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Food Scares, Market Power and Relative Price Adjustment in the UK

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Abstract

This paper is concerned with the impact of food scares, principally the BSE crisis, in the UK and focuses on price adjustment at different stages in a vertically-related market. From a theoretical perspective we show that if market power has an effect on the margin between retail and farm prices then this determines the specification of the co-integrating relationship. We also account for different aspects of the BSE crisis including the shift in the retail demand function as well as the shift in the farm supply function due to the mutually opposing effects of a worldwide export ban and the cull of infected and older beef cattle. The results suggest that we cannot reject the importance of market power in the UK food sector in influencing the retail-farm margin following the outbreak of BSE. The results also suggest that the impact of the BSE crisis on farm prices to be more than double that of retail prices thus corroborating public interest concerns of a differential impact of the food scares on retailers and producers.

Keywords: BSE crisis; price adjustment; impulse response functions

Introduction

In recent years, there has been growing concern about the health and safety of food. In some extreme cases, this has resulted in a food scare, with perhaps the most well-known example in recent years being the BSE crisis in the UK. Whilst known since 1986, the BSE crisis erupted in the UK in March 1996 following a Ministerial announcement to Parliament suggesting a link between bovine spongiform encephalopathy (BSE) and the invariably fatal human disease, variant Creutzfeld-Jakob disease (vCJD). To date, 129 deaths can be linked to vCJD in the UK. The announcement led to an immediate 40% fall in the consumption of beef in the UK, and the complete loss of all export markets (including all Member States of the European Union) worth an estimated $1.7bn in 1995 (DTZ Pieda Consulting, 1998). In response to the crisis the UK government introduced a large number of measures to lessen the losses to the beef industry and avoid BSE entering the downstream food sector, the most significant of which was the national cull of infected and older cattle.

Apart from the obvious concern with human health, an additional concern has been raised that the BSE crisis had a differential effect on UK retailers and farmers. Specifically, it was argued that while the BSE crisis reduced the consumption and price of beef, the decline in beef prices at the retail level was substantially less than that faced at the producer level resulting in a substantial increase in the retail-producer price margin. In this regard, attention was drawn to market concentration at the retail level, the 5-firm concentration ratio in UK food retailing being around 67 per cent. The issue was one of the primary reasons for the investigation by the UK anti-trust authorities, the Competition Commission, which noted one of their main concerns being to address:

'...[the] public perception of...an apparent disparity between farm-gate and retail prices...which is seen as evidence by some that grocer multiples were profiting from the crisis in the farming industry'. (Competition Commission, Vol. 1, p.3, 2000)

The 18-month inquiry concluded that supermarkets routinely engaged in 29 practices that were adjudged to be against the public interest and recommended a code of conduct be drawn-up to outlaw such practices in the future. While part of the concern of the Competition Commission related to oligopoly power, they were also concerned with the exercise of oligopsony power. While we do not distinguish between the two, we address the issue of market power in determining the adjustment of prices at the retail and farm levels. Specifically, we provide an empirically tractable test for the presence of market power that permits us to address whether market power exercised by retailers caused the margin between retail and farm prices to widen as a consequence of the BSE crisis in the UK[1].

Whilst there have been a number of studies and influential reports in to BSE, most notably the 16 volume report of the Royal Commission into BSE itself (BSE Inquiry, 2000), there has been little formal analysis of the potential differential impact of BSE on retail and farm level prices despite the public policy concern of the distributional impact of this major food scare. This paper aims to make two important contributions. First, we formally highlight the links between market power and price transmission following shocks to the retail demand and farm supply functions. We show that if market power (in the form of oligopoly and/or oligopsony power) exists then this will influence the specification of the co-integrating relationship describing price transmission, and as such becomes a hypothesis that may be tested using readily available data. Empirical results suggest that market power characterised the marketing of beef in the UK during the sample period. Second, as noted above, the BSE crisis was multi-faceted, in that, while there was a substantial shift in the retail demand function as consumers reduced their consumption of beef, there were also significant changes in the supply side due to the cull of the 30 month or older cattle and the export ban, both of which began in March 1996 and remained in force throughout the period analysed in this study. We account for these aspects of the BSE crisis in our econometric model and gauge their relative importance on the retail-farm price margin. Our calculation suggest that because the number of cattle culled was approximately equal to the numbers exported prior to the crisis, the net supply-side effect on beef prices was, in fact, negligible and, in turn, that the effect of consumer reaction on retail and producer prices dominated this food scare.. The central message conveyed by our results is that the BSE crisis caused prices at the producer

[1] Of the 29 practices identified as acting against the public interest, two arose due to oligopoly and 27 due to oligopsony. The former included below cost selling and pricing according to the degree of local competition (so called 'price-flexing') Examples of the latter include the request or requirement for discounts from suppliers sometimes retrospectively; changes to contractual arrangements without notice and the unreasonable transfer of risk from supermarket to supplier. See Competition Commission Commission (2000) for details.

level to fall by more than double that of retail prices. This is consistent with the concerns raised by the UK anti-trust authorities, that price transmission between the retail and farm stages in this vertically-related market would have been influenced by market power in the UK food retail sector.

The paper is organised as follows. In section 1 we present a brief overview of the development of the UK BSE crisis over the 1990s. The theoretical framework for identifying the varying impact on retail and farm level prices is developed in section 2. This forms the basis for the econometric strategy that is outlined in section 3 while in section 4 we present the empirical results. In section 5 we summarise and conclude.

1. BSE in the UK

Detailed accounts of the UK's experience of BSE are available elsewhere (see *inter alia,* BSE Inquiry *op. cit*., DTZ Pieda Consulting, *op. cit.*) and thus we merely sketch some of the key aspects of the crisis here. The existence of BSE in cattle was first identified in the UK in the 1980s, although at that time, it was not thought to have implications for human health. This view was challenged in the 1990s when it was discovered that that BSE could jump species following the death of a cat from BSE symptoms. However, there was continued re-assurance from the UK government and its Chief Medical Officer that British beef was safe to eat. However, when the first human death from vCJD occurred in 1995, official confirmation of the possible link between vCJD and BSE was announced. To date there have been 129 deaths due to vCJD, though the expectation is that this number could rise dramatically in the future, particularly as vCJD has a long incubation period (New Scientist, 2000).

Following the discovery of the link between BSE and vCJD, consumption of beef fell immediately by 40 per cent. In addition, there were significant policy interventions that also affected the market. First, a European Union-wide ban on all UK beef sales was imposed in March 1996, in effect meaning British farmers faced an export ban. Net exports of beef, which stood around 39,000 calves and 23,000 tonnes of fresh and frozen carcass beef per month, ceased at this point, although it is interesting to note that imports did not change markedly after the ban. This reluctance to consume beef – even from BSE-free sources- reflects the reported 'over-reaction' to food-based risks (Kinnucan *et. al,*1997).

