Food Scares, Market Power and Price Transmission: the UK BSE Crisis

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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 transmission in vertically-related markets. We show that if market power has an effect on the farm-retail margin, this determines the specification of the cointegrating relationship and thus provides a test of market power. The results for the UK beef chain suggest that we cannot reject the importance of market power. The impact of the BSE crisis on farm prices is found to be more than double that of retail prices, thus corroborating public concerns regarding a differential impact of food scares on retailers and producers.

Keywords: BSE crisis; price transmission; market power

JEL Classification: L13, Q13

1. Introduction

In recent years, growing concern about the health and safety of food has been exacerbated by a number of food scares, 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)[1]. The announcement led to an immediate 40 per cent 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 prevent meat from BSE-infected animals 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, a complementary concern has been that the BSE crisis had differential effects on UK retailers and farmers. Specifically, it was argued that while the BSE crisis reduced the consumption and price of beef, beef prices at the retail level declined significantly less than at the producer level, resulting in a substantial increase in the retail-producer price margin. Although principally affecting the beef sector, the BSE crisis was widely believed to exacerbate the more longstanding and widespread hardship afflicting British farming in the 1990s. In this regard, attention was drawn to market concentration at the retail level, the 5-firm concentration ratio in UK food retailing at the time being around 67

[1] As of late 2005, 139 deaths can be linked to vCJD in the UK.

per cent and rising. This issue was one of the primary reasons for the investigation by the UK anti-trust authority, the Competition Commission, one of whose main concerns was 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, 2000: 3).

It could be argued, as indeed some supermarkets did at the time, that this disparity arose from higher marketing costs. However, this was not the verdict of the Competition Commission's 18-month investigation, which concluded that supermarkets routinely engaged in 29 practices that were adjudged to be against the public interest. The majority of these practices related to the relationship between the retailers and their upstream suppliers, and whilst falling short of enacting new legislation, the Commission recommended a code of conduct be drawn up to outlaw such practices in the future. Furthermore, despite a detailed examination, there was no evidence to suggest anti-competitive behaviour by upstream suppliers such as abattoirs, packers and wholesalers: indeed they had been adversely affected by market power at the retail level (Competition Commission, 2000, Appendix 11.5)[2]. Though our study does not distinguish empirically between oligopoly and oligopsony power, it addresses their potential influence on the adjustment of prices at the retail and farm levels. Specifically, we provide an empirically tractable test that permits us to assess

[2] 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 (2000) for details.

whether market power exercised by retailers caused the margin between retail and farm prices of beef to widen as a consequence of the BSE crisis in the UK.

Although there have been a number of studies and influential reports on the BSE crisis, most notably the 16 volume report of the Royal Commission (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 three contributions. First, a theoretical model formally highlights the links between market power and price transmission following shocks to retail demand, farm supply and marketing cost functions. The model also allows for substitution in consumption at the retail level, a notable characteristic of meat markets. Second, we show that if market power (in the form of oligopoly and/or oligopsony) exists, then this will influence the specification of the cointegrating relationship describing price transmission. Thus the framework delivers a hypothesis for the existence of market power that may be tested using readily available data. Third, the paper contributes to the empirical understanding of the impact of BSE by explicitly accounting for regulatory change (a beef export ban, a national cull and a more rigorous regime of abattoir inspection) as well as consumer concerns over the safety of beef (proxied by an index of media coverage). The empirical model accounts for many of these factors directly, although the effect of some aspects of regulatory intervention can be imputed only indirectly since adequate time series data do not exist that would allow direct observation of these factors.

Our results suggest that market power did influence the relative change in retail and farm prices, and indicate that the BSE crisis caused prices at the producer level to fall by more than double those at the retail level. We find little support for cost-based explanations of the growth in the retail-producer margin, although owing to a paucity of data on costs, inference is based on indirect evidence only. These results are consistent with the findings of the Competition Commission that price transmission between the retail and farm stages in these vertically-related markets was influenced by market power in the UK food retail sector. Indeed, our approach provides a simple and tractable empirical test that has wider application beyond the beef market.

The paper is organised as follows. In section 2, we present a brief overview of the development of the UK BSE crisis over the 1990s. The theoretical framework for identifying the differential impact on retail and farm level prices is developed in section 3. This forms the basis for the econometric investigation that is outlined in section 4, while in section 5 we present the empirical results. In section 6, we summarise and conclude.

2. BSE in the UK

Detailed accounts of the UK's experience of BSE are available elsewhere (see *inter alia,* BSE Inquiry, 2000; DTZ Pieda Consulting, 1998) and thus we merely sketch some key aspects of the crisis here. 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 early 1990s when it was discovered that BSE could jump species following the death of a cat from BSE symptoms. Nevertheless, there was continued reassurance 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. Following the discovery of the link between BSE and vCJD, UK consumption of beef fell immediately by around 40 per cent. Consumers that continued to eat meat tended to switch to pork and lamb. In addition, there were significant policy interventions that also affected the market during our sample period.

First, a European Union-wide ban on all UK beef sales was imposed in March 1996, meaning that in effect British farmers faced an export ban. Exports of beef, which stood at around 39,000 calves and 23,000 tonnes of fresh and frozen carcass beef per month, ceased at this point, while imports also fell after the ban.

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 per cent of the 4.9 million cattle destroyed during the sample period. The ban was finally lifted from all EU countries in 2002 and the cull is currently under review. Both were in force during our sample period.

Third, as additional safeguards, the then Ministry of Agriculture, Fisheries and Food (MAFF, now the Department for Environment, Food and Rural Affairs) required abattoirs to remove from the food chain so-called ‘specified risk material’ (SRM, that is neurological tissues and some types of offal) from BSE-free cattle. Abattoirs were also subject to a more rigorous regime of inspection by government veterinarians. While these safeguards are likely to have increased abattoir costs, they could have been partially offset by government intervention, since MAFF paid subsidies to the renderers for SRM disposal and covered the full costs of inspection. Uncertainty as to the net outcome of these changes on prices and hence the retail-producer margin is further increased owing to significant restructuring of the abattoir sector in the UK that had been in train over many years. Over-capacity in beef slaughter was estimated at 49 per cent during the 1990s and as a result only 412 of the 1,000 abattoirs that had existed in 1986 remained in 1999 (MLC 1999). Those that remained were able to absorb higher costs by virtue of their high-throughput low-cost nature. Unfortunately, owing to their commercial sensitivity, industry cost data are unavailable. Nevertheless, we do attempt to capture the effects of cost changes in the empirical analysis that follows.

3. The Impact of Food Scares on Price Margins

3.1 Related Literature

There is a broad literature on the margin between the retail and farm levels and what factors may influence it. A notable early paper on this issue is Gardner (1975), which identified a range of factors that would influence price transmission between the farm and retail sectors. In the Gardner model, the margin reflects marketing costs only. However, Gardner assumed perfect competition, which clearly does not fit with the concerns raised by the UK anti-trust authorities. 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) showed that the extent of returns to scale characterising the food industry cost function will also be important. Other important influences on the retail-farm margin and hence price transmission are likely to be oligopsony power (Lloyd *et al*., 2002), the source of the exogenous shock (i.e. whether the shift occurs in the retail demand, farm supply or marketing services functions (Gardner, 1975). Recently, Sanjuán and Dawson (2003) investigated price transmission issues in the wake of the BSE crisis using a bivariate cointegration model relating to farm and retail prices. Their focus differs from ours in that, rather than offering a statistical description of price behaviour in the wake of the BSE crisis, we relate the BSE issue to public policy concerns about the impact of market power in the UK food chain, and in so doing explicitly account for the way in which the food scare affected the UK beef sector.

