along with North America have seen food safety become more important politically and thus the profile of the food industry has been raised to unprecedented heights. A key part of this debate has been the increased public reaction to food safety and the issue of 'food scares'. This is particularly the case in Europe, and is exemplified by the development of the bovine spongiform encephalopathy (BSE) crisis in the UK since 1985, which has had a marked effect on the consumption of all meat products, but especially beef, in the UK and other European countries.

While a scare over a particular food product is not new, for example in 1988 a salmonella scare hit the UK poultry sector, what is new is the direct impact it is believed to have on human health. The general health issues over eating red meat have been debated for many years but the fact that BSE has now been related to new variant Creutzfeld-Jakob disease (CJD), which to date has claimed more than 80 lives in the UK, was a significant change in the nature of the health issue facing the consumer. Indeed, when the link between new variant CJD in humans and BSE was announced in March 1996, there was an immediate collapse in consumption of beef products by around 40% in the UK, but also in countries such as Germany and Italy which had no reported cases of BSE at the time (DTZ Pieda Consulting 1998). The domestic market was also affected by the immediate ban imposed on the export of beef products from the UK to its traditional export markets in the European Union.

What is of interest in this paper is the impact of food scares on the beef market and the extent to which these effects spilled over into the markets for other meats such as lamb and pork-[1].

In trying to assess these effects, the paper adds to a significant literature in food related issues that has taken two distinct strands. The first has placed an emphasis on the demand for food while acknowledging health-driven changes in dietary patterns. Examples include Brown and Schrader (1990), Burton and Young (1996), Kinnucan *et al.* (1997) and Rickertsen and von Cramon-Taubadel (2000) among others. For example, the Burton and Young study on the impact of BSE in the UK takes a standard methodology for assessing the determinants of meat demand and include a variable (relating to media stories) to account for BSE. Their results showed a significant but not very strong impact of BSE but it should be noted that their data precedes the crisis linking new variant CJD in humans to BSE that was announced in 1996.

The second focus for academic research has been on regulation (see, for example, the symposia published in the *American Journal of Agricultural Economics*, December 1997). There has been little analysis of these issues in the UK although the regulatory structure has now changed in response to the BSE crisis with the establishment of an independent Food Standards Agency that is separate from MAFF which previously had responsibility for protecting consumer interests as well as protecting the interests of farmers.

[1] . The Phillips Report (2000), an independent government report into the development of BSE and new variant CJD in the UK, highlighted inadequacies by scientists, government ministers and civil servants, who failed to deal quickly and effectively to protect the interests of consumers.

There has been little or no analysis of the impact of food scares on prices at different stages of the marketing chain. Given the highly integrated nature of food supply chains, this is potentially a serious omission from the literature and one which the current paper addresses. To incorporate the vertical nature of food chains, the paper examines the nature of price adjustment at different stages in UK meat markets. To economise on space and given the key role that beef plays in the specific BSE crisis and in the meat complex more generally, the paper focuses on the results from the beef sector with an outline of the results from the other meat markets. In particular it explores the impact on adjustment in meat prices of the outbreak, increased awareness and likely effects, of BSE. This feature of the current study also has an important public policy dimension since the observation that prices at the retail level did not fall as much as prices at the wholesale and farm level was one of the key reasons for the recent enquiry by the UK Competition Commission into market power in the UK food sector, which emphasised the nature of vertical links between successive stages in the food marketing chain.

An important feature of this paper therefore is that we consider price adjustment at three stages (retail, wholesale and producer) of the meat marketing chain. By doing so, we highlight not only the impact of price adjustment but also the effect of food scares on price spreads. Our data show that prices have fallen at all marketing stages in the 1990s but that spreads between have *not* remained constant. Specifically, whereas retail prices of beef have fallen by 18%, wholesale and producer prices have fallen by around 40% each. During this period all spreads have been observed to grow, but the retail-wholesale spread has grown five times more than the wholesale-producer spread. While this price decline is unsurprising in the face of heightened

consumer awareness, the change in spreads is perhaps less obvious. However, as McCorriston, Morgan and Rayner (1999) show, this result is consistent with the outcome of model of vertical markets characterised by market power in which a shock to retail demand passes through the chain where the price transmission elasticity is greater than unity. Similarly, price spreads in the pork and lamb sectors have also widened over the sample period.

The paper is organised as follows. In Section 2, we briefly survey recent changes in the patterns of meat consumption in the UK and the development of the BSE crisis since 1985. In Section 3 we present the data and in Section 4 we discuss the framework for the empirical analysis. We adopt a co-integration framework that allows us to account for the co-movement of beef prices at all stages of the chain. The results of the estimation are reported in Section 5 with the main focus being on the beef sector results. These show that beef prices do not co-integrate without the inclusion of a measure of food safety publicity - the food publicity index. The negative impact of the index differs according to the marketing level and may account for growing price spreads observed empirically. Section 6 concludes by highlighting briefly issues relating to on-going research.

2. Consumption Trends, Health Concerns and BSE

(a) General Trends

As in many developed countries, consumption of meat products has undergone considerable change in recent years. The most common feature of this change has been due to the switch away from red meat consumption towards the consumption of white meats such as pork and particularly poultry which has appealed to consumers as

being less fatty, lower in cholesterol and generally a 'healthier' product. Other changes which have affected meat consumption include lifestyle changes such as the increased consumption of prepared and frozen meals and food-away-from home. These changes on meat consumption have been well-documented in the agricultural economics literature. With respect to the UK, Burton and Young (*op. cit*., 1992) identify the role of preference changes in the consumption of meat in the UK.