Second, and contemporaneous with the export ban, was the imposition of a culling order which consisted of three elements: an "Over 30 Month" cull where all cattle over this age were culled; a "Selective Cull" where known infected cattle were culled; and an "Offspring Cull" where the young of infected cows were culled. The "Over 30 Month Scheme" represented approximately 98% of the 4.9 million cattle destroyed during the sample period. The ban was lifted in 2003 although the cull is ongoing. Both were in force during our sample period.

2. The Impact of Food Scares on Price Margins

As noted in the introduction, one of the main concerns in the UK in the latter half of the 1990s was that the BSE crisis appeared to have a more significant impact on farmers than on food retailers. As a consequence, one of the main aspects of the Competition Commission enquiry into the food retailers was that market power at the retail level resulted in smaller declines in retail beef prices compared to those faced by farmers. In this section we outline a simple framework that is consistent with this argument. In addition, we also pay some attention to the role of related markets for substitute meats in determining the impact on the price transmission effect of the food scare.

There is a broad literature on the issue of the margin between the retail and farm levels and what factors may influence it. The most notable early paper on this issue was by Gardner (1975) which identified a range of factors that would influence the price transmission between the farm and retail sectors. Gardner assumed perfect competition which clearly does not fit with the concerns raised by the UK anti-trust authorities. To this end, McCorriston *et al*. (1998) showed that oligopoly power in the food sector would have an impact on determining the price transmission elasticity following a supply side shock depending on the functional form of the demand curve while McCorriston *et al*. (2001) show that the extent of returns to scale characterising the food industry cost function will also be important. Other important influences of the retail-farm margin and hence price transmission are likely to be oligopsony power (Lloyd *et al*., 2002), and the source of the exogenous shock (i.e. whether the shift occurs in the retail demand or farm supply function (Gardner, *op. cit*.). Related to this, the nature of the shift in the demand or supply function is likely to take (i.e. whether it is an intercept or rotation of the relevant curve) will also have an impact.

In the theoretical framework outlined below, we draw on this literature to highlight the potential role of market power on the retail-farm margin. However, rather than derive an explicit price transmission elasticity, we use the framework to determine our econometric strategy. Explicitly, we show that if market power characterises the UK food sector then both the exogenous demand and supply shifters should enter the reduced form retail-farm margin equation. If market power is not a feature of the sector, then there would be no *a priori* case for their inclusion. Therefore, while we do not retrieve an explicit measure of market power, in terms of deriving the relative effect of BSE on retail and farm prices, market power will influence the outcome if the demand and supply shifters are found to be statistically significant in the reduced form model.

There are some parallels with this approach and the empirical industrial organisation literature. First of all, in estimating the degree of market power, exogenous rotations in the demand curve are necessary in order to identify the degree of market power in a structural econometric model (Bresnahan (1989) provides a useful review of this literature while Corts (1999) provides a critique). In the model outlined below, we do not aim to identify the degree of market power explicitly but to ascertain only whether it exists in driving the price differential between vertically-related stages. Second, and consistent with empirical industrial organisation models, we employ the use of conjectural variations. While recognising the theoretical issues associated with this, we appeal to this empirical literature and interpret them as an 'index of market power' (see, for example, Genoseve and Mullin, 1997).

Economic Framework

The demand function for the processed product is given by:

$$Q = h(R, R^s, X) \tag{1}$$

where R is the retail price of the good under consideration and R^s is the price of a substitute good which firms in this sector take as given. X is the demand shifter. The supply function of the agricultural raw material is given by (in inverse form):

$$P = k(A, N) \quad (2)$$

where A is the quantity of the agricultural raw material and N is the exogenous shifter in the farm supply equation.

For a representative firm, the profit function is given by:

$$\pi_i = R(Q)Q_i - P(A)A_i - C_i(Q_i) \quad (3)$$

where C_i is other costs and, assuming a fixed proportions technology, $Q_i = A_i / a$ where a is the input:output coefficient which is assumed to equal 1. This assumption corresponds closely to the construction of the data in the vertical market chain used in the empirical analysis that follows[2]. The first-order condition for profit maximisation is given by:

$$R + Q_i \frac{\partial R}{\partial Q}\frac{\partial Q}{\partial Q_i} = \frac{\partial C_i}{\partial Q_i} + aP + aA_i \frac{\partial P}{\partial A}\frac{\partial A}{\partial A_i} \quad (4)$$

In order to get an explicit solution, consider linear functional forms for equations (1) and (2) and assume $a = 1$ (which is consistent with the construction of the data series):

$$Q = h - bR + eR^s + cX \quad (1')$$

$$P = k + gS \quad (2')$$

with domestic supply being given by:

$$S = Q + N$$

where N is the level of exports which are exogenously determined. From this, and aggregating over n-firms, (4) can be re-written as:

$$R - \frac{\theta}{nb}Q = M + P + \frac{\mu g Q}{n} \quad (4')$$

where θ and μ represent the conjectures relating to oligopoly and oligopsony power respectively. These parameters can be interpreted as an index of market power with $\theta = \mu = 0$ representing competitive behaviour and $\theta = \mu = 1$ representing collusive behaviour. M represents other costs that enter the industry cost function which are assumed to be marketing costs, the price of which is taken as given. Assume for ease

[2] Note that we are not pre-judging the form of technology that links these two sectors. However, the nature of the technology was not a specific issue in the Competition Commission investigation into the food retailers. It should also be observed that with a Leontief technology, the nature of the exogenous shock is important in identifying market power. However, we are not interested in identifying market power parameters explicitly but only if the presence of market power would have been likely to influence the retail-farm spread over the BSE crisis period.

of interpretation, θ and μ are n-firm weighted indices of market power where n is small. Using (1'), (2') and (4'), we can derive an explicit solution for the endogenous variables:

$$Q = \frac{h + cX + eR^s - b(M + k + gN)}{(1+\theta) + bg(1+\mu)} \quad (5)$$

$$R = \frac{\theta(h + cX + eR^s)/b + g(1+\mu)(h + cX + eR^s) + M + k + gN}{(1+\theta) + bg(1+\mu)} \quad (6)$$

$$P = \frac{(1+\theta)(k + gN) + bg\mu(k + gN) + g(h + eR^s + cX - bM)}{(1+\theta) + bg(1+\mu)} \quad (7)$$

To derive the retail-farm spread, use (6) and (7) to give:

$$R - P = \frac{M(1+bg) - (\theta + bg\mu)(k + gN) + (\theta/b + g\mu)(h + eR^s + cX)}{(1+\theta) + bg(1+\mu)} \quad (8)$$

Note that if neither oligopoly nor oligopsony power matters in the determining the retail-farm price spread (i.e. $\theta = \mu = 0$), then equation (8) reduces to:

$$R - P = M \quad (9)$$

i.e. the source of the retail-farm price margin in a perfectly competitive industry is due to marketing costs. In this case, the role of the exogenous shifters play no role in determining the spread. This is not to say that they do not affect each price individually, but in a perfectly competitive industry they play no role in determining the relative gap between the prices at each stage of the food chain. Correspondingly, if either oligopoly and/or oligospony power in the food sector is important, then they will influence the margin between retail and farm prices i.e. they will influence these prices by differential amounts.