In the theoretical framework outlined below, we draw on the previous 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. Specifically, 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 the inclusion of the shifters and the margin would simply reflect marketing and regulatory costs. Therefore, while we do not retrieve an explicit measure of market power, we show that market power influences the relative effect of BSE on prices if the demand and supply shifters are found to be statistically significant in the reduced form model of the retail-farm gate margin.

There are some parallels with this approach and the empirical industrial organisation literature. First, 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) offers a critique. Our model does not aim to identify the degree of market power explicitly, but only to ascertain whether it exists in driving the price differential between vertically-related stages. Second, consistent with empirical industrial organisation models, we use conjectural variations. While recognising the theoretical issues associated with this approach, we appeal to this empirical literature and interpret them as an 'index of market power' (see, for example, Genesove and Mullin, 1998).

3.2 Theoretical Framework

This section outlines a simple framework that accounts for the shocks that characterise the BSE crisis affecting the retail and farm sectors. In addition, we also consider the potential role of markets for substitute meats in determining the impact on the price transmission effect of the food scare. More specifically, if consumers believed that all meats were unsafe to eat then there would be a decline in demand and prices for all meats. If, however, consumers felt substitute meats were "safe", then they would switch consumption away from beef to other meats. This would cause the price of other meats to rise and then possibly lead to some demand switching back to the lower-priced beef and thus moderating some of it original price fall.

The demand function for the product at the retail level 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 an exogenous demand shifter. The supply function of the agricultural raw material is given by (in inverse form):

$$P = k(A, N) \tag{2}$$

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

The Competition Commission (2000) found the source of market power in the food chain to be at the retail level. Note that the wholesale (abattoir) sector has low levels of concentration (the five-firm concentration ratio being around 30 per cent), so there is little justification for extending the model to include an intermediate sector. We provide further justification for this in the empirical section below.

For a representative retail firm, profit is given by:

$$\pi_i = R(Q)Q_i - P(A)A_i - C_i(Q_i) \tag{3}$$

where C_i is other costs and, assuming a fixed-proportions technology, $Q_i = A_i / a$, where a is the input-output coefficient, assumed to equal 1 (which is consistent with the construction of the data series). This assumption corresponds closely to the construction of the data in the vertical market chain we use in the empirical analysis[3]. In common with most empirical industrial organisation studies, constant returns to scale are assumed[4]. The first-order condition for profit maximisation is given by:

[3] 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 rather if the presence of market power would have influenced the retail-farm spread over the BSE crisis period.

[4] See later for discussion of this assumption.

$$R + Q_i \frac{\partial R}{\partial Q}\frac{\partial Q}{\partial Q_i} = \frac{\partial C_i}{\partial Q_i} + P + Q_i \frac{\partial P}{\partial Q}\frac{\partial Q}{\partial Q_i} \tag{4}$$

In order to get an explicit solution, we adopt linear functional forms for equations (1) and (2). Specifically:

$$Q = h - bR + eR^s + cX \tag{1'}$$

$$P = k + gS \tag{2'}$$

with domestic supply being given by:

$$S = Q + N$$

where N is the supply shifter (in this case the level of net exports) which are exogenously determined. From this we can rewrite (4) as:

$$R - \frac{\theta}{b}Q = M + P + \mu g Q \tag{4'}$$

where θ and μ are average output and input conjectural elasticities respectively, such that with n firms in the industry $\theta = (\Sigma_i\ [\partial Q/\partial Q_i][Q_i/Q])/n$ and $\mu = (\Sigma_i\ [\partial Q/\partial Q_i][Q_i/Q])/n$. 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 is a composite variable that represents all other costs that affect the retail-farm price margin.

To allow for changes in costs due to the BSE crisis, we assume a linear marketing cost function of the form:

$$M = y + zE + G \tag{5}$$

where y is a constant, zE represents the costs of inputs from the marketing sector (for example, wages) and G represents regulatory costs which we assume to be exogenous and determined by government.

Using (1'), (2'), (4') and (5), and for convenience suppressing the constants *y* and *k*, we can derive an explicit solution for the endogenous variables:

$$Q = \frac{h + eR^s + cX - bzE - bG - bgN}{(1+\theta) + bg(1+\mu)} \tag{6}$$

$$R = \frac{h + [(1+\theta) + bg(1+\mu)][(1-b)(G+gN) + (1-bz)E + eR^s + cX)]}{(1+\theta) + bg(1+\mu)} \tag{7}$$

$$P = \frac{g[h + eR^S + cX - bzE - bgG] - g[b - ((1+\theta) + bg(1+\mu))(N)]}{(1+\theta) + bg(1+\mu)} \tag{8}$$

To derive the retail-farm spread, use (7) and (8) to give

$$R - P = \frac{h(\theta/b + g\mu) + (1+bg)(zE+G) + (\theta/b + g\mu)(eR^s + cX) - (\theta + bg\mu)(gN)}{(1+\theta) + bg(1+\mu)} \tag{9}$$

Note that if neither oligopoly nor oligopsony power matters in determining the retail-farm price spread (i.e. $\theta = \mu = 0$), then equation (9) reduces to:

$$R - P = zE + G\ . \tag{10}$$

That is, the source of the retail-farm price margin in a perfectly competitive industry is due to changes in marketing and regulatory costs only. In this case, the exogenous shifters relating to the retail and agricultural supply functions 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 gap *between* the prices at each stage of the food chain. Correspondingly, if either oligopoly and/or oligopsony power in the food sector is important, then the shifters will influence the margin between retail and farm prices. In other words, each shifter will affect the two prices differentially and thus the margin between the prices will change. 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 demand shock on retail prices can be given by:

$$\frac{dR}{dX} = \frac{\partial R}{\partial X} + \left(\frac{\partial R}{\partial R^s} \frac{\partial R^s}{\partial X} \right)$$

Assuming the shock to be a food scare, then the expected sign on the first term on the right-hand side is negative. A food scare shifts the demand curve to the left and hence reduces retail prices. The sign of the second term 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 (7)-(9) form the basis of our econometric model. Consider first equation (9), which relates to the retail-farm spread. If market power in some form does characterise the chain, 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. Depending on whether or not these shifters are significant, we can use (7) or (8) with (9) 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. In the empirical section, we test this proposition using data from the UK beef market that explicitly accounts for demand and supply side shifters associated with the BSE crisis.

However, as in all empirical industrial organisation studies, tests for market power are conditional on the assumptions underlying the base model such as choice of functional form and the nature of the technology, and (of particular relevance here) the assumption of constant returns to scale. As noted above, McCorriston *et al*. (2001) highlight the possibility that returns to scale in the food sector may influence price transmission between stages in the food chain. Given this, it is worthwhile investigating the role of scale economies on the margin equation (9). To do so, we assume that marketing costs are independent of the level of output in the beef sector due to the multi-product nature of retailers[5]. The inverse farm supply function is therefore adapted to allow for variable marginal costs. Specifically, following Martin (1993: 41), we re-write (2') as:

$$P = gS + sS^2 \qquad (2'')$$

If $s = 0$, there are constant returns to scale. If $s < 0$, there are increasing returns to scale and average costs fall with output; if $s > 0$, there are decreasing returns to scale and average costs rise. Re-working the model outlined above with this amendment, the retail-farm price spread can now be written as:

$$R - P = \frac{(\mu g + \theta / b)(h) + [1 + bg + bs(Q + 2N)](G + zE) + (\mu g + \theta / b)cX}{(1 + \theta) + (1 + \mu)bg + bs(Q + 2N} + \frac{(\mu g + \theta / b)eR^s - bg(\mu g + \theta / b)N - bs(\mu g + \theta / b)N^2}{(1 + \theta) + (1 + \mu)bg + bs(Q + 2N)} \qquad (9')$$

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[5] Admittedly, this is a narrow view of the returns to scale issue since, by assumption, the source of non-constant returns to scale relates to costs originating from the farm supply function only. Nevertheless, it does suggest caution should be exercised in the interpretation of price transmission as in McCorriston *et al*. (2001). Millán (1999) deals with returns to scale issues in a broader context with reference to the Spanish food sector.