Table 1 details changes in meat consumption (in volume terms) in the UK between 1986 to 1995. Focussing first of all on the final column, over this period total consumption of all meat products has been more or less constant. However, there have been significant preference shifts across meat products. Note first of all, the consumption of red meats (column 1) which have shown a decline of 22 per cent over this 10-year period. On a per capita basis, this represents a 35 per cent decrease in consumption of beef in the UK. Red meats' share of overall consumption of meats has declined from 31 per cent in 1986 to 24 per cent in 1995. The other most notable change from the table has been the increased consumption of poultry products which has increased by almost 33 per cent over the same period. The share of poultry meat consumption in total meat consumption has increased from 27 per cent to 34 per cent over this period while the consumption of other meat categories has remained more or less constant. Although growing awareness of health concerns and BSE in particular will likely have contributed to these trends, the fact that these trends were observed in many other countries suggests that structural change in the demand for meat, particularly the decline in the consumption of red meat, was already taking place and would have expected to have continued even in the absence of the more serious developments in the BSE crisis in the mid- to late-1990s.

Table 1. Meat Consumption in the UK, 1986-1995 (thousand tonnes)

(b) The Development of BSE in the UK

BSE first came to the public's attention in the mid-1980s when a cow that died following symptoms of head tumours and lack of co-ordination was confirmed as having a new cattle disease, bovine spongiform encephalopathy (BSE). Nevertheless, in the early chronology of this disease, there was little concern that the BSE represented a threat to human health, with the public being reassured by a government-sponsored working party (the Southwood working party) that BSE was unlikely to cause any harm to consumers. The next most significant step in the BSE crisis occurred in may 1990 following the death of a Siamese cat from a BSE-like disease, the significance of which was the BSE appeared capable of jumping between species. Although public awareness increased dramatically, the public was again re-assured by government ministers and the UK Chief Medical Officer that meat was safe to eat. Although public awareness had been increasing and no doubt contributed to the decline in the consumption of red meat over the early 1990s (as Burton and Young, *op. cit*., detail), it was not until the mid-1990s that BSE was fully recognised as a crisis following the first human death from new variant CJD in 1995 followed by the confirmation in 1996 of a link between new variant CJD and BSE. Consumption of red meat fell immediately by 40 per cent while bans on imports of beef from the UK by European countries were imposed. Since then, the link between new variant CJD in humans has been confirmed and to date (November 2000) 84 deaths have been recorded in the UK. Although regulation in the meat processing sector has intensified as a response to the BSE crisis (see below), awareness of the crisis among the public

is still high given that new variant CJD is known to have a potentially long incubation period. Even recent estimates suggest that the total number of deaths in the UK may be in the thousands (*New Scientist*, 4 November 2000).

3. Data

In the empirical analysis we employ real meat prices at the producer, wholesaler and retailer level (R_t, W_t and P_t respectively) in England and Wales. The data have been calculated by the Meat and Livestock Commission and represent carcass weight equivalents (CWE) to facilitate direct comparison of prices at all three stages. The data are monthly and cover the period January 1990 to December 1998 (see Figures 1 and 2).[2] Again, for reasons of space, we will focus solely on the beef sector here. They are deflated by the Retail Price Index (January 1990 base) and clearly show a trend decline over the period: retail and wholesale prices fall at a rate of 1.7% per year, producer prices by 5.4% over the sample period. Casual inspection of Figure 1 also reveals that prices have a tendency to co-move, in that movements at prices in one level of the chain seem to be reflected in prices elsewhere in the chain. Other features of interest are the upturn in prices in the first half of 1993 and the rapid decline in March- April 1996. Whereas the former is accounted for by the UK Chief Medical Officer confirming that beef was safe to eat, the latter is a response to the now-notorious Ministerial announcement on 20 March 1996 in which the link between BSE in cattle and CJD in humans was officially recognised.

Figure 1. Monthly UK Beef Prices

[2] For details on data construction see MAFF (1999).

Figure 2. Monthly UK Beef Price Spreads

These price series are supplemented by a "food publicity index". This is a count of the number of articles printed per month in national broad-sheet newspapers that relate to the safety of meat.[3] In general, these reports are negative in nature and reflect the concerns regarding the safety of meat, in terms of its production and processing. Articles relating to BSE dominate the index although other similar topics are also covered such as the health standards in abattoirs. The index reflects consumer concerns regarding the safety aspects of meat consumption and also the impact of regulation on suppliers of meat. Consequently, the index will be correlated with developments that affect both the demand and supply of beef although, as discussed above, it is likely to be the food scares issue that dominates given the public furore over BSE.

Whilst by no means the first 'food scare' in the UK (for example, in 1988 salmonella was linked to consumption of eggs), the publicity surrounding the BSE crisis was unprecedented, overwhelming all concerned, including government ministers and their officials in the Ministry of Agriculture, Fisheries and Food and the Department of Health (as noted in the introduction, the recent government sponsored BSE inquiry, known as the Phillips report, has been highly critical of the way in which government ministers, civil servants and scientists responded to this crisis). Despite estimates that the probability of contracting the disease was smaller than wining the lottery on successive occasions[4], the public's response to the many uncertainties that surrounded

[3] The newspapers are the Times, Sunday Times, Telegraph, Independent and the Guardian.