Note also that the above framework includes the role of substitutes at the retail level in affecting the outcome of the BSE crisis. In general form, the impact of a food scare on retail prices can be given by:

$$\frac{\partial R}{\partial X} = \frac{\partial R}{\partial X} + \frac{\partial R}{\partial R^s}\frac{\partial R^s}{\partial X}$$

The first argument on the right-hand side is negative. A food scare shifts the demand curve to the left (i.e. an increase in X is equivalent to negative impact on demand) and hence reduces retail prices. The second argument is potentially ambiguous and will depend on how consumers respond to meat consumption as a whole. If $\partial R^s / \partial X$ is positive (negative), then the presence of substitute meats will offset (exacerbate) the impact of the food scare on retail prices.

Equations (6) and (8) form the basis of our econometric strategy. Using equation (6), we derive the direct effects of the demand and supply shifters on retail prices. Using equation (8), we focus on the retail-farm spread. Note that if market power in some form does characterise the UK food sector, then the exogenous supply and demand shifters should enter our econometric model of the margin between retail and farm prices. Hence the test for the existence of market power is whether the coefficients on these variables in the retail-farm spread equation are statistically significant. If market power does play a role, then this will influence the retail and farm level prices to varying degrees. Consequently, we can use (6) and (8) to derive the impact of the BSE crisis on retail and farm prices with N capturing the farm-level shifts associated with the export ban and the cull of cattle and X capturing the impact of the food scare at the retail level.

3. Econometric Strategy

General

Applied to the current context, the theoretical model set out above demonstrates the differential effect on producer and retailer beef prices following the BSE crisis in the UK. Since prices are likely to be non-stationary and co-integrated, it is appropriate to couch the empirical analysis in a vector autoregressive (VAR) framework (Hendry and Doornik, p129, 2001). Consider a VAR(p) model:

$$\mathbf{x}_t = \mathbf{\Phi}_1 \mathbf{x}_{t-1} + \mathbf{\Phi}_2 \mathbf{x}_{t-2} + \ldots + \mathbf{\Phi}_p \mathbf{x}_{t-p} + \mathbf{\Psi} \mathbf{w}_t + \boldsymbol{\varepsilon}_t \tag{10}$$

where $\mathbf{x}_t$ is a $(m \times 1)$ vector $(1,2,\ldots,i, j, \ldots,m)$ of jointly determined I(1) variables, $\mathbf{w}_t$ is a $(q \times 1)$ vector of deterministic and or exogenous variables and each $\mathbf{\Phi}_i$ ($i = 1,\ldots, p$) and $\mathbf{\Psi}$ are $(m \times m)$ and $(m \times q)$ matrices of coefficients to be estimated using a (t = 1, . . .T) sample of data. $\boldsymbol{\varepsilon}_t$ is a ($m \times 1$) vector of n.i.d. disturbances with zero mean and non-diagonal covariance matrix, $\boldsymbol{\Sigma}$.

The error correction representation of (10) is observationally equivalent but facilitates estimation and hypothesis testing since all terms are stationary (Hendry and Doornik, p60, *op. cit.*). This re-parameterisation is given by:

$$\Delta\mathbf{x}_t = \boldsymbol{\alpha}\boldsymbol{\beta}'\mathbf{x}_{t-p} + \sum_{i=1}^{p-1}\boldsymbol{\Gamma}_i\Delta\mathbf{x}_{t-i} + \boldsymbol{\Psi}\mathbf{w}_t + \boldsymbol{\varepsilon}_t \qquad (11)$$

Attention focuses on the ($n \times r$) matrix of co-integrating vectors, $\boldsymbol{\beta}$, that quantify the 'long-run' (or equilibrium) relationships between the variables in the system and the ($n \times r$) matrix of error correction coefficients, $\boldsymbol{\alpha}$, the elements of which load deviations from equilibrium (*i.e.* $\boldsymbol{\beta}'\mathbf{x}_{t-k}$) into $\Delta\mathbf{x}_t$, for correction. The $\boldsymbol{\Gamma}_i$ coefficients in (11) estimate the short-run effect of shocks on $\Delta\mathbf{x}_t$, and thereby allow the short and long-run responses to differ.

In the current context, $\boldsymbol{\beta}$ represents the linkages that bind the prices together in the long run. As section 2 demonstrates, these linkages occur either across substitutes at the retail level or between marketing stages for a single good. However, as Lütkephol and Riemers (1992) make clear, despite offering estimates of the 'long run' they are by construction partial derivatives predicated on the *ceteris paribus* assumption. When the variables in a co-integrated system are characterised by rich dynamic interaction (such that x_1 affects x_2 and x_2 affects x_1, possibly with lags and/or through other variables), inference based upon 'everything else held constant' may have limited value. Interpretation can be confounded further when more than one co-integrating vector is present in the system (Lütkephol, 1994).[3] If what is actually wanted is an estimate of what might happen following a specific shock, then impulse response analysis, which takes account of these interactions, provides a tractable and potentially attractive solution.

In what follows we use the generalised impulse response function (Pesaran and Shin, 1998) to assess the impact of demand and supply side shocks that characterised the

[3] An illustration of this problem is given in the empirical analysis that contains two co-integrating vectors.

BSE crisis in the UK on beef prices at both retail and farm levels. These are used to (a) infer whether the food sector is characterised by market power and (b) gauge the relative importance of the demand and supply shocks that characterise the BSE crisis.

Data

Monthly price data spanning January 1990 to December 2000 are supplied by the UK's Department of Environment, Food and Rural Affairs (DEFRA).[4] Retail price series are those collected as part of the UK's Meat and Livestock Commission Retail Prices Survey. The survey covers purchases in a variety of retailers (such as independent butchers and supermarkets) in 21 locations in England and Wales. A representative retail price for each meat is constructed through aggregation of prices recorded for individual cuts according to their share in a carcass. The producer price of beef is derived from a weekly survey of average live-weight prices at 190 auctions market in Great Britain. All prices have been deflated by the retail price index (December 1999 base) and are measured in pence per kilogram (p/kg). To facilitate comparison between retail and producer levels of the marketing chain all prices are expressed in 'carcass weight equivalents'.

These price data are augmented by two variables representing demand and supply shifters in the UK beef market. To capture the importance of the BSE food scare, we use an index of media coverage based upon a count of newspaper articles per month on the food and health related issues in four national quality newspapers.[5] Since consumers reportedly 'over-react' to food-based risks (see Kinnucan *et al. op cit.*), a media index such as this is likely to provide a more representative proxy for the demand-side shock than other more objective assessments of risks.