There are several points to note about (9'). First, N^2 enters the retail-farm price margin; second, the level of output (*Q)* and the supply shifter (*N*) also appear as both separate terms and interactively with the other variables. It is evident therefore that the presence of non-constant returns to scale affects the specification and tractability of the test of market power; nevertheless, the primacy of the market power parameters is unaffected. Specifically, the impact of scale economies is always mediated through the market power parameters, such that if the food sector was competitive, i.e. $\theta = \mu = 0$, then (9') collapses to:

$$R - P = zE + G$$

which is exactly the same as (10). In other words, non-constant returns to scale matter only in so far as they interacts with market power. As a result, in an empirical setting, the statistical significance of the shifters can only arise from the presence of market power; it cannot come about from scale economies alone. If there is no market power, the shifters will not affect the margin. Moreover, for reasonable values for the parameters used in (9'), the presence of non-constant returns to scale will not change the sign on any of the shifters although, of course, it will be the combination of market power and non-constant returns that will determine the size of the changes.

In terms of linking theory with empirics, it would be desirable to work with (9'). However, it is not possible in this case since, even if a composite shifter were constructed, this construct would be arbitrary, given that the value of *s* is not known (even assuming the presence of market power)[6]. This confines us to working with (9) but since the signs on the shifters will not change with returns to scale, the significance of the shifters will still detect the presence of market power in determining the retail-farm price margin. In sum, if returns to scale are important, they only serve to amplify the effect of market power on the margin, they alone cannot widen the margin; the issue that market power is important in the food chain will stand.

4. Econometric Issues

4.1 General

The theoretical model set out above can be applied to analyse the effect on producer and retailer beef prices following the BSE crisis in the UK. Since prices are likely to be non-stationary and cointegrated, it is appropriate to couch the empirical analysis in a vector autoregressive (VAR) framework (Hendry and Doornik, 2001: 129). Consider a VAR(p) model:

$$\mathbf{x}_t = \mathbf{\Phi}_1 \mathbf{x}_{t-1} + \mathbf{\Phi}_2 \mathbf{x}_{t-2} + \ldots + \mathbf{\Phi}_p \mathbf{x}_{t-p} + \mathbf{\Psi} \mathbf{w}_t + \boldsymbol{\varepsilon}_t \qquad (11)$$

where $\mathbf{x}_t$ is a ($m \times 1$) vector 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 by Johansen's (1988) maximum likelihood procedure 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, Σ.

The error correction representation of (11) is observationally equivalent but facilitates estimation and hypothesis testing since all terms are stationary (Hendry and Doornik, 2001: 60). This re-parameterisation is given by:

[6] The difficulty in separately distinguishing market power and returns to scale has already been noted elsewhere. See Millán (1999).

$$\Delta \mathbf{x}_t = \boldsymbol{\alpha\beta}'\mathbf{x}_{t-p} + \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_i \Delta \mathbf{x}_{t-i} + \boldsymbol{\Psi}\mathbf{w}_t + \boldsymbol{\varepsilon}_t \tag{12}$$

Attention focuses on the $(m \times \mathrm{r})$ matrix of co-integrating vectors, $\boldsymbol{\beta}$, that quantify the 'long-run' (or equilibrium) relationships between the variables in the system and the $(m \times \mathrm{r})$ 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 (12) estimate the short-run effect of shocks on $\Delta\mathbf{x}_t$, and thereby allow the short and long-run responses to differ.

Given the proceeding discussion, $\boldsymbol{\beta}$ represents the economic linkages that bind the prices together in the long run. As section 2 demonstrates, these linkages occur either between substitutes at the retail level or between marketing stages for a single good and as such provide the identifying restrictions required to interpret the cointegrating relationships in an economically meaningful way.[7] However, as Lütkephol and Reimers (1992) made 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 cointegrated 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. 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. Whilst impulse response functions are readily calculated from reduced forms such as (12), knowledge of the structural economic representation from which (12) derives is required if the correlations upon which the impulse response functions are based are to be legitimately attributed to economic (causal) mechanisms.

As we shall see, it is the dynamic effect of shocks to the supply and demand shifters that are sought. While these have an intuitively 'structural' interpretation, in that the shifters reflect influences that can be thought of as driving prices rather than being driven by them, it is straightforward to formalise. To do so, consider the structural economic representation of (12), namely:[8]

$$\mathbf{A}\Delta\mathbf{x}_t = \tilde{\boldsymbol{\alpha}}[\boldsymbol{\beta}\mathbf{x}_{t-p}] + \sum_{i=1}^{p-1}\tilde{\boldsymbol{\Gamma}}_i\Delta\mathbf{x}_{t-i} + \tilde{\boldsymbol{\Psi}}\mathbf{w}_t + \boldsymbol{\nu}_t \quad (13)$$

where $\mathbf{A}$ represents the $(m \times m)$ matrix of coefficients defining the contemporaneous structural linkages in the system, $\tilde{\boldsymbol{\alpha}} = \mathbf{A}\boldsymbol{\alpha}$, $\tilde{\boldsymbol{\Gamma}}_i = \mathbf{A}\boldsymbol{\Gamma}_i$, $\tilde{\boldsymbol{\Psi}} = \mathbf{A}\boldsymbol{\Psi}$ and

$$\boldsymbol{\nu}_t = \mathbf{A}\boldsymbol{\varepsilon}_t \quad (14)$$

are the structural shocks which, as pure disturbances, are assumed to be serially uncorrelated and uncorrelated with each other with zero means and diagonal variance-covariance matrix, $\boldsymbol{\Omega} = E[\boldsymbol{\nu}_t\boldsymbol{\nu}_t'] = \mathbf{A\Sigma A}'$ (Hamilton, 1994: 329). The m^2 restrictions on $\mathbf{A}$ (one normalisation and $m-1$ homogenous linear restrictions per equation) required for exact identification of (13) are excessive for our purposes since all we require is that some (i.e. the two shifter equations in our case) be identified. Decomposing $\mathbf{x}_t = (\mathbf{x}_{1t}', \mathbf{x}_{2t}')'$ where, using the notation from the previous section,

[7] Like any set of equations, the usual rank and order conditions must be satisfied if $\boldsymbol{\beta}$ is to be unique and the cointegration relationships given valid economic interpretations.

[8] Shocks to (say) the price of a substitute are less obviously 'structural', since they themselves are likely to reflect shocks to other meat prices.