[4] Although unknown, the probability of contracting CJD from BSE infected meat was considered to be minuscule despite the frenzied media interest in the acknowledgement of a possible link between the two. Some media reports at the time went so far as to claim that one was more

BSE significantly affected consumption behaviour. The now notorious and disturbing televised image of an infected cow helplessly stumbling in the latter stages of the disease, shocked the viewing public instantly. Repeated broadcasts fixed the image in the national psyche and became a potent emblem of the frightening potential of BSE for human health.

By any measure, the publicity was staggering. Prior to the Ministerial announcement on 20 March 1996 linking BSE in cattle to its human variant, new variant CJD, there were around 14 articles per month relating to food safety in the national broad-sheet press. In the same month, the European beef export ban took effect (European Commission Decision 96/293) and the count peaked at 333, averaging 93 per month for the remainder of the 1990s. Other key points in the chronology of food safety in Britain are identifiable in the series plotted (in logs) in Figure 3, such as the summer of 1990 peak reflecting advice relating to beef on the bone products for exports, the conclusion that there was no need for direction to farmers relating to the breeding from the off-spring of BSE cases and the publication of the Agriculture Select Committee Fifth Report (which summarised the situation to date) and the 'Specified Bovine Offal (Amendment) Order 1995 (SI 1995/3246)' prohibiting the use (and export) of certain offals destined for human consumption.

Figure 3. The Food Publicity Index

As a preliminary to the statistical analysis all the data series are tested for non-stationarity using standard Dickey-Fuller procedures. Model selection criteria are

likely to find a mislaid wining lottery ticket in the street on two successive weeks than die from

presented in Table 2 with ADF test statistics under the null of a unit root. The results clearly demonstrate that the three prices are non-stationary in levels (and stationary in first differences), although inference regarding the order of integration of the food publicity index (i_t) is less clear cut. Since, both the AIC and HQC tests select a model with 2 lags in which the null of a unit cannot be rejected at the 5% level, we conclude that the index is also I(1), as visual inspection of the Figure 3 suggests.[5]

Table 2. ADF Tests for the Order of Integration

4. Methodology

The formal analysis of price transmission is conducted in a vector auto-regressive (VAR) framework to exploit the properties of integration and co-integration that appear to exist in the data. VAR methods offer a tractable framework for the investigation of dynamic relations, particularly when the variables are co-integrated. If co-integration is ignored, estimation and inference are at best impaired, at worst, invalidated (Harris, 1995). VAR models also readily facilitate investigation of the dynamic response path of variables to exogenous shocks, using what is called, impulse response analysis.

Given the familiarity of these methods we merely offer a sketch of the relevant aspects here[6]. Consider the general polynomial distributed lag, or VAR(*k*), model:

$$\mathbf{x}_t = \mathbf{\Pi}_1 \mathbf{x}_{t-1} + \ldots + \mathbf{\Pi}_k \mathbf{x}_{t-k} + \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t \qquad (1)$$

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eating beef (reported on BBC Radio 4, 17 May 1996).

[5] This discrepancy is relatively common since Schwarz Bayesian Criterion penalises over-parameterisation more severely than the other model selection criteria.

[6] Those seeking an induction are referred to Enders (1995), Johnston and DiNardo (1997)

where t = 1,. . . , T; $\mathbf{x}_t$ is an $(n\times1)$ vector variables and $\boldsymbol{\mu}$ is an $(n\times1)$ vector of deterministic components (such as constant, seasonal factors and dummy variables) and $\boldsymbol{\varepsilon}_t$ an $(n\times1)$ vector of normally distributed disturbances of zero mean and non-diagonal variance-covariance matrix $\boldsymbol{\Omega}$, i.e. $\boldsymbol{\varepsilon}_t \sim$ n.i.d.$(0,\boldsymbol{\Omega})$. The order (k) of the VAR is also determined by the data, and here we adopt standard model selection criteria (AIC, SBC and HQC) for this purpose. Following Johansen (1988), (1) has an equilibrium correction representation given by

$$\Delta\mathbf{x}_t = \boldsymbol{\alpha\beta}\,\mathbf{x}_{t-k} + \sum_{i=1}^{k-1}\boldsymbol{\Gamma}_i\Delta\mathbf{x}_{t-i} + \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t \qquad (2)$$

In this model,

$$\boldsymbol{\Gamma}_i = (-\mathbf{I} + \boldsymbol{\Pi}_1 + \boldsymbol{\Pi}_2 + \ldots + \boldsymbol{\Pi}_i) \qquad i = 1,\ldots,k-1$$

captures the dynamic effects of the system and

$$\boldsymbol{\Pi} = (-\mathbf{I} + \boldsymbol{\Pi}_1 + \boldsymbol{\Pi}_2 + \ldots + \boldsymbol{\Pi}_k)$$

defines the relationships pertinent to static (or long-run) equilibrium. Since the apparent co-movement of prices is a property relating to the long-run behaviour of the variables, attention initially focuses on the coefficients comprising $\boldsymbol{\Pi}$.