Whilst not exclusively about the crisis, BSE and its implications for the safety of beef consumption dominates the index, although reports about other scares such as E Coli 157 and related issues such as abattoir hygiene and cholesterol are also recorded. The

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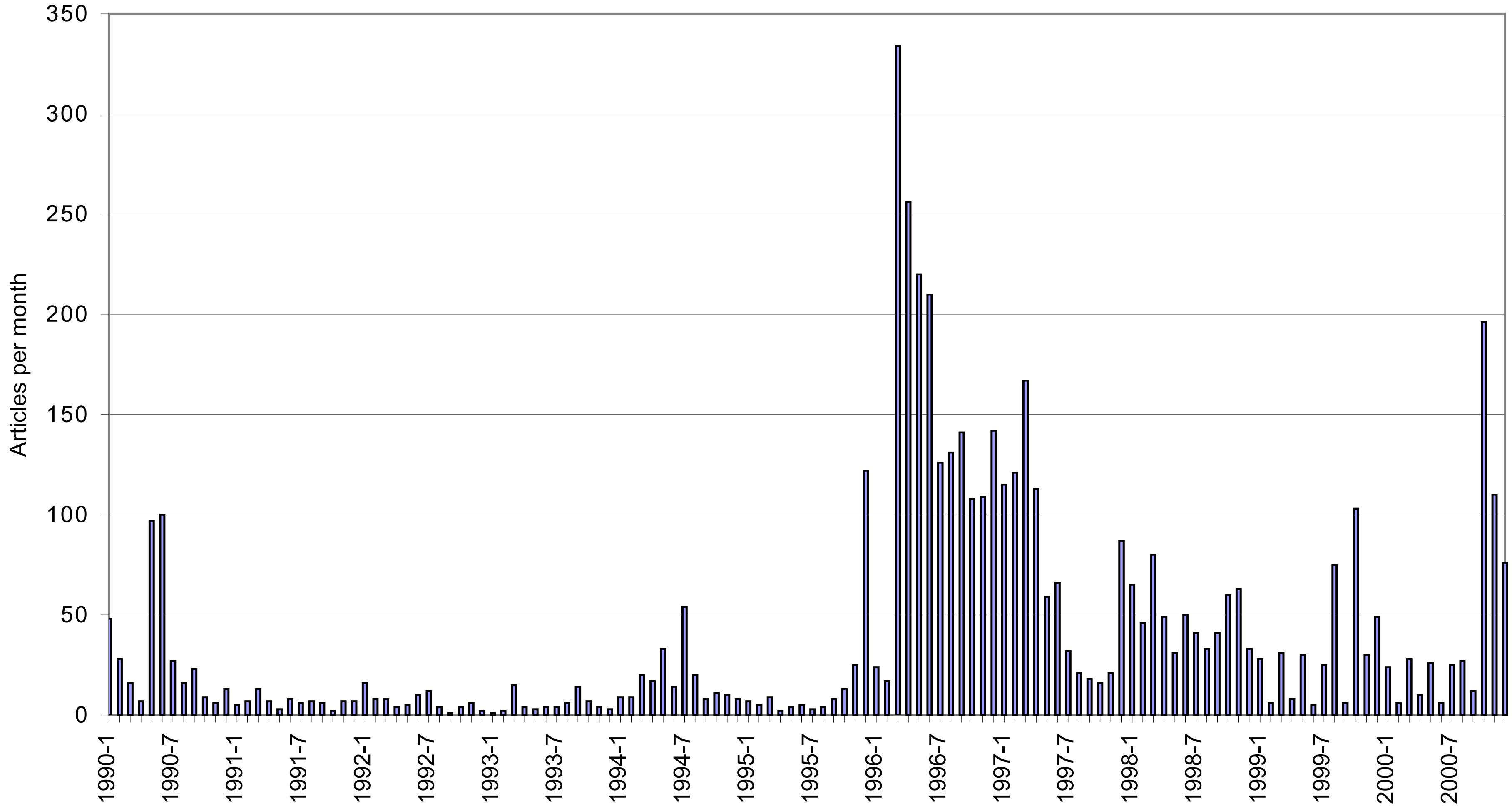
[4] Details regarding the collection and transformation of data are in MAFF (1999).

[5] The newspapers are The *Times*, *Sunday Times*; *Guardian*, *Observer*. The count is compiled by Euro-PA Associates of Northampton, UK (www.euro-pa.co.uk).

monthly count of articles is shown in Figure 1 and the series enters the empirical analysis in log form (s_t).

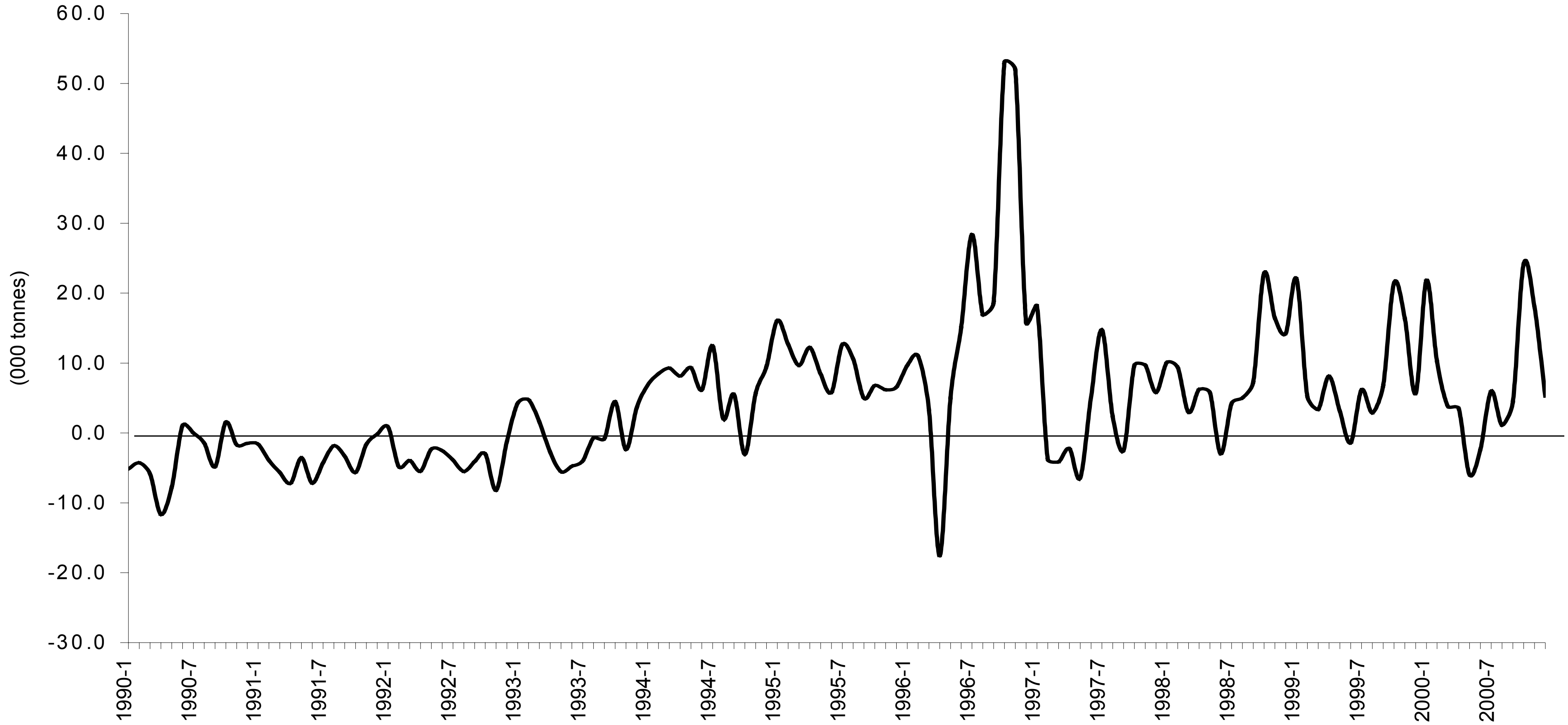
Figure 1: The Newspaper count (January 1990 to December 2000)



