ELSEVIER

Agricultural Economics 25 (2001) 347–357

AGRICULTURAL ECONOMICS

www.elsevier.com/locate/agecon

The impact of food scares on price adjustment in the UK beef market

Tim Lloyd [a,*], S. McCorriston [b], C.W. Morgan [a], A.J. Rayner [a]

[a] *School of Economics, University of Nottingham, Nottingham NG7 2RD, UK*
[b] *School of Management and Business, University of Exeter, Exeter, UK*

Abstract

This paper considers the impact of 'food scares', predominately concerns relating to BSE, on UK beef prices at retail, wholesale and producer levels over the 1990s. Acknowledging the co-movement that exists between prices in the meat marketing chain, we use a co-integrating framework, the results of which show the importance of publicity regarding the safety of food in the transmission of beef prices in the UK. The 'food publicity' index that we use has a marked negative impact on the prices at all levels, a result that is consistent with the effect of an inward shift in the demand function. Moreover, the extent of price decline varies between the marketing stages entailing that the price spreads rise in response to an increase in the (negative) publicity about food safety. While not a formal test of market power, these observations are consistent with recent theoretical results demonstrating that market power exacerbates price changes in the upstream sectors for a given change in the retail demand function. The implication of these varying price changes is that the food safety concerns also cause the marketing margins between the stages to widen. The UK's Competition Commission has recently investigated the abuse of market power in the food sector, inspired largely by this specific issue.

JEL classification: C32; I10; Q11

Keywords: Food scares; Food publicity index; Beef prices; BSE; Price adjustment

1. Introduction

In recent years, issues relating to food safety have risen to the top of the political agenda in many countries, particularly in Europe and North America. Much of this agenda has related to the increased awareness over health, changing dietary patterns and the differences in standards between the countries that lie at the heart of trade disputes. However, perhaps the most notable feature of the increased public reaction to food safety is the issue of 'food scares'. This is particularly the case in Europe, and is exemplified by the outbreak of BSE in the UK, which according to estimates (DTZ Pieda Consulting, 1998) saw beef consumption fall temporarily by 40%, not only in the UK itself, but also in countries such as Germany and Italy which had no reported cases of BSE (at the time).

To some extent, the academic literature has responded by paying greater attention to food safety concerns. This has essentially focused on two themes. The first has been to re-visit food demand studies taking into account health-driven changes in dietary patterns. Examples include Brown and Schrader (1990), Burton and Young (1996), Kinnucan et al. (1997) and Rickertsen and von Cramon-Taubadel (2000) among others. The other main theme in the food safety

* Corresponding author. Tel.: +44-115-951-5474; fax: +44-115-951-4159.
E-mail address: tim.lloyd@nottingham.ac.uk (T. Lloyd).

0169-5150/01/$ – see front matter
PII: S0169-5150(01)00091-3

literature has been to focus on the appropriate regulatory structure for dealing with food safety concerns (see, for example, the symposia published in the *American Journal of Agricultural Economics*, December 1997). However, to the best of our knowledge, the literature has not addressed the impact of food scares on the prices at different stages of the marketing chain. This is the focus of the present paper which studies the nature of price adjustment in the UK beef market in response to the outbreak, increased awareness and likely effects of BSE. An important feature of the paper is that we consider price adjustment at three stages (retail, wholesale and producer) of the beef marketing chain. By doing so, we highlight not only the impact of price adjustment but also the effect of food scares on price spreads. Our data show that prices have fallen at all levels in the 1990s but that spreads have not remained constant. Specifically, whereas retail prices have fallen by 18%, wholesale and producer prices have fallen by around 40% each. During this period all spreads have been observed to grow, but the retail–wholesale spread has grown five times more than the wholesale–producer spread. While this price decline is unsurprising in the face of heightened consumer awareness, the change in spreads is perhaps less obvious. However, as McCorriston et al. (1998) show, this result is consistent with the outcome of the model of vertical markets in which a shock to retail demand passes through a chain characterised by a price transmission elasticity that is greater than unity. The value of the elasticity depends on a host of factors, one of which is the degree of market power.

In this paper, we present casual observations of the data before exploring econometrically the relationships between prices along the UK's meat chain, which are shown to be dependent on the publicity given to issues of food safety. To incorporate this empirically, we employ a newly developed measure, the 'food publicity' index.