The rank of $\boldsymbol{\Pi}$, denoted by r, corresponds to the number of linearly independent combinations of $\mathbf{x}_t$ that are integrated of order zero {I(0)}. These linear combinations represent the long-run relationships between the variables in $\mathbf{x}_t$. Empirically, the rank of $\boldsymbol{\Pi}$ is determined using the trace and maximal eigenvalue statistics which are compared against critical values derived by Osterwald-Lenum (1992). The reduced

rank condition (where $r < n$) implies that there exist linear combinations of the I(1) variables that are I(0). This special case, where the components of $\mathbf{x}_t$ co-integrate, allows $\boldsymbol{\Pi}$ to be rewritten as

$$\boldsymbol{\Pi} = \boldsymbol{\alpha}\boldsymbol{\beta}' \tag{3}$$

where $\boldsymbol{\beta}'$ is the matrix of co-integrating vectors and $\boldsymbol{\alpha}$ is a matrix of loading (or error correction) coefficients. Substituting (3) into (2) yields

$$\Delta\mathbf{x}_t = \boldsymbol{\alpha}\boldsymbol{\beta}'\mathbf{x}_{t-k} + \sum_{i=1}^{k-1}\boldsymbol{\Gamma}_i\Delta\mathbf{x}_{t-i} + \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t \tag{4}$$

where the elements of $\boldsymbol{\beta}'$ quantify the long-run relationships between the variables in the system and the elements of $\boldsymbol{\alpha}$ load deviations from the equilibrium (i.e. $\boldsymbol{\beta}'\mathbf{x}_{t-k}$) into each equation. Thus the loading vector links the long- and short-run components of the model and comprises coefficients that feed back information about long-run dis-equilibrium to the short run for correction.

Following Stock and Watson (1988), with *n* variables, there can be at most $n-1$ co-integrating relations and $n-r$ common trends. Therefore, with a triplet of prices, there can be at most two such co-integrating combinations, since if any two pairs of prices co-move (co-integrate) then so must the third. In this case, the prices share a single common trend and may be expected to co-move over time. The presence of a single co-integrating relation among the triplet of prices implies two separate common trends among the price triplet. As a result, price pairs do not co-integrate since any two prices will possess different trends. In this case, price co-movement between any pair will be much less apparent when 'eyeballing' the series together, but the presence

of co-integration implies that the long run behaviour of any two variables is reflected in the third. Where there are no co-integrating combinations among the triplet, each price has its own (possibly similar, but nevertheless) distinct trend. If the price triplet is to co-integrate then at least one additional variable is required. Owing to the parallels between common trends, co-integration and co-movement, formal tests for co-integration offer insights in to the economic relationships at hand, not only signalling the extent of economic integration in vertical markets but factors necessary to induce such market integration.

Should there be more than one co-integrating vector, as is likely to be case here, it is often difficult to interpret the co-integrating vectors directly (Lütkepohl and Reimers, 1992). Impulse response analysis provides a tractable means of evaluating the time path of variables in $\mathbf{x}_t$ to exogenous shocks. As such it offers insights into the dynamic behaviour of variables in the system by combining the short- and long-run behaviour embodied in (4). Calculation of the impulse response functions for a system of co-integrated variables follows much the same approach as that used in standard (stationary) VARs (Lütkepohl and Reimers, 1992). However, the fact that co-integration implies an error correction mechanism has implications for calculation and interpretation of impulse responses, not least since shocks to a co-integrated system do not die out, but persist in the long run, albeit via a time path that leads to a new equilibrium.

The time paths of variables to shocks, or impulse response functions, are found by imposing a recursive structure on the moving average representation of the VAR.

Lütkepohl and Reimers (1992) show that the impulse response function of (1) is given by

$$\mathbf{\Phi}_s = \left(\varphi_{ij,s}\right) = \sum_{l=1}^{s} \mathbf{\Phi}_{s-l}\mathbf{A}_l \qquad s = 1,2,\ldots$$

where $\mathbf{\Phi}_0 = \mathbf{I}_n$, $\mathbf{A}_l = 0$ for $l > k$. A plot of $\varphi_{ij,s}$ is the impulse response function of variable i with respect to a unit shock to variable j, s periods ago, all other variables at the time of the shock (and earlier) held constant. Whilst this is useful measure of the dynamics, it ignores the contemporaneous correlation that may exist between the variables (expressed in the off-diagonal elements of $\boldsymbol{\varepsilon}_t$). Consequently, orthogonal impulses, which take account of this may be preferred, although the impulse response function that result differ according to the order in which the variables appear in the VAR (see Hamilton, 1994). In the current application, given that changes in the food publicity index are likely to drive price changes and not *vice versa*, the index is treated as exogenous to prices in the impulse response analysis.

5. Results

(a) Co-integration Tests

As an initial step, equation (1) is estimated for the price triplet (R_t, W_t and P_t). An unrestricted VAR(12) model, augmented by four impulse dummy variables[7] gives a good approximation, such that residuals conform to the stated assumptions for $\boldsymbol{\varepsilon}_t$. Given that prices are I(1), the model is examined for the presence of co-integration implied by the co-movement of prices apparent in Figure 1. Panel (a) of Table 2 reports the co-integration test statistics for this model.

[7] Dummies are for 1993(3), 1995(9), 1996(3) and 1996(4). Whilst they have a negligible impact on parameter estimates they are included to satisfy the normality assumption.

Table 3. Co-integration Tests Results

Whilst there appears to be an indication of co-integration amongst the triplet, the formal evidence is at best weak. Specifically, the trace test statistic rejects the null hypothesis of no co-integration at the 5% significance, but the maximal eigenvalue test does not. In addition, the test statistics do not provide any substantive evidence of the multiple co-integrating relationships suggested by the pair-wise co-movement of the data. One literal, albeit bald, interpretation of this result is that beef markets are poorly integrated. Alternatively, the explanation might lie in the role of omitted variables, in particular given the preceding discussion, the impact of BSE and related health concerns on price movements.