Supply side shocks of BSE are incorporated in a variable called Net Withdrawals, (NW_t) which represents the sum of net exports (of live cattle, fresh and frozen beef) and cattle removed from the food chain as part of the UK Government's official cull of old and infected cattle The data are expressed in thousand tonnes of carcass weight equivalent.[6]

[6] The authors are grateful to Tony Fowler of the Meat and Livestock Commission and Ken Addison of the Rural Payments Agency for help and advice in construction of the data series, further details of which are available from the authors upon request.

Figure 2 : Net Withdrawals from the UK Beef Sector (1990-2000)



4. Empirical Results

As an initial step, the data are tested for the order of integration. The series used comprise 132 monthly observations on retail prices of beef, pork, lamb (RB_t, RP_t and RL_t respectively), the producer price of beef (PB_t), the Meat Scares Index (s_t) and net withdrawals of beef from the UK market (NW_t).[7] The results are reported in Table 1 and confirm that the data series are non-stationary in levels and stationary in first differences, as visual inspection of the data (see Appendix) suggests.

Table 1: Augmented Dickey-Fuller test statistics

Variable	Levels (lag)	Differences (lag)	Inference
RB_t	-1.73 (0)	-10.98** (0)	RB_t ~I(1)
RP_t	-1.65 (0)	-9.87** (0)	RP_t ~I(1)
RL_t	-2.23 (3)	-7.39** (2)	RL_t ~I(1)
PB_t	-2.47 (2)	-6.63** (0)	PB_t ~I(1)
NW_t	-3.17 (7)	-6.33** (10)	NE_t ~I(1)
s_t	-2.76 (7)	-5.87** (0)	s_t ~I(1)

Notes: Lag length of the ADF regression is selected according to the Akaike Information Criterion and reported in parentheses adjacent to test statistic; the Augmented Dickey Fuller regression includes a constant and trend (and seasonals for lamb) for the levels and constant (and seasonals for lamb) in differences; critical values derived by MacKinnon; 5% significance denoted by *, 1% by **.

Using these data, equation (10) is estimated for $p = 1,\ldots,5$ unrestricted seasonals and intercepts restricted to the co-integration space. The Akaike Information Criterion selects a VAR(2) model, and diagnostic testing for residual auto-correlation, ARCH, and heteroscedasticity does not suggest departure from stated assumptions at the 5% level using either vector or equation-based tests. The null of normally distributed residuals is however strongly rejected owing to the presence of outliers in most of the equations around April 1996, corresponding to the Ministerial announcement in the

[7] Being a potentially important substitute for beef, the retail price of chicken was included but was found to be stationary about broken mean at the 1% significance level according to Perron (1989) tests. It also had no statistically significant impact in the co-integration analysis and is excluded from the models reported here.

UK linking BSE and vCJD. Plots of actual and fitted values from each of the equations and their corresponding scaled residuals are given in the appendix.

Co-integration Analysis

Co-integration results, reported in Table 2, show two (or possibly three) large eigenvalues which point to the presence of at least two equilibrium relations among the variables. Both formal tests indicate the presence of two such relationships at the 5% level, as indeed visual inspection of the co-integrating residuals might suggest (see Appendix).

Table 2: Co-integration Test Statistics

Eigenvalues:	0.37	0.28	0.17	0.05	0.03	0.0
H_0	Trace	5% c.v		Maximal Eigenvalue	5% c.v.	
$r=0$	136.3**	102.1		59.3**	40.3	
$r=1$	77.0*	76.1		42.0**	34.4	
$r=2$	35.0	53.1		23.6	28.1	
$r=3$	11.4	34.9		7.3	22.0	
$r=4$	4.1	20.0		3.9	15.7	
$r=5$	0.3	9.2		0.3	9.2	

Notes: Critical values are asymptotic, derived by Osterwald-Lenum; ** and * denote significance at 1% and 5% respectively.

In the absence of additional restrictions, the long-run relations are unidentified and merely represent statistical rather than meaningful economic relationships. However, given the discussion in the preceding sections, it is possible that they may represent the (horizontal) relationship between meat prices at the retail level (see equation 6) and the (vertical) price transmission relationship between retail and producer beef prices (see equation 8). As a first step, an exactly identified model is estimated in which producer prices are excluded from the first (retail) relation and enter the second (vertical) relation with a unit coefficient. This yields the following (t ratios in parentheses):

$$\begin{array}{l} RB_t = 37.48 + 0.88 RP_t + 0.67 RL_t - 24.09 s_t + 0.30 NW_t \\ \quad\quad (0.35) \quad (4.89) \quad\quad (1.56) \quad\quad (-4.92) \quad (0.17) \end{array} \tag{15}$$

$$(RB_t - PB_t) = -0.46 - 0.32RP_t + 0.53RL_t + 10.29s_t - 0.17NW_t \qquad (16)$$
$$\quad (-0.01)\ (-1.14) \quad (1.23) \quad (2.06) \quad (-1.50)$$

Note how the price of substitutes (RP_t and RL_t) appear to be relevant in the retail model (15) but not so in the price transmission relationship (16). Incorporating theory relevant restrictions and dropping insignificant regressors yields a final pair of cointegrating vectors given by:

$$RB_t = 0.74RP_t + 0.99RL_t - 30.07s_t \qquad (17)$$
$$\quad (3.22) \quad (4.13) \quad (-3.63)$$

$$(RB_t - PB_t) = 33.71s_t - 3.86NW_t \qquad (18)$$
$$\quad (6.88) \quad (-3.64)$$

A likelihood ratio test supports the over-identifying restrictions embodied in (17) and (18) at the 5% level [$\chi^2(5) = 9.1$; p-value = 0.11] indicating that the model represents a congruent simplification of the data[8]. As such, these equations may be interpreted as the equilibrium relations posited in section 2 characterising the vertical links between retail and farm prices and the role of inter-related markets at the retail level. Equation (17) describes the 'horizontal' retail relationship and shows that as the price of substitute goods rise so does the retail price beef in a manner indicative of substitution. The meat scares index (s_t) enters equation (17) as a retail demand 'shifter', akin to X in the theoretical model. The empirical results show that consumer concerns over the safety of meat, as measured by media activity, have a negative impact on the retail price of beef.