The nature and timing of this research is apt. There has been debate in the UK relating to the (casual) observation that price changes at the retail stage were smaller than those occurring at the farm level. This was a principal motivation for the recent Competition Commission inquiry, which among the other things investigated the market power in the UK food sector with a particular emphasis on the vertical relationships. While we present no formal model of the market structure in this paper, McCorriston et al. (1998, 1999) have shown that when the markets are imperfectly competitive, price adjustment will vary between the sectors.

Both demand and supply effects are likely to have influenced the pattern of price changes in the beef sector over the 1990s. Most obviously, the BSE crisis is likely to have caused shifts in the retail demand function for beef, which will have had an impact on the upstream prices. However, the cost side effects may also be pertinent given new meat sector regulations. These have been introduced to reassure consumers of the safety of British beef in the aftermath of the crisis and are likely to have increased costs. For example, higher charges for the Meat Hygiene Service and Specified Risk Material (SRM) disposal, reduced subsidies for rendering and increased transactions costs are widely held to have arisen from the BSE crisis (Meat and Livestock Commission, 1999). Costs have also increased due to the greater use of Controlled Atmosphere Packaging (CAP). However, in the absence of reliable estimates the impact of these changes is difficult to verify, not least because partial compensation was received by many of those affected. [1] Clearly, in considering the impact of food scares on the UK beef sector, there are likely to be both demand and supply factors determining prices at each vertical stage. However, as discussed in the following section, it should not necessarily be expected that these exogenous factors should have a symmetric impact on prices (and hence price spreads) throughout the marketing chain. More specifically, while the rising costs due to tighter regulatory standards will lead to a decrease in price spreads, the shift of the retail demand function will lead to an increase in price spreads. Moreover, even if the shift factors are equi-proportionate, these effects will not cancel out, with the retail demand shifts dominating the impact of the regulatory standards.

The paper is organised as follows. In Section 2, we briefly survey both the theoretical and empirical literature relating to price adjustment in the vertically related markets. This suggests that even though the prices change in the same direction, the extent of the price changes vary according to the retail stage and hence marketing margins will change. In the case

[1] For example, the Over 30-Month Scheme of compensation received by abattoirs (DTZ Pieda Consulting, 1998).

studied here, marketing margins are expected to increase even if the marketing costs and the retail demand curve shift to the same extent. This notwithstanding, the nature of the data relating to food scares would suggest that demand shifts are likely to dominate. Section 3 presents the data and in Section 4 we discuss the framework for the empirical analysis. Acknowledging the co-movement of beef prices at all stages of the chain, we adopt a co-integration framework for the empirical analysis, the results of which are reported in Section 5. These show that beef prices do not co-integrate without the inclusion of a measure of food safety publicity — the food publicity index. The negative impact of the index differs according to the marketing level and may account for the growing price spreads observed empirically. Section 6 concludes by highlighting issues relating to the on-going research.

2. Price adjustment: theoretical and empirical issues

2.1. Theoretical issues

In the agricultural economics literature, the most popular framework for considering the impact of exogenous shocks to the food sector is in the context of the equilibrium displacement models originating with Gardner (1975). The basis of this framework is to consider the impact of price adjustment (and corresponding welfare effects) at different stages of the marketing chain and how the farm-retail spread may change as a consequence. An important feature of the Gardner framework relates to the source of the exogenous shocks. In particular, a demand-side shock directly affecting, say, the retail sector, may have a different effect on retail and farm prices than a supply-side shock originating at the farm sector.

However, one important criticism of the standard equilibrium displacement framework is that it assumes that the downstream food market is perfectly competitive. There is increasing evidence that this is not an appropriate characterisation of the food sector in many developed countries. For example, Bhuyan and Lopez (1997) measure market power across 40 sub-sectors of the US food industry and find that in all but three cases, the null hypothesis of competitive behaviour can be rejected. Although studies of the food sector in other developed countries are generally lacking, high levels of concentration at least suggest that similar phenomena characterise the food sector in most European countries. Moreover, the recent investigation by the UK Competition Commission clearly reinforces the suspicion that market power is a feature of the food sector in the UK.