Augmenting the price transmission model with (the natural logarithm of) the food publicity index i_t has a marked effect on inference. As the results in Panel (b) of Table 1 show, evidence in favour of co-integration is now much stronger: the trace and maximal eigenvalue test statistics now reject the null of no co-integration at the 1% significance level. Moreover, both tests suggest the presence of three co-integrating vectors, a result consistent with pair-wise co-movement (in combination with the food scares variable). The clear conclusion of the co-integration analysis is that the food publicity index plays a key role in the long-run evolution of UK beef prices and that once the effect of the index is taken into account, prices co-move in a manner consistent with market integration.

(b) Impulse Response Analysis

The above result begs a number of questions, not least those relating to the precise role that the food publicity index plays in price formation. To investigate this issue empirically, consider Figure 4 that shows the impulse response functions of the three beef prices to a unit (one per cent) shock in the index. These functions summarise graphically the dynamic behaviour of the variables in the system to shocks in the food publicity index. These indicate that heightened publicity regarding food safety initially increases beef prices at all stages of the marketing chain, but that thereafter, they fall. The long-run effect is negative on all beef prices, with estimates suggesting that retail prices fall by 1.70p/kg producer wholesale prices fall by 2.25p/kg and producer prices by fall by 3.0 p/kg.[8] This represents a "food publicity" elasticity of around 1.4.[9]

Figure 4. Impulse Response Functions of Beef Prices to a One per cent Shock in the Food Publicity Index

These results indicate that: first, UK beef prices were responsive and negatively related to the public's awareness of food safety issues (principally BSE) in the 1990s but that; second, the impact was not common across stages in the marketing chain. This second point suggests that price spreads also move systematically in response to publicity about the safety of food. Shocks to the food publicity index cause the wholesale-producer price spread to expand more than the retail-wholesale price spread. Moreover, the difference between retail and producer prices, the measure that receives most attention in the public debate on this issue, rises by an even larger

[8] Similar responses are obtained using orthogonal innovations.

amount in response to BSE publicity. Specifically, a one percent increase in the meat scares index induces a 0.5p/kg increase in the retail-wholesale spread, a 0.75p/kg increase in the wholesale-producer spread and thus a 1.25p/kg increase in the retail-producer spread. Given that media interest has generally risen over the sample period, price spreads are observed to rise over time.

The observation that the food scares index should lead to decline in prices at each marketing stage is, to a large degree, expected and consistent with the dominance of the demand relative to supply sources (i.e. due to increased regulation) of exogenous shocks in the beef sector over the 1990s. That this price decline should vary between stages is a little more surprising, particularly so, given the nature of the data which, being consistent with the fixed proportions technology, might otherwise suggest that the price declines be equal. The fact that these price declines vary between stages, implying a widening of the price spreads, is indicative of a food chain characterised by some degree of market power at each vertical stage.

(c) Other Meat Sectors

The results from the VAR analysis of the pork and lamb sectors are briefly commented upon here Specifically, in conducting the co-integration tests for these sectors, it was also necessary to include the food scares index to find evidence of co-integration which suggests the importance of food scares for consumption of these other meats. Moreover, for some of the price pairs, it was also necessary to include the beef marketing spread in order for the system to co-integrate. Consequently, the increase in food scares, due to the increased awareness of BSE has not only affected

[99] At mean values the food scares elasticities are 1.27, 1.60 and 1.12 respectively.

the beef sector but has also likely had significant effect on the prices of other meats and the spreads between different stages of the marketing chain.

This can be shown using the impulse response results in a similar fashion to the beef sector. When considering the impact of a one percentage point change in the scares index, it is apparent that the lamb and pork sectors react differently to each other. For both, the short run effects of the shock are larger than the long run effects although similarities are limited to this broad conclusion. Both sectors display a different response to the beef sector when there is a significant effect from change in the index. To clarify, the effects are opposite (as expected) to those found in beef and the strongest effects are found in the lamb sector. This might imply that consumers are more likely to switch between beef and lamb rather than between beef and pork when there are concerns over the safety of beef.

The shock in retail and wholesale lamb prices has a long-run effect with elasticities of response being 1.31 and 2.55 respectively when evaluated at the mean price level. Producer prices for lamb, however, do not experience a long-run shock with the elasticity being effectively zero. In all three cases, the short-run elasticities are much larger (2.45, 4.46 and 2.04) suggesting that the markets do respond strongly to the scare and in a positive fashion in that prices rise as a result of a shock. The results from the pork sector are somewhat different in that the long-run effects are negligible with the elasticities being 0.205, 0.257 and 0.132 for the retail, wholesale and producer stages respectively. Again however there are much larger short-run effects with elasticities being 0.514, 1.804 and 2.632. These illustrative results are indicative of the strong inter-relationships that exist between the consumption of different meats

and suggest that any analysis of food scares must take account of these substitution effects if it is to capture the full impact of the scare.

6. Conclusions

Bovine spongiform encephalopathy (BSE) and its link to new variant Creutzfeld-Jacob (CJD) in humans has been the most significant food scare to have affected the UK and Europe more generally in recent years. This paper has focussed on the impact of publicity, predominately concerns relating to the emerging BSE crisis, on the development of meat prices in the UK, with particular emphasis on the beef sector during the 1990s. Acknowledging the co-movement that exists between prices in the beef marketing chain, we use a co-integrating framework, the results of which show the importance of information as embodied in the food publicity index in price transmission. Prices at all levels have tended to decrease during the 1990s, a result that is consistent with inward shifts in the demand function. Perhaps more interestingly, is that the extent of price adjustment varies between marketing stages. In particular, price changes at the retail (wholesale) sector decline but less so than price changes at the wholesale (farm) sector. In sum, the focus of this work has been on the impact of food scares on the UK beef market highlighting specifically the fact that the incidence of the BSE crisis has not fallen equally on the various sectors in the beef marketing chain. While prices at each stage have fallen, marketing margins between stages have increased suggesting that the incidence of the BSE crisis has fallen primarily on farmers, less so on the processing sector and least of all on retailing. The evidence also suggest significant spillovers between the beef and other meat sectors and the part of the adjustment to food scares occurs via relatively strong substitution effects.