Note that in the price transmission relationship (18), the two exogenous variables representing the shock to the farm supply function and the retail demand function respectively are statistically significant. Given our discussion following the derivation of equation (8), this implies that market power (either in the form of oligopoly or oligospony power or both) characterises the UK food sector. As such, we can reject the hypothesis that market power did not play a role in influencing the impact of the BSE crisis on the retail-farm margins in the latter half of the 1990s.

[8] Note also that the variables have the correct sign. Recall that a positive shift in s_t represents a shift to the left of the retail demand function. The coefficients in the farm-retail spread are also correctly signed which can be seen by re-arranging (18) in terms of *PB* alone, [see equation (19)].

The extent to which demand shocks at the retail level are passed back to farmers can be derived by re-writing (18) in terms of producer prices which gives:

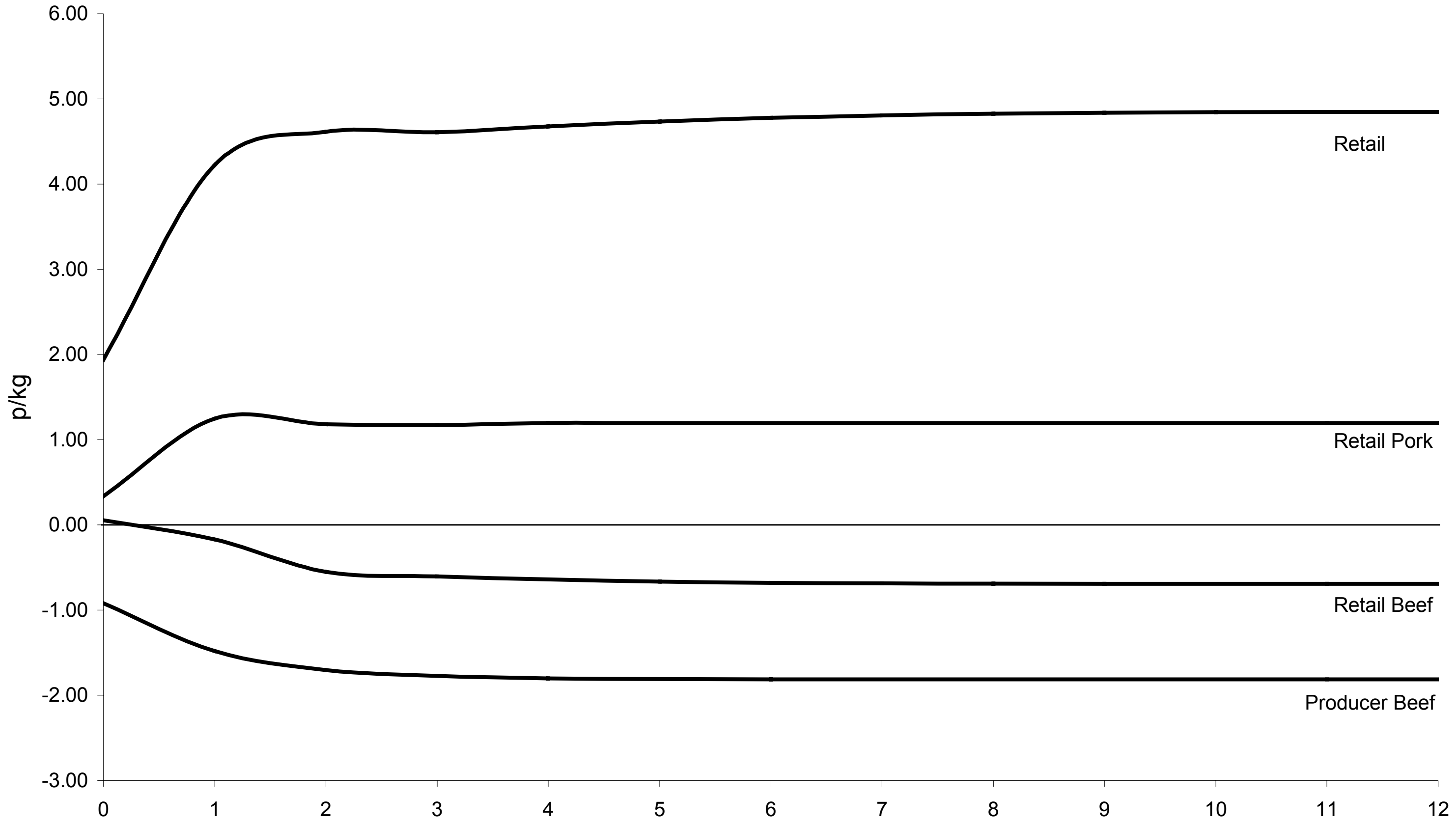
$$PB_t = RB_t - 33.71 s_t + 3.86 NW_t \qquad (19)$$

The negative coefficient on s_t shows that media activity also depresses producer prices *ceteris paribus* Also, changes in NW_t that lead to a reduction in domestic supply via exports or by culling raise the producer price of beef.

Impulse response analysis

The generalised impulse response function developed by Pesaran and Shin (*op. cit.*), which explicitly allows for the dynamic interactions between the variables in a system following a specific shock, offers a convenient tool with which to investigate what might be more appropriately called 'long-run' responses – the eventual impact that one might observe following a shock to one of the variables. Figure 3 shows the simulated effect of a shock of typical size (one standard error, or 79% or the mean) to the meat scares index on all meat prices in the twelve months following this hypothetical shock.

Figure 3: The Simulated Dynamic Effect of a (one standard error) Shock to the Meat Scares Index



There are two obvious outcomes from the impact on prices following the food scare. First, shocks to the meat scares index leads to a decline in the price of beef whereas the prices of substitute meats rise. Estimates suggest that the retail prices of pork and lamb rise by 0.8% (1.20 p/kg) and 1.8% (4.85 p/kg) respectively, while retail beef prices fall by around 0.3% (0.70p/kg) following a one standard error shock. This would seem to imply that following a food (BSE) scare, consumers reduce their demand for beef, but increase demand for substitute meats. In effect, the results suggest that consumers do not simply stop buying beef following heightened concerns about its safety, but rather they switch at least part of their beef consumption into lamb and pork. Whilst these 'knock-on' effects are unsurprising, their quantification underscores the usefulness of impulse response analysis in the inter-related market setting, since they cannot be inferred directly from estimates from the co-integrating regressions.[9]The second result to note is the differential effect on beef prices at the retail and farm stages. Thus while the retail price of beef falls by around 0.7p/kg, the farm gate price of beef falls by 1.81p/kg, suggesting a 'pass-back' coefficient of 2.59. Clearly, shocks at the retail level have far greater impact on farmers than retailers.