$\mathbf{x}_{1t} = (X_t, N_t)'$ denotes the shifters and $\mathbf{x}_{2t} = (R_t, R_t^s, P_t)'$ denotes the prices, we may partition the structural model (13) accordingly, to yield[9]:

$$\begin{pmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} \\ \mathbf{A}_{21} & \mathbf{A}_{22} \end{pmatrix} \begin{pmatrix} \Delta\mathbf{x}_{1t} \\ \Delta\mathbf{x}_{2t} \end{pmatrix} = \boldsymbol{\mu}_{t-1} + \begin{pmatrix} \mathbf{v}_{1t} \\ \mathbf{v}_{2t} \end{pmatrix} \tag{15}$$

where

$$\boldsymbol{\mu}_{t-1} = \tilde{\boldsymbol{\alpha}}\left[\boldsymbol{\beta}\mathbf{x}_{t-p}\right] + \sum_{i=1}^{p-1} \tilde{\boldsymbol{\Gamma}}_i \Delta\mathbf{x}_{t-i} + \tilde{\boldsymbol{\Psi}}\mathbf{w}_t$$

and

$$\begin{pmatrix} \mathbf{v}_{1t} \\ \mathbf{v}_{2t} \end{pmatrix} \sim n.i.d\left[\mathbf{0}, \begin{pmatrix} \boldsymbol{\Omega}_{11} & \boldsymbol{\Omega}_{12} \\ \boldsymbol{\Omega}_{21} & \boldsymbol{\Omega}_{22} \end{pmatrix}\right]$$

Exact identification of the equations in $\Delta\mathbf{x}_{1t}$ (and the impulse response functions associated with them) is achieved providing:

$$\mathbf{A}_{12} = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}, \quad \mathbf{A}_{11} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \quad \text{and} \quad \boldsymbol{\Omega}_{11} = \begin{pmatrix} \omega_X & 0 \\ 0 & \omega_N \end{pmatrix}.$$

The first set of restrictions state that prices are not contemporaneously causal for the shifters; the second, that the shifters themselves are contemporaneously unrelated; and the third that shocks to the shifters are orthogonal to each other. Given that we can safely assume that the contemporaneous causality is from the shifters to prices rather than *vice versa* and that each shifter reflects changes in disparate parts of the economy (and are thus at least contemporaneously unrelated), the equations comprising $\Delta\mathbf{x}_{1t}$ are exactly identified. This is helpful empirically, since the impulse response functions of the variables contained in $\Delta\mathbf{x}_{1t}$ do not require the equations in $\Delta\mathbf{x}_{2t}$ to be identified nor is $\boldsymbol{\Omega}_{12} = 0$ a requirement, so that shocks between prices and shifters need not be orthogonal.

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[9] Note that there are two substitutes in the empirical model hence $\mathbf{x}_{2t}$ contains four variables.

In what follows, we use the generalised impulse response function (Koop *et al*. 1996, Pesaran and Shin, 1998) [10] to assess the impact of demand and supply side shocks that characterised the 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 as reflected in equation (9), and (b) gauge the relative importance of the demand and supply shocks that characterise the BSE crisis arising by combining equation (7) or (8) with (9).

4.2 Data

Monthly price data spanning January 1990 to December 2000 were supplied by the Department of Environment, Food and Rural Affairs (DEFRA).[11] Retail price series on beef, pork, and lamb were collected as part of the Meat and Livestock Commission Retail Prices Survey. The survey covers purchases in a variety of retailer premises (such as independent butchers and supermarkets) in 21 locations in England and Wales. A representative retail price for each meat is constructed by aggregating prices recorded for individual cuts weighted by their share in a carcass. The producer price of beef is derived from a weekly survey of average live-weight prices at 190 auction markets in Great Britain. All prices are measured in pence per kilogram (p/kg) and have been deflated by the retail price index (December 1999 base). To facilitate comparison between retail and producer levels of the marketing chain all prices are expressed in 'carcass weight equivalents'.

The theoretical model shows that marketing and regulatory costs also represent a potentially important influence on the retail-farm margin. Due to their commercial

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[10] Therefore, results are also invariant to the ordering of the variables in $\mathbf{x}_{1t}$ (see Garratt *et al*., 2003).

sensitivity, detailed industry-specific costs are not in the public domain. As with other empirical studies of the retail-farm price margin, marketing costs are proxied by unit labour costs (in UK manufacturing, expressed in real terms and obtained from the UK's Office of National Statistics). This procedure was followed by, for example, Reed and Clarke (2000). As Wohlgenant (2001) noted, since a large share of non-farm input costs are associated with labour, wage rates are an appropriate proxy to use for marketing costs. Regulatory costs are potentially more difficult to account for. As a first step, we therefore follow Sanjuán and Dawson (2003) and account for BSE-related cost changes using dummy variables. We return this issue to below.

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 on demand, we use an index of media coverage based upon a monthly count of newspaper articles on the food and health related issues in four national quality newspapers.[12] Since consumers reportedly 'over-react' to food-based risks (Kinnucan *et al.* 1997), such a media index 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 dominate 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 monthly count of articles is shown in Figure 1 and the series enters the empirical analysis in log form (s_t).

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

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

Figure 1: Article Count of the Health and Safety of Beef (about here)

Supply side BSE-related shocks 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 government's official cull of old and infected cattle. The data are expressed in thousand tonnes of carcass weight equivalent.[13] Note that since we are working with a two-level food chain, we do not separate out withdrawals that may occur at different stages within the food chain. Aggregating withdrawals would be a concern only if there was imperfect price transmission between the farm and wholesale stages. We investigate this possibility in section 5.3.

Figure 2: Net withdrawals of Beef from the UK Market (about here)

5. Empirical Results

5.1 Time series properties of the data

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), net withdrawals of beef from the UK market (NW_t) and manufacturing unit labour costs (L_t).[14] As an initial step, the data were tested for the order of integration. The ADF results are reported in Table 1 and confirm that the

[13] 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 on constructing the data series. Further details of the data used and all statistical results are available from the authors upon request. *PCGive 10.0* (Hendry and Doornik, 2003) was used for the cointegration analysis and *Microfit 4.0* (Pesaran and Pesaran, 2001) was used to generate the generalised impulse response functions.

[14] Being a potentially important substitute for beef, the retail price of chicken was included but was found to be stationary about a broken mean at the 1 per cent significance level according to Perron

series are non-stationary in levels and stationary in first differences, as visual inspection of the data suggests (see appendix).[15]

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)
L_t	-0.76 (1)	-15.46** (0)	L_t ~I(1)
NW_t	-3.17 (7)	-6.33** (10)	NW_t ~I(1)
s_t	-2.76 (7)	-5.87** (0)	s_t ~I(1)

Notes: Lag length of the ADF regression was selected according to the Akaike Information Criterion and is reported in parentheses adjacent to test statistic; the Augmented Dickey Fuller regression includes a constant and trend (and seasonal dummies for lamb) for the levels and a constant (and seasonal dummies for lamb) in differences; critical values derived by MacKinnon (1991); 5% significance denoted by *, 1% by **.

Using these data, the levels representation of the VAR (equation 10) was estimated for $p = 1,\ldots,5$ unrestricted seasonals and intercepts restricted to the cointegration space. The Akaike Information Criterion selected a VAR(2) model, and diagnostic tests for residual autocorrelation, ARCH, and heteroscedasticity did not suggest departure from stated assumptions at the 5 per cent level using either vector or equation-based tests. The null of normally distributed residuals was, however, strongly rejected owing to the presence of outliers in most of the equations around April 1996, corresponding to the Ministerial announcement in the UK linking BSE and vCJD.

(1989) tests. It was found to be redundant in the cointegration analysis and is excluded from the models reported here.

[15] Perron (1989, 1997) tests of the price series used here, and reported by Sanjuán and Dawson (2003) confirmed the presence of a unit root in all price series when allowing for a break in both level and level and trend. Similar tests on the shifters, NW_t and s_t, reached the same conclusion for these data.

5.2 Cointegration Analysis

The cointegration analysis was conducted within the VECM (equation 11). Acknowledging the potentially important role of BSE on beef marketing costs, the long run model was augmented to include dummy variables to allow for changes in its slope and intercept post March 1996 but their coefficients were statistically insignificant at conventional levels. Furthermore, the marketing costs proxy (L_t) was also insignificant in the cointegration analysis, and as a result both the dummy variables and the marketing cost index were excluded from the VAR as part of a general to specific modelling strategy. Plots of the actual and fitted values from each of the resulting equations and their corresponding scaled residuals in the unrestricted VAR(2) model are given in the appendix.

Cointegration results, reported in Table 2, show two large eigenvalues suggesting the presence of two equilibrium (stationary) relations among the variables. Formal cointegration tests (Johansen, 1988) confirmed the presence of two cointegrating relationships at the 5 per cent level, as indeed visual inspection of the cointegrating residuals suggests (see Appendix)[16].