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Table 1. Meat Consumption in the UK, 1986-1995 (thousand tonnes)

Year	Beef and Veal	Lamb	Pork	Bacon and Ham	Poultry	All Meat Products
1986	1,134	381	728	459	978	3,680
1987	1,153	376	772	451	1,017	3,769
1988	1,104	383	803	450	1,094	3,834
1989	1,063	411	759	448	1,061	3,742
1990	1,003	429	772	434	1,105	3,743
1991	1,014	424	775	424	1,133	3,770
1992	999	378	772	395	1,199	3,743
1993	903	338	807	404	1,167	3,619
1994	920	343	801	415	1,252	3,731
1995	895	359	758	422	1,298	3,732

Source: Meat and Livestock Commission Yearbooks

Table 2. ADF Tests for the Order of Integration

	Lag Length	ADF Test Statistic	AIC	SBC	HQC
R_t	0	-1.54	-281.57	-285.60	-283.21
	1	-1.53	-282.57	-287.93	-284.74
	2	-1.78	-281.90	-288.61	-284.62
	3	-1.89	-282.55	-290.59	-285.81
ΔR_t	0	-10.40	-281.78	-284.46	-282.86
	1	-6.28	-281.53	-285.56	-283.17
	2	-5.07	-282.40	-287.76	-284.57
	3	-4.22	-283.14	-289.85	-285.86
W_t	0	-1.31	-309.45	-313.47	-311.08
	1	-2.31	-297.16	-302.52	-299.33
	2	-2.06	-297.92	-304.63	-300.64
	3	-2.07	-298.86	-306.91	-302.13
ΔW_t	0	-6.36	-297.86	-300.54	-298.95
	1	-6.01	-298.11	-302.13	-299.74
	2	-5.20	-299.10	-304.47	-301.28
	3	-4.99	-299.78	-306.48	-302.50
P_t	0	-1.36	-293.87	-297.90	-295.51
	1	-2.13	-285.63	-291.00	-287.81
	2	-2.14	-286.57	-293.27	-289.29
	3	-2.22	-287.37	-295.41	-290.63
ΔP_t	0	-6.96	-285.94	-288.62	-287.03
	1	-5.79	-286.93	-290.96	-288.56
	2	-4.95	-287.92	-293.29	-290.10
	3	-4.48	-288.92	-295.62	-291.64
i_t	0	-3.87	-144.08	-146.76	-145.16
	1	-3.28	-144.16	-148.18	-145.79
	2	-2.66	-142.39	-147.75	-144.56
	3	-2.44	-142.80	-149.50	-145.52
Δi_t	0	-12.90	-148.43	-151.12	-149.52
	1	-10.70	-144.95	-148.97	-146.58
	2	-8.51	-144.82	-150.19	-147.00
	3	-5.97	-145.43	-152.14	-148.15

Notes
Tests are evaluated from lag 12, although only lag 3 and down are reported. The ADF regression of the levels (e.g. R_t) includes a constant, trend and seasonals, with 95% critical value of the ADF statistic given as -3.45 . The ADF regression of the levels (e.g. ΔR_t) includes a constant and seasonals (but no trend) with a 95% critical value of the ADF statistic of -2.88. The highest numerical value of the model selection criteria, [AIC (Akaike Information Criterion), SBC (Schwarz Bayesian Criterion) and HQC (Hannan-Quinn Criterion)] indicates the preferred model.

Table 3. Co-integration Tests Results

(a) R_t, W_t and P_t				
H_0:	Maximal Eigenvalue	95% C.V.	Trace	95% C.V.
$r = 0$	20.4	21.0	30.7*	29.7
$r \leq 1$	10.0	14.1	10.3	15.4
$r \leq 2$	0.3	3.8	0.3	3.8
(b) R_t, W_t, P_t and i_t				
H_0:	Maximal Eigenvalue	95% C.V.	Trace	95% C.V.
$r = 0$	44.3**	27.1	105.0**	47.2
$r \leq 1$	37.0**	21.0	60.8**	29.7
$r \leq 2$	22.3**	14.1	23.7**	15.4
$r \leq 3$	1.4	3.8	1.4	3.8

Note: * denotes rejection of H_0 at the 5% significance level; ** denotes rejection of H_0 at the 1% significance level.