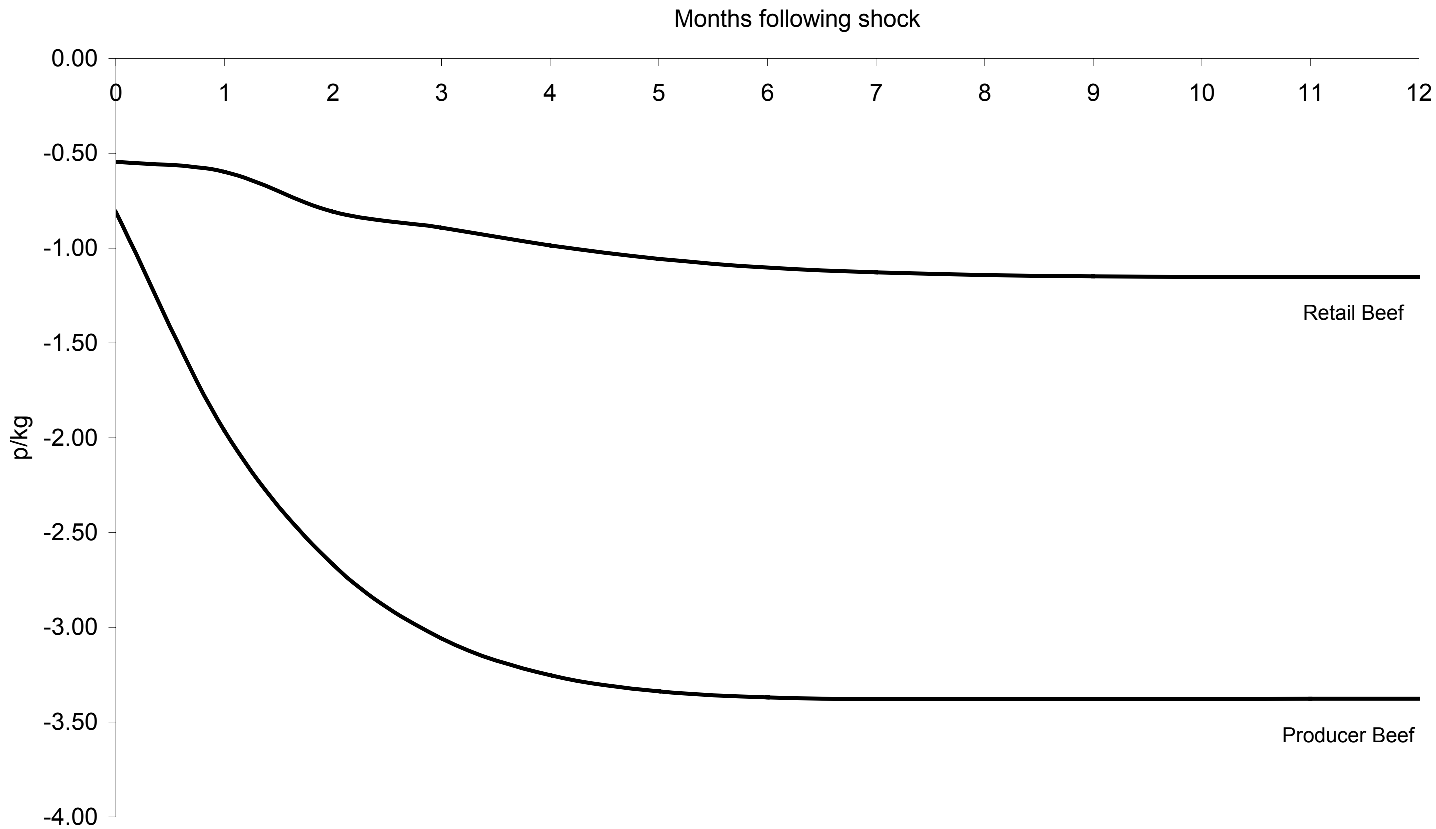
On the supply side, BSE impacted on the national herd via the international ban on UK exports of beef cattle and products and the cull of infected and older cattle. Figure 4 charts the simulated effect of a typical (i.e. one standard error –6,458 tonnes) shock on the retail and producer price of beef. Both prices decline following the reduction in exports but farm gate prices fall 3.38p/kg whereas retail prices fall by 1.15p/kg, implying a 'pass-through' elasticity of 0.34. These results are consistent with our observation of (18) that market power will affect the retail-farm spread. If

[9] Given the strength of the substitution between the various red meats the partial food scare elasticity of retail beef prices (0.118 at mean values) gives a poor estimate of the total elasticity (of 0.003 at mean values).

market power did not matter, the demand shock would not have a differential effect on farm and retail prices (see equation 8)[10].

[10] In addition to the measures we account for in the model, BSE was variously claimed to be associated with higher marketing costs arising from numerous legislative changes, particularly those banning specified risk material (neurological tissues and some offals) from entering the human food chain. Indeed, this explanation was typically cited as accounting for the growth in the retail price margin by the food retailing sector. Our results suggest that such claims may have been over-stated, in that we are unable to detect growth in the spread over and above that accounted for by included in the model. In any event, the cost explanation fails to account for the marked decrease in the spread that was observed during the period in which the Competition Commission were scrutinising the market.

Figure 4: The Simulated Dynamic Effect of a (one standard error) Shock to Net Withdrawals



The Impact of BSE on UK Beef Prices

As noted, the BSE episode can be characterised as having both demand- and supply-side effects. The demand side is manifested in the reduction in domestic demand while the supply side is shown through both the ban on exports and the cull of older cattle. Two questions then arise: what is the total impact of these effects on prices in the beef market and what is the relative size of them? We present some indication of the answers to these questions[11].

To calculate the supply-side effects we note that monthly exports of fresh and frozen beef which had averaged 22,810 tonnes (cwe) and exports of around 39,200 live calves ceased in April 1996. Equating 40 calves to one tonne of (cwe) beef means that the ban prevented the export of around (22,810+39,200/40=) 23,790 tonnes of (cwe) beef per month. Using estimates from the impulse response analysis suggests that the long-run impact of the ban was to lower average monthly retail prices by 4p/kg and producer prices by 12p/kg.

The impact of the cull requires a conversion from head count figures into tonnes of cwe for consistency. During the 1996(4) to 2000(12) sample period the average number of cattle culled per month was 86,014 and the average weight of cows culled was 556 kg. Thus, the average weight of culled cattle per month was 48,014 tonnes. These figures are live-weight, so need to be adjusted by the ‘killing-out percentage’ of 0.54. Hence, the monthly cull amounts to 25,928 tonnes of cwe. Using the impulse response estimates again suggest that the long-run impact of the cull was to raise average monthly retail prices by 5p/kg and producer prices by 14p/kg.

Calculation of the demand side effects of BSE are less straightforward, not least because media activity was not in the form of a once-and-for-all shock but was staggered over the entire period. Furthermore, whilst it is possible to accumulate the price effect of these shocks, it seems reasonable to assume that consumers’ recent

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[11] Note that whereas the export ban and cull resulted in the abrupt step-change in the amount of beef on the domestic market, the effect on demand was staggered over a long period of time. This means that when we attempt to estimate the impact of BSE on prices, we need to treat the demand and supply side shocks differently.

experience of media activity carries more weight than those that occurred in the past. To do otherwise, might exaggerate the effect of media activity on beef prices. In addition, estimates are in terms of proportionate shocks and thus a baseline from which to measure proportionate shocks is required. To allow for these factors we compute a baseline that is a one-year moving average that is updated as new articles are published i.e. we compare the actual count as a proportion of the number of articles appearing in the last 12 months. Multiplying these shocks by the estimates generated from the impulse response functions (which estimated that a doubling in media activity induces price falls of 0.87p/kg at retail and 2.29p/kg at the producer level) we accumulate the monthly effects over time. Under this scenario, retail prices fall by 19p/kg and producer prices fall by 45p/kg following the BSE crisis.

The price effects of these factors are summarised in Table 3. Overall, the results show that the impact resulting from the shift in the retail demand function dominated (by a factor of three or four) that of the export ban or cull. Furthermore, for all factors, the impact on producer prices was significantly higher than the impact on retail prices. Indeed, the net effect of the BSE crisis is calculated to be almost more than double the impact on retail prices. Despite the relatively crude nature of the calculations they suggest that the cull completely offset the price effects of the export ban. This arises since the cull removed approximately the same quantity of beef as had been exported prior to the ban.

Table 3: Estimated Price Impacts of the BSE Crisis (p/kg)

Effect due to:	Retail Prices	Producer Prices
Export Ban	-4	-13
Cull	5	14
Media activity	-20	-46
Net Effect	**-19**	**-45**

5. Summary and Conclusions

This paper has focussed on the impact of BSE in the UK on prices at both the retail and producer levels. Specifically, it was motivated by the public concerns raised about the differential impact on retailers and producers, the concern being that prices at the farm level fell by more than retail prices in the wake of the BSE crisis. The principal source of that concern was market power of food retailers which lead to a subsequent investigation by the UK Competition Commission. The contribution of this paper has been two-fold. First, we have shown formally that if market power exists, then exogenous shocks to either the retail or farm supply function will have an effect on the retail-farm price margin. Second, since the BSE crisis in the UK can be represented as a combination of demand and supply side shocks, we can gauge the effects of these shocks on retail and farm prices respectively. The economic model we outline forms the basis for our econometric strategy, results from which confirm that shocks to the retail demand and farm supply functions affected the retail-farm margin. While they do not identify the extent of market power, nor whether oligopoly power dominates oligopsony power, the results provide a *prima facie* justification for the issues addressed by the UK Competition Commission i.e. that market power in the UK food sector was a source of concern against the background of the BSE crisis.

Second, the results from the empirical model show that as a consequence of the BSE crisis, producer prices fell by more than twice that of retail prices. Moreover, the effect of the shift in the retail demand function, as consumers reduced their consumption of beef and switched into substitute meat products, had a more significant impact on retail and producer prices than the shift in the farm supply function due to the effect of the export ban on UK beef or the cull of older cattle. Indeed, it appears that the numbers culled were similar to the number exported prior to the crisis and thus were to all intents and purposes mutually offsetting. As a result, the net effect of BSE is solely due to its effect on domestic demand, which is substantial. The overall implication of the analysis presented above is that, while direct concern of food scares obviously relates to the health and well-being of consumers, where market power in the food sector exists, it will also give rise to distributional effects between the retail and farm sectors.

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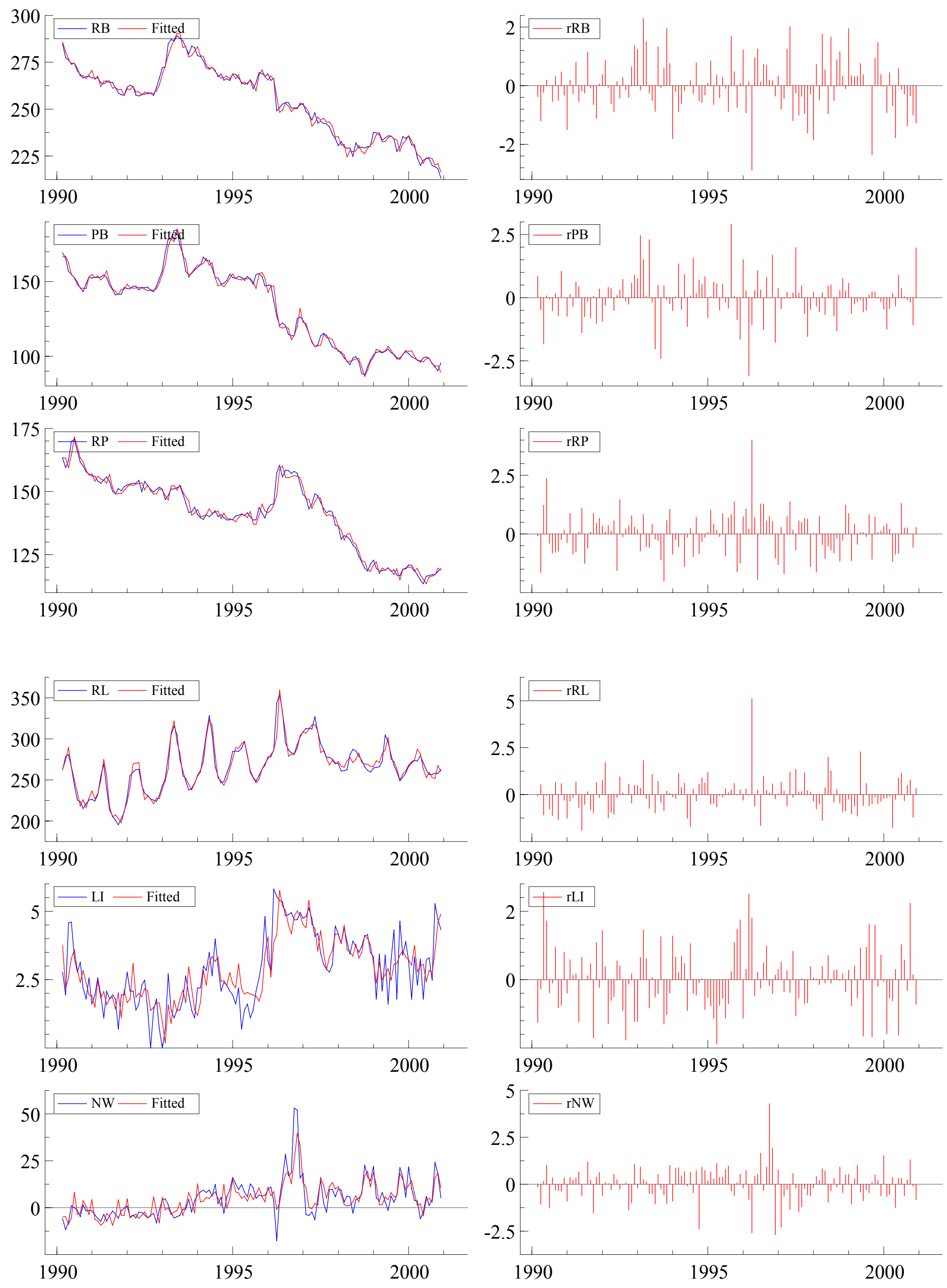
Appendix : Plots of the VAR(2) model (unrestricted constant and seasonals)

(a) Actual and Fitted values

(b) Scaled Residuals



(c) Residuals from all potential co-integrating vectors