Table 2: Cointegration 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 (1992); ** and * denote significance at 1% and 5% respectively.

In the absence of further restrictions, the long-run relations that have been detected are unidentified and merely represent statistical rather than meaningful economic relationships. However, given the discussion in section 3, it is reasonable to assume that they represent the pricing relationships given by equations (7), (8) and (9), of which we would only expect to find two because the margin (9) is the linear combination of (7) and (8). In other words, any two of these equations will by definition determine the third. While the choice is arbitrary as to which two equations to identify, we specify a model in which producer prices are excluded from the first (retail) relation and enter the second (margin) relation with a unit coefficient. This yields the following (*t* ratios in parentheses):

$$\underset{}{RB_t} = \underset{(0.35)}{37.48} + \underset{(4.89)}{0.88RP_t} + \underset{(1.56)}{0.67RL_t} - \underset{(-4.92)}{24.09s_t} + \underset{(0.17)}{0.30NW_t} \tag{16}$$

$$(RB_t - PB_t) = \underset{(-0.01)}{-0.46} - \underset{(-1.14)}{0.32RP_t} + \underset{(1.23)}{0.53RL_t} + \underset{(2.06)}{10.29s_t} - \underset{(-1.50)}{0.17NW_t} \tag{17}$$

Inspection of these suggest that they do indeed represent empirical analogues of the retail and margin relationships as described in (7) and (9). Specifically, the prices of

[16] In the absence of any evidence of a break in the level or trend of these residuals during 1996 we do

substitutes (RP_t and RL_t) appear to be relevant in (16), the retail model, but not so in (17), the margin or price transmission relationship. Dropping insignificant regressors yielded a final pair of cointegrating vectors given by:

$$RB_t = 0.74RP_t + 0.99RL_t - 30.07s_t \quad (18)$$
$$\qquad (3.22) \quad (4.13) \quad (-3.63)$$

$$(RB_t - PB_t) = 33.71s_t - 3.86NW_t \quad (19)$$
$$\qquad (6.88) \quad (-3.64)$$

A likelihood ratio test supported the over-identifying restrictions embodied in (18) and (19) at the 5 per cent level [$\chi^2(5) = 9.1$; *p*-value = 0.11] indicating that the model represents a congruent simplification of the data. All variables are correctly signed in both equations. Equation (18) describes the retail relationship and shows that as the prices of pork and lamb rise, so does the retail price of beef, in a manner indicative of substitution. Hence the presence of substitutes partially offsets the impact of the BSE crisis on price adjustment. The meat scares index (s_t) enters equation (18) 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. However, because demand shocks are greater at producer rather than retail level, the effect of the index on the margin is to widen it, as can be seen in (19).

The net withdrawal variable, NW_t, enters the margin equation (19) like N in the theoretical model, and as a supply shifter, it reduces the margin by raising producer prices by more than retail prices. In other words, a decrease in net withdrawals (such

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not apply the Johansen *et al*. (2000) cointegration tests that allow for structural breaks.

as an export ban) will lead, *ceteris paribus*, to an increase in supply on the domestic market and hence prices fall.

Regarding the issue of market power, we note that in the price margin equation (19), the two exogenous variables (NW_t, s_t) are statistically significant at conventional levels.[17] Given the discussion following equation (9), this implies that market power (in the form of oligopoly or oligospony power, or both) appears to characterise the UK beef sector. Thus, the results reject the hypothesis of perfect competition and imply that market power played a role in influencing the impact of the BSE crisis on the beef retail-farm margins in the latter half of the 1990s.

The extent to which demand shocks at the retail level are passed back to farmers can be derived by re-writing (19) in terms of producer prices, which gives:

$$PB_t = RB_t - 33.71 s_t + 3.86 NW_t \tag{20}$$

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.

5.3 Costs Revisited

Mindful of the important role that marketing costs may play in determining the size of the retail-producer margin, it is somewhat puzzling that they do not figure more prominently in the empirical analysis presented here. Of course, this may simply reflect the unrepresentative nature of the proxies that are available to measure actual

[17] Note that *t*-ratios are only asymptotically valid under cointegration, although likelihood ratio exclusion tests confirm the statistical significance of these variables to at least one of these cointegrating relations in the system at the 1 per cent level.

but unobservable costs. Although unit labour costs are a widely used proxy in the literature, we found that alternatives such as packaging and energy costs also failed to provide any evidence of a role for marketing costs. The dummy variables that were used to account for regulatory costs post-BSE are similarly crude and equally ineffective, although this may simply reflect the offsetting effect of government subsidisation and restructuring of the abattoir on prices sector (see MLC, 1999)[18].

Given the lack of data on regulatory costs, we used an alternative approach in an attempt to better locate the source of the market imperfection within the chain. This involved the use of monthly ex-abattoir beef prices produced by DEFRA that are also expressed in carcass weight equivalent terms and thus directly comparable with the producer and retail prices used in this paper. These ex-abattoir prices (loosely referred to below as 'wholesale' below) are pertinent because they reflect the *net* effect of factors such as the regulatory environment, government subsidy and sectoral re-structuring, all of which impacted on the abattoir sector during the 1990s. Moreover, since abattoirs bore the brunt of regulatory measures following BSE, they can be expected to reflect the costs associated with them (see Pooley, 1999; Maclean 2000).[19] If changes in the margin were being driven by a rise in costs in the wholesale sector, we would expect to find that wholesale prices matter in determining the retail-producer spread and hence enter the cointegrating relation for it. In turn, a price at one level would not cointegrate with a price at any other level in a pair since each pairing omits the stochastic trend of the third (excluded) price. As is shown in Table 3,

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[18] Of course, there is the possibility that unobserved marketing and/or regulatory costs might be collinear with the demand and supply shifters but uncorrelated with the proxies for costs used here. While this possibility cannot be ruled out, we do not find any evidence in support of it.

[19] The Pooley Report published the findings of an investigation into the effect of the regulatory burden following BSE. It focussed exclusively on the abattoir sector since the new rules applied to the practises and procedures used in slaughterhouses and cutting plants, rather than the transport or

cointegration tests of the three price pairings indicate that neither the retail-wholesale nor retail-producer prices cointegrate, whereas the wholesale-producer pair does at conventional levels of significance. This suggests that wholesale prices share the same stochastic trend as producer prices and that the margin between them has remained broadly constant over the period analysed.

Table 3: Cointegration Test Statistics for Price Pairs [1990(3) to 2000(12)]

$H_0 : rank(r)$	Maximal Eigenvalue	95% C.V.	Trace	95% C.V.
Retail and Wholesale Prices				
$r = 0$	9.518	14.1	10.15	15.4
$r = 1$	0.637	3.8	0.637	3.8
Retail and Producer Prices				
$r = 0$	10.66	14.1	11.59	15.4
$r = 1$	0.9324	3.8	0.9324	3.8
Wholesale and Producer Prices				
$r = 0$	18.79**	14.1	20.63**	15.4
$r = 1$	1.846	3.8	1.846	3.8

*(**) denotes significance at 5% (1%). The models include a constant but no trend since to include a trend could account for and mask the very costs we are interested in detecting. As a result, this specification is a more stringent test than a model that in includes a trend. Full details of models and results are available upon request.

In other words, this supplementary econometric evidence suggests that a *net (positive) effect* of BSE–related changes in the abattoir sector cannot be discerned in wholesale prices and thus it is unlikely to account for growth in the retail-farm price margin observed in this period. The overall implication of this is that because ex-abattoir and farm gate prices behave similarly (in that they cointegrate) they may be used

packaging of beef (see Pooley, 1999, p.11). A follow-up report by the Meat Inspection Charges Taskforce (Maclean Report, 2000) was similarly focussed.

interchangeably for the purpose of the analysis of shocks.[20] These findings are also relevant for interpreting the role of market power since they suggest that it is market power at the retail stage that matters, not at the wholesale stage. If market power was exercised in wholesaling, then we should observe a change in both the retail-wholesale and wholesale-farm margins in the presence of the BSE shocks. As noted, the evidence does not support this.