Figure 1. Real UK Beef Prices

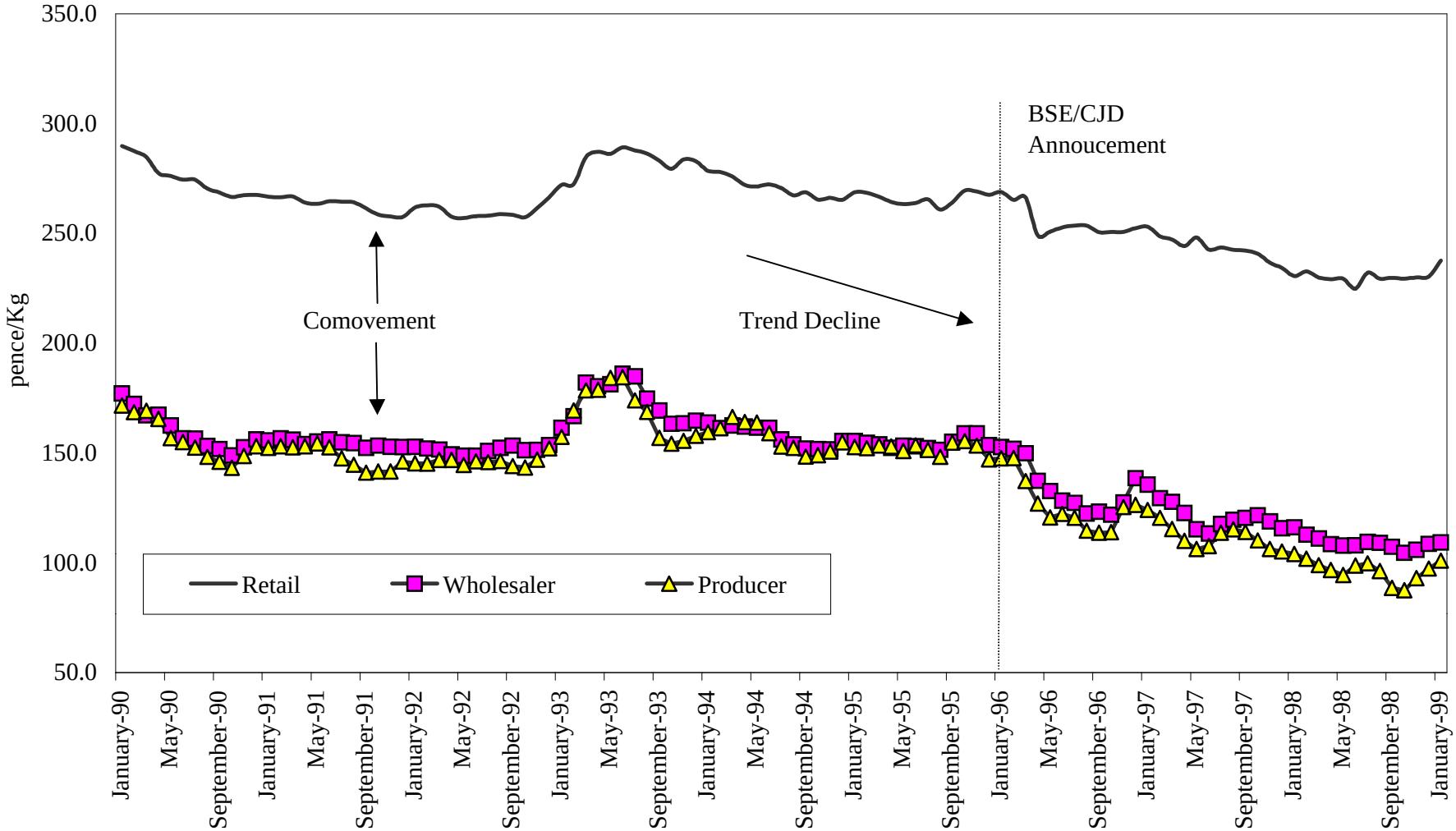

Figure 2. UK Beef Price Spreads

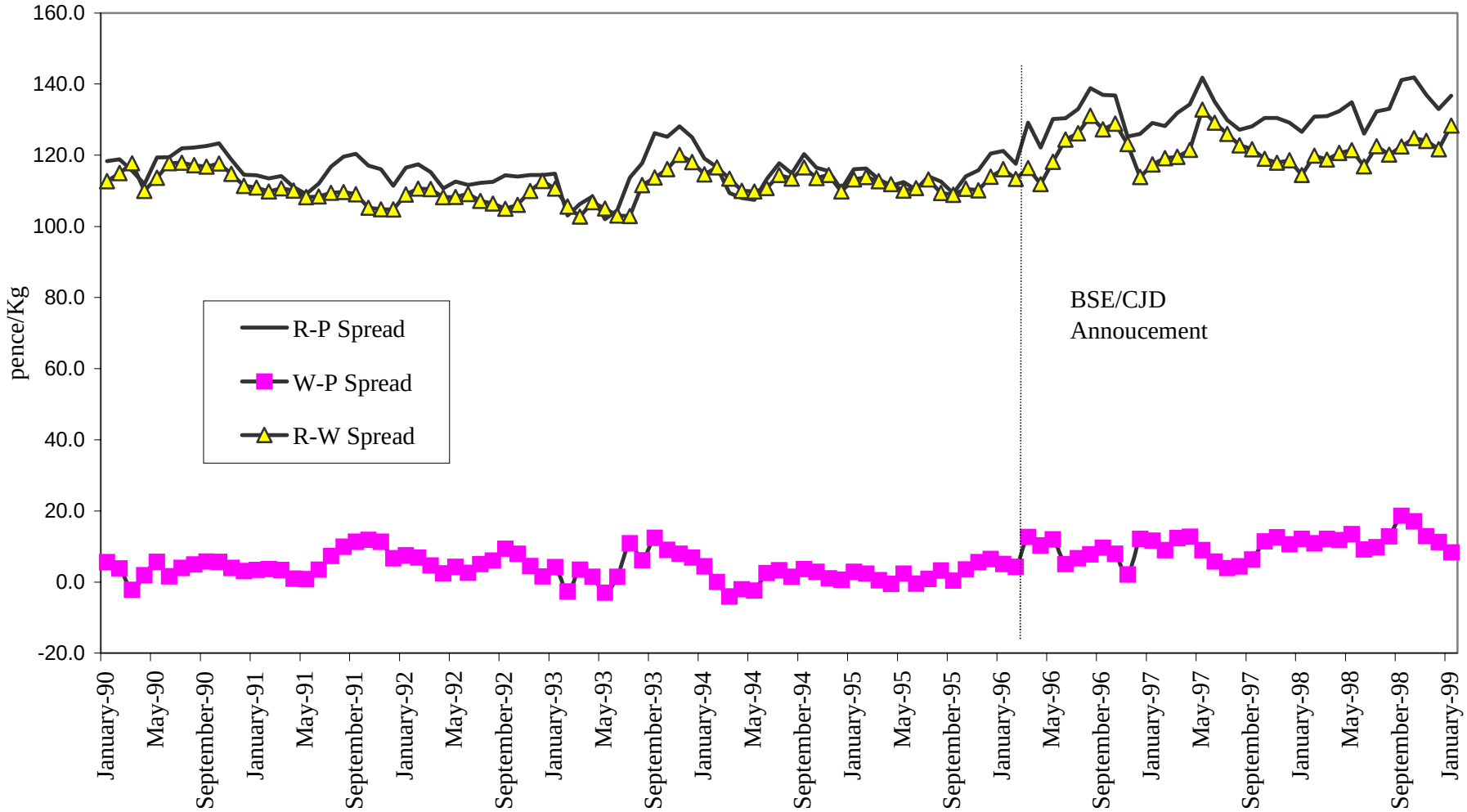