What difference does this make to our understanding of price adjustment? A number of studies from the industrial organisation literature have shown that imperfect competition has a considerable impact on price adjustment. Specifically, under 'reasonable' conditions, for a supply shock, price transmission is reduced if the downstream sector is characterised by market power. Recently, McCorriston et al. (1998) introduce market power into the Gardner framework; they show that for an increase in costs at the farm level, market power in the downstream food sector will reduce the level of price adjustment compared with the competitive benchmark. The implication is that in the presence of a supply shock at the farm level, the model predicts a narrowing of price spreads. The same holds true for a shift in the marketing services supply function which captures the increase in costs due to tighter regulatory standards. Under imperfect competition, an increase in the input costs causes retail prices to rise but this increase is proportionately less than the increase in input costs. Consequently, price spreads should narrow where processing costs increase.

However, this still leaves open the issue of the source of the exogenous shock. As highlighted above, distinguishing between a demand and cost shock matters. McCorriston et al. (1999) also consider this issue and label price adjustment due to a demand shock affecting the retail sector as a 'pass-back' effect. They show formally that for an inward shift in the demand function, market power in the downstream food sector will increase the magnitude of the price changes occurring upstream compared to the competitive benchmark. In other words, price changes at the farm level will be greater than those occurring at the retail level for a given shift in the retail demand function. The implication is that price spreads should widen following such a demand shock. Given that the meat sector was likely to be subject to both sources of exogenous change over the 1990s, the impact on prices at each vertical stage (and, by extension, the development of

price spreads) will be the net outcome of both sources of exogenous shocks to the beef sector. Moreover, even if marketing costs and the demand curve shifted by equal amounts, the shift in the retail demand function should dominate the impact of the rise in the costs associated with tighter regulatory standards. Thus, unless the extent of marketing cost increases was significantly greater than the direct effect of the food scares (which is unlikely to be the case), a priori we should expect to observe a widening of price spreads over this period in the presence of market power.

2.2. Empirical issues

A growing number of studies focus on the empirical aspects of price adjustment in the agricultural and related markets. Owing to the apparent co-movement in prices, many of these recent studies apply a co-integration methodology since it, (a) accounts appropriately for the time-series properties of the data and, (b) measures the short-run and long-run nature of price adjustment. Examples of such studies include von Cramon-Taubadel (1998), Chang and Griffith (1998) and Goodwin and Holt (1999) among others. The latter two papers differ from the earlier literature in that they focus on multiple stages of the marketing chain by separately identifying price adjustment at the farm, wholesale and retail levels, a practice that is also followed in this paper. However, in most cases, these empirical studies confine the sources of price adjustment to be 'within' the food chain. Exogenous influences, apart from a time trend or a given structural break, are not accounted for.

In summary, investigating the impact of food scares, it is important to recognise that this type of exogenous shock represents primarily a demand-side shift to the food sector. As a result, it is reasonable to expect price adjustment in the upstream stages of the marketing chain. However, the extent of these price changes will vary between the stages if the downstream sectors are characterised by imperfect competition. Although the analysis of price adjustment is not a formal test of market power, higher levels of price adjustment in the upstream stages are certainly consistent with it. If the extent of price changes between each marketing stage varies, this implies that the price spreads (or marketing margin) will also change. Where prices are non-stationary and potentially exhibit co-movement, a co-integration framework offers an appropriate methodology for considering the extent of price adjustment. The data and the role of food scares on the beef market are outlined in the next section.

3. Data issues and 'food scares'

We employ real beef prices at the producer, wholesaler and retailer level (P_t, W_t and R_t, respectively) in England and Wales. The data have been calculated by the Meat and Livestock Commission and represent carcass weight equivalents (CWE) to facilitate direct comparison of prices at all the three stages. The data are monthly and cover the period from January 1990 to December 1998 (see Figs. 1 and 2).[2] They are deflated by the Retail Price Index (January 1999 base) and clearly show a declining trend over the period. Retail prices fell by 60 pence/kg, wholesale prices by 69 pence/kg and producer prices by 75 pence/kg over the period. Casual inspection of Fig. 1 also reveals that prices have a tendency to co-move, in that price movements at one level of the chain seem to be reflected in prices elsewhere in the chain.

These price series are supplemented by a 'food publicity index', which is a count of the number of articles printed in broad-sheet newspapers on a monthly basis that relate to the safety of meat. In general, these reports are negative in nature and reflect the concerns regarding the safety of meat, in terms of its production and processing. Articles relating to BSE dominate the index although other similar topics such as health standards in abattoirs are also covered. The index reflects consumer concerns regarding the safety aspects of meat consumption and also the impact of regulation on the suppliers of meat. Consequently, the index will be correlated with the developments that affect both the demand and supply of beef, though it is likely to be the food scares issue that dominates given the public furore over BSE. In the empirical analysis, the natural log of this index (denoted i_t) is used. A plot of the series is shown in Fig. 3. Augmented Dickey–Fuller tests indicate that each price series and i_t are integrated of order 1 [$I(1)$], as visual inspection of Figs. 1 and 3 suggests.

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

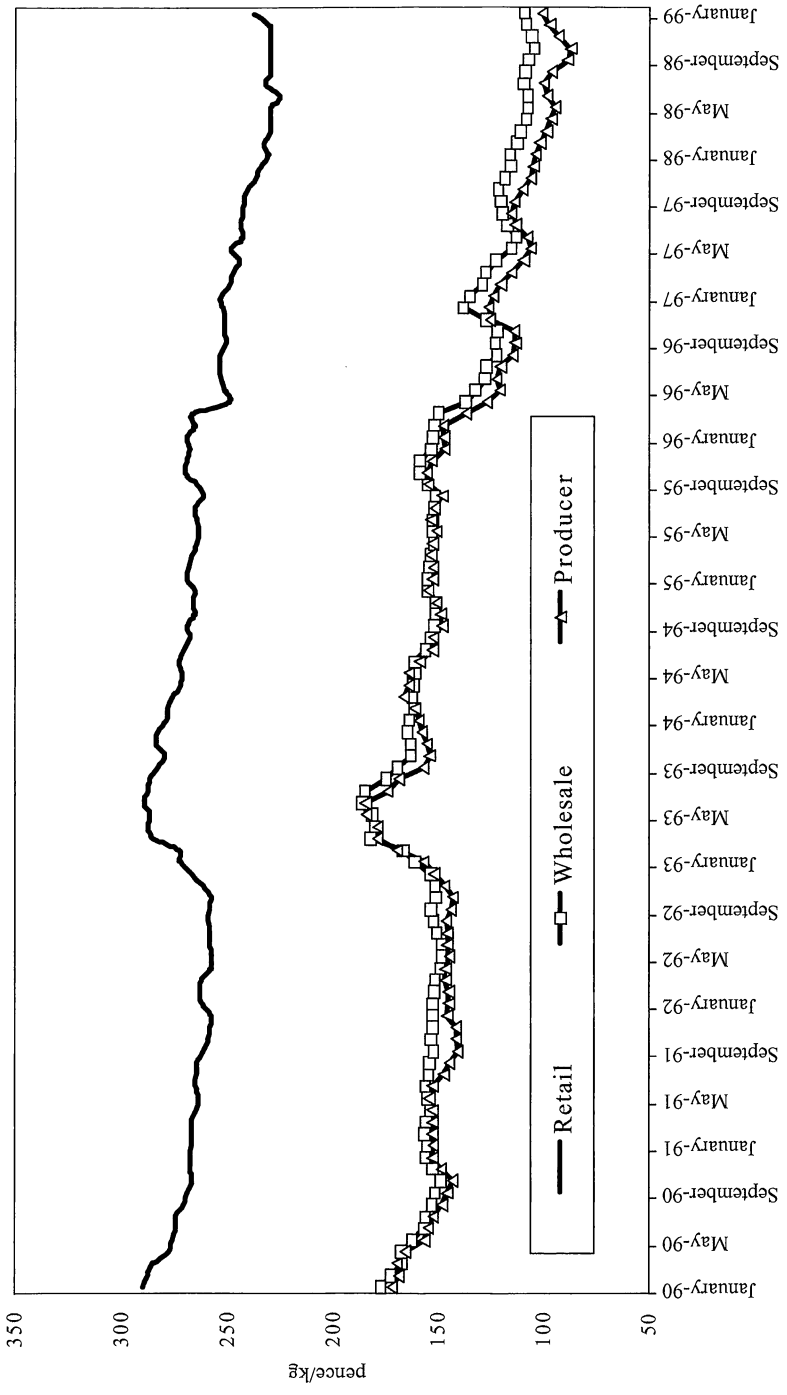

Fig. 1. Monthly UK beef prices, 1990–1998 (pence/kg).

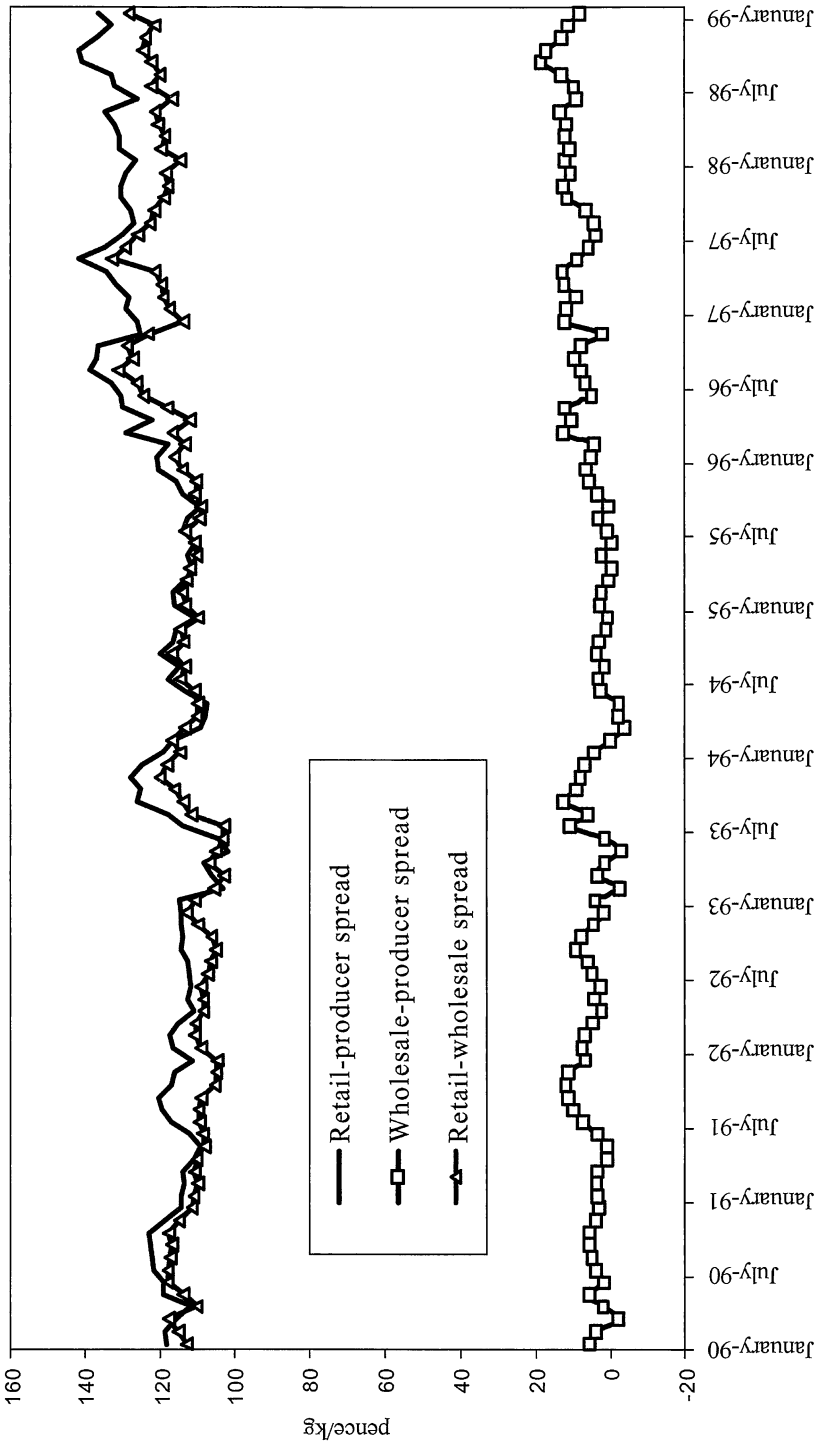

Fig. 2. Monthly UK beef price spreads, 1990–1998 (pence/kg).