5.4 Impulse response analysis

Given that the presence of market power was detected through the significance of the shifters, the next step was to examine the specific effects of each shock on beef prices[21]. Prior to reporting the results from this exercise, it is worthwhile to note that so far it has been assumed that all prices and shifters are potentially endogenous. If the shifters are actually exogenous for the estimation of the long-run parameters, estimation efficiency may be improved if they are treated accordingly (Pesaran *et al*, 2000). While it is clear that shocks to the shifters are logically prior to the prices and hence contemporaneously causal for them, the issue of long-run weak exogeneity is largely an empirical issue. It is conceivable that the evolution of prices feeds back on to the shifters, affecting trade (the supply shifter) or the topicality of media interest in health and safety issues (the demand shifter). Using the restricted model given by (18)

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[20] Replacing producer prices with wholesale prices in the model produces results that are almost identical, both in terms of the cointegration and impulse response analyses, as indeed would be expected if their stochastic trends were the same. Results of this analysis are available upon request.

[21] There may of course be other aspects of price transmission that characterise the change in prices, including the possibility of asymmetric adjustment, price levelling and threshold adjustment. Some of these have been considered elsewhere (Lloyd *et al*. 2001). However, given the focus of this paper and the nature of the shocks we are considering, these additional features do not shed any additional light on the presence of imperfect competition on the retail-farm level margin and how it may impact on price adjustment when the demand and supply side shocks are unidirectional and of significant size.

and (19), the null of weak exogeneity is firmly rejected for each shifter confirming the endogeneity of the shifters in the system.[22]

The generalised impulse response function developed by Koop *et al*. (1996.) and 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. Given the discussion in section 4, we treat the shocks to the shifters as contemporaneously causal for meat prices and Figure 3 shows the simulated effect of a shock of typical size (one standard error, or 79 per cent of 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) Shocks to the Meat Scares Index (about here)

There are two obvious outcomes from the impact on prices following the food scare. First, shocks to the meat scares index lead 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 per cent (1.20 p/kg) and 1.8 per cent (4.85 p/kg) respectively, while retail beef prices fall by around 0.3 per cent (0.70p/kg) following a one standard error shock. This would seem to imply that following the BSE scare, consumers reduced

[22] For each shifter (*i*), the null of weak exogeneity is tested using a likelihood ratio statistic proposed by Johansen (1992) of the restrictions $\alpha_{i,1} = \alpha_{i,2} = 0$. The resulting $\chi^2(2)$ test statistics (of 26.9 and

their demand for beef, but increase demand for substitute meats, a result consistent with findings for Dutch consumers (see Mangen and Burrell, 2001). 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 cointegrating regressions.[23] 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. a one standard error, –6,458 tonne) 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 the results in (19) that market power will affect the retail-farm spread. If market

22.0) reject the null at the 1 per cent level confirming their endogeneity to the long-run parameters in β. We would like to thank a referee for seeking clarification on this point.

[23] 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).

power did not matter, the demand shock would not have a differential effect on farm and retail prices (see equation 9)[24].

Figure 4: The Simulated Dynamic Effect of a (one standard error) Fall in Net Withdrawals (about here)

6. Summary and Conclusions

This paper has focussed on the impact of BSE in the UK beef market on prices at the retail and producer levels. Specifically, it was motivated by the public concern 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's Competition Commission. We have shown formally that if market power exists, then exogenous shocks to the retail demand and/or farm supply functions will have an effect on the retail-farm price margin. In the absence of market power, the margin is determined solely by marketing costs and thus the significance of the exogenous shocks becomes our test for the existence of retail market power.

The empirical results confirm that shocks to the retail demand and farm supply functions affected the retail-farm margin, suggesting the existence of retail market power. While our results do not identify the extent of market power, nor whether oligopoly dominates oligopsony, they do confirm the findings of the UK's

[24] To put these price transmission elasticities in context, with perfect competition the 'pass-through' elasticity should equal the share of the raw commodity in the industry cost function while the 'pass-back' elasticity should reflect the reciprocal of the share of the raw commodity in the industry cost function. Under fairly reasonable assumptions, imperfect competition serves to reduce the pass-through elasticity while increasing the pass-back elasticity.

Competition Commission investigation, namely that market power was being exercised. We also show that, as a consequence of the BSE crisis, producer prices fell by more than twice that of retail prices.

No evidence was found that the widening margin could be attributed to regulatory costs associated with the BSE crisis or other marketing costs, although future work that has access to better and more specific data may qualify this conclusion. Notwithstanding this caveat, the overall implication of the analysis 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, shocks such as the BSE crisis will also give rise to distributional effects between the retail and farm sectors.

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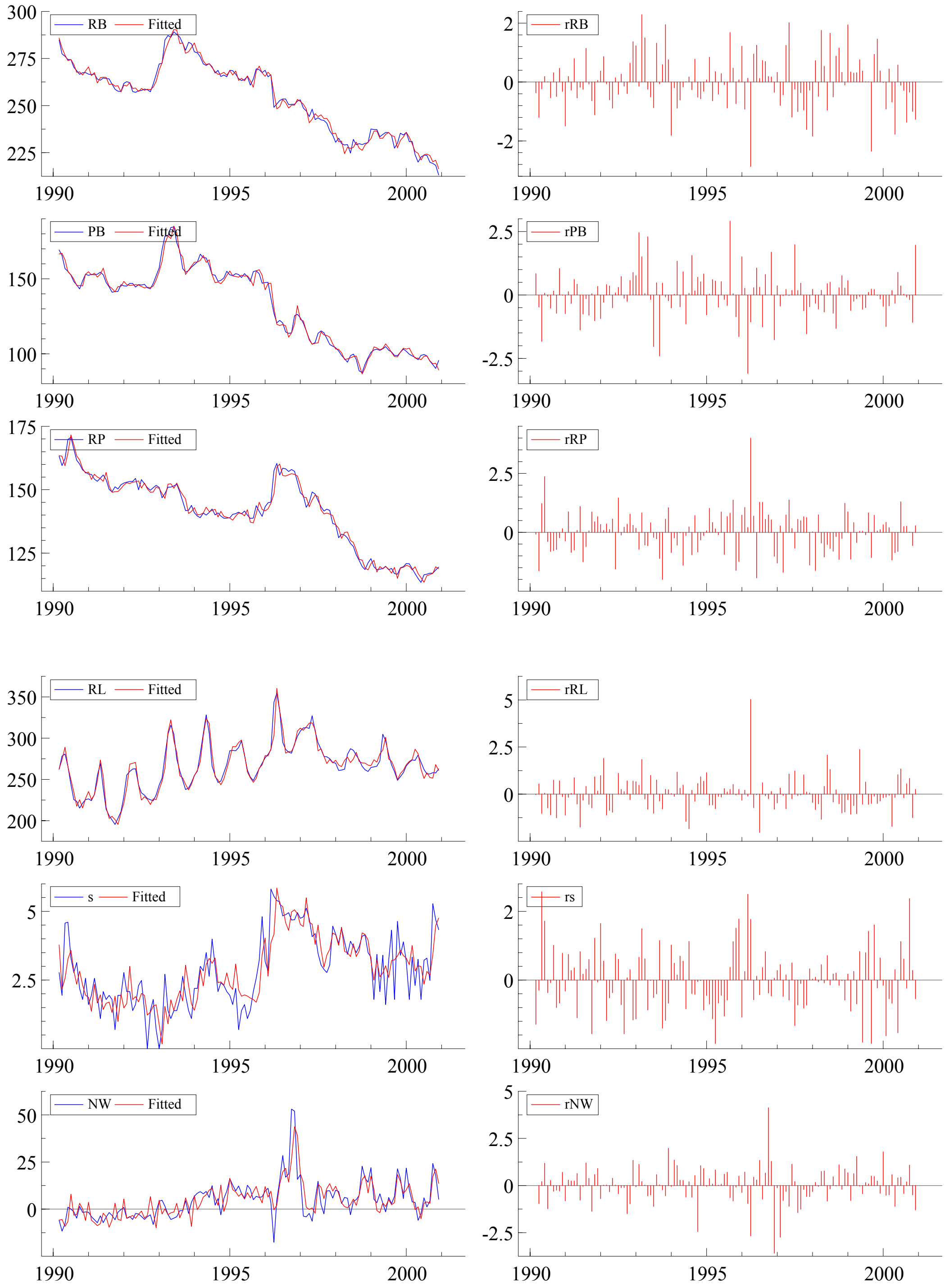
Appendix : Plots of the VAR(2) model (unrestricted constant and seasonals)

(a) Actual and Fitted values (b) Scaled Residuals



(c) Residuals from all potential co-integrating vectors

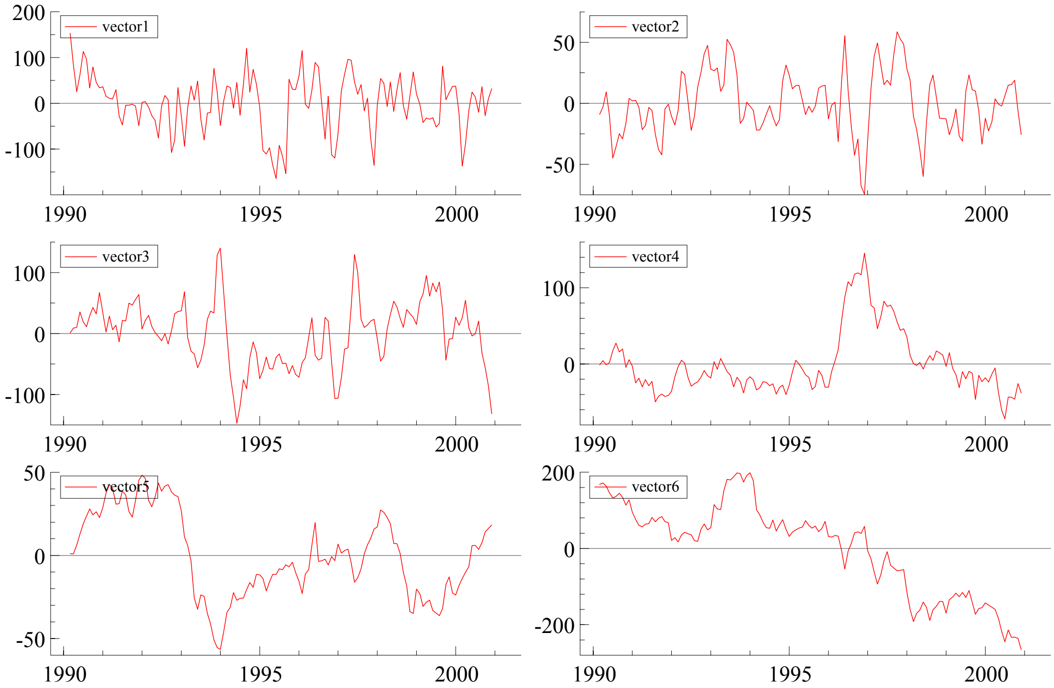


Figure 1: The Newspaper count (January 1990 to December 2000)

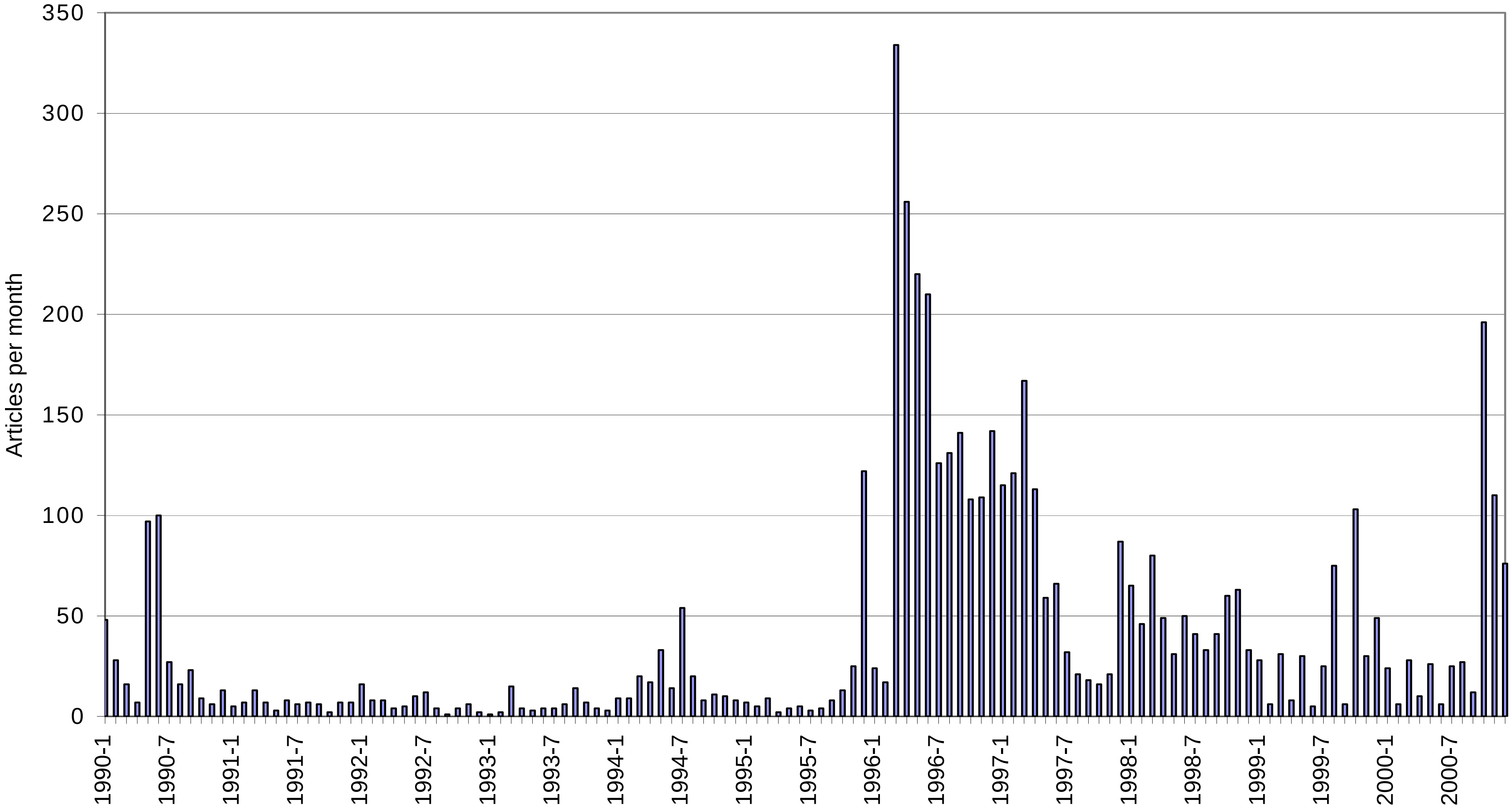


Figure 2 : Net Withdrawals from the UK Beef Sector (1990-2000)

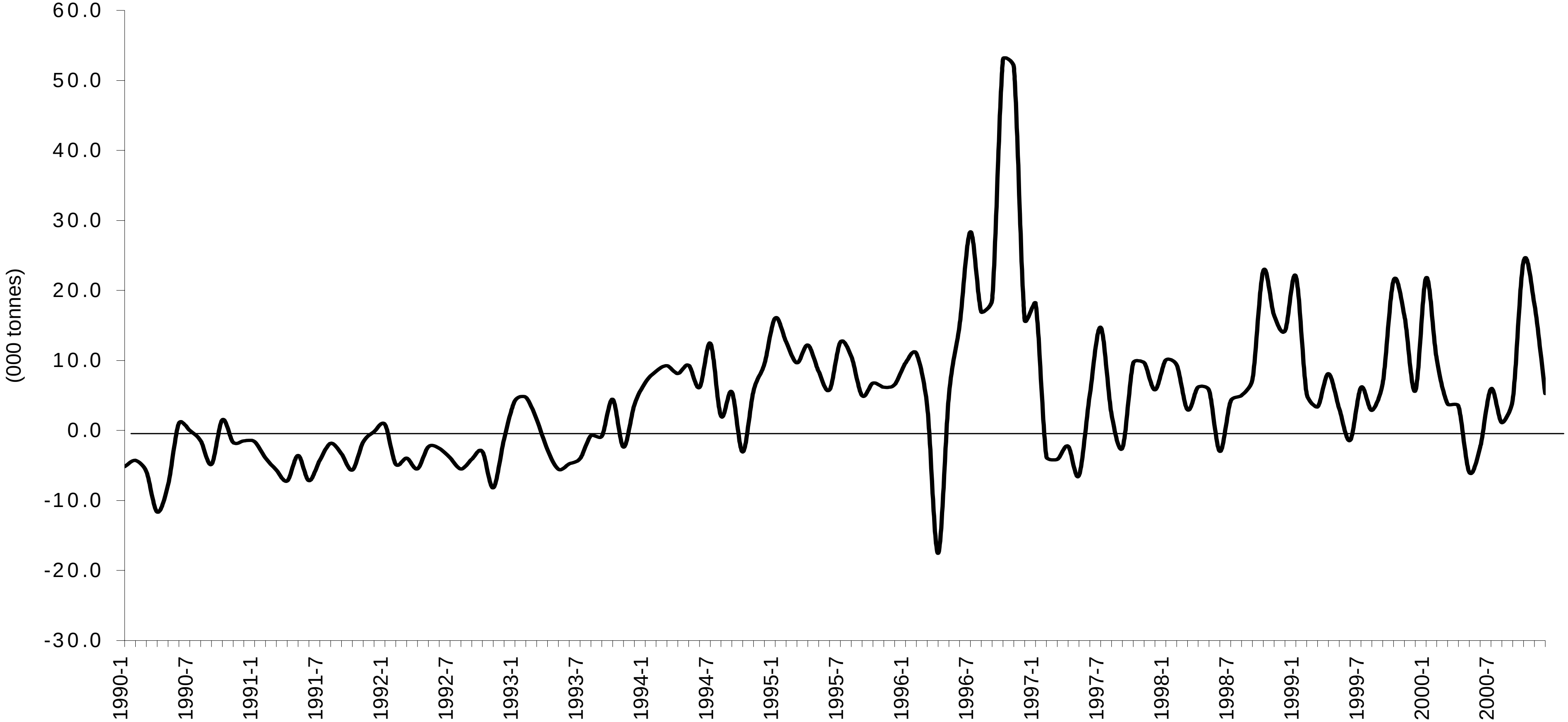


Figure 3: The Simulated Dynamic Effect of a (one standard error) Shock to the Meat Scares Index

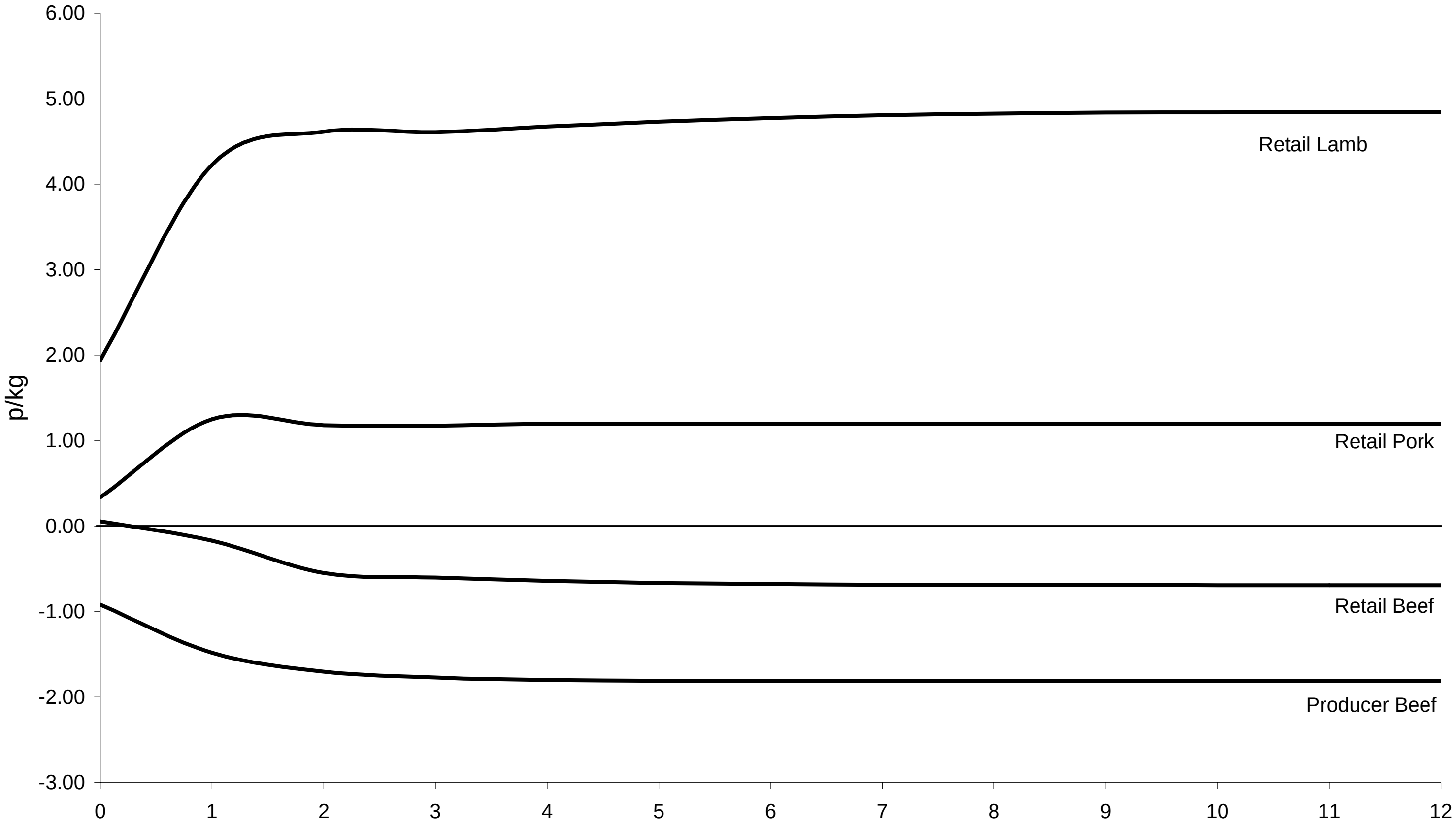


Figure 4: The Simulated Dynamic Effect of a (one standard error) Fall in Net Withdrawals