Figure 3. The Food Publicity Index (logs)

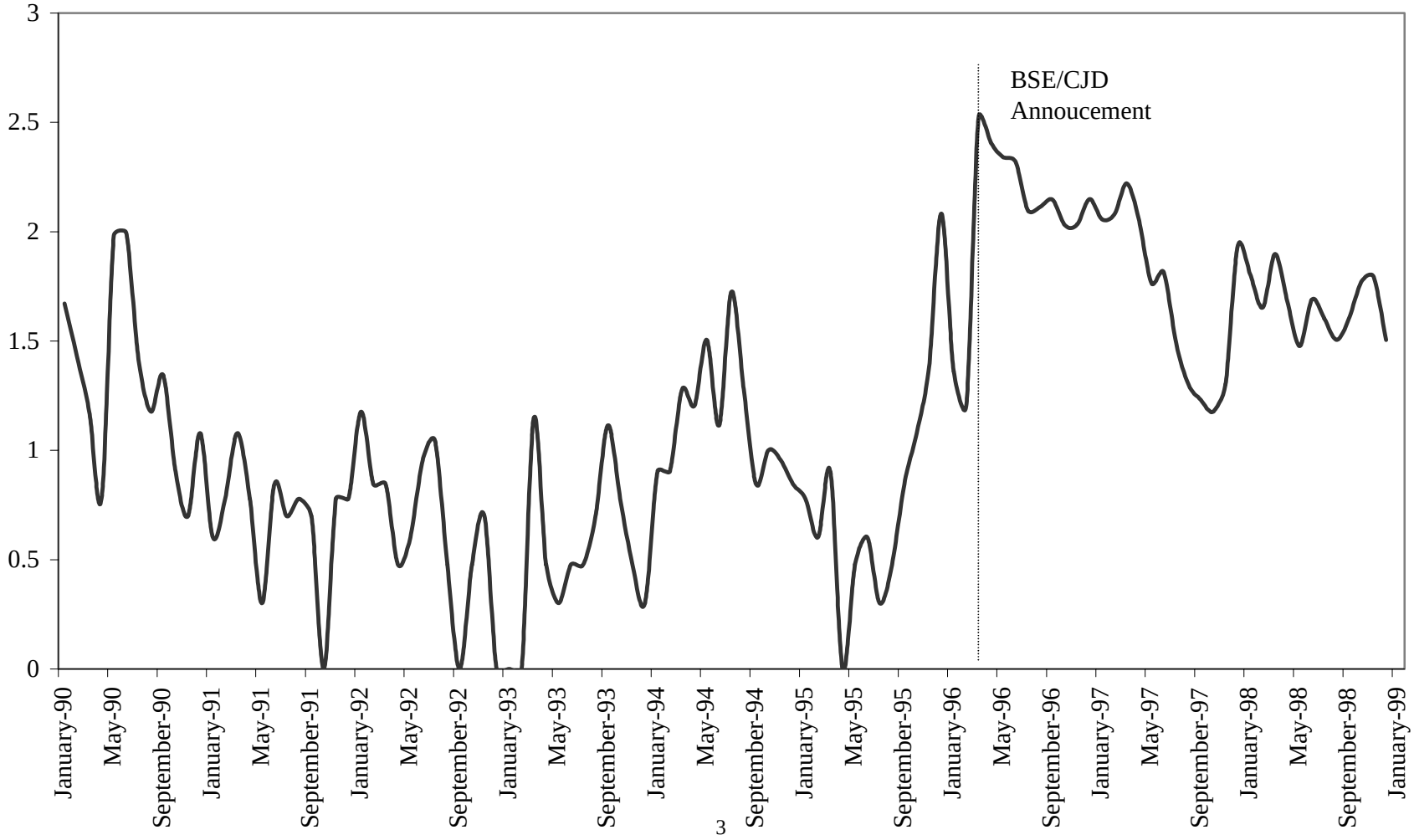

Figure 4. Impulse Response Functions of Beef Prices to a One per cent Shock in the Food Publicity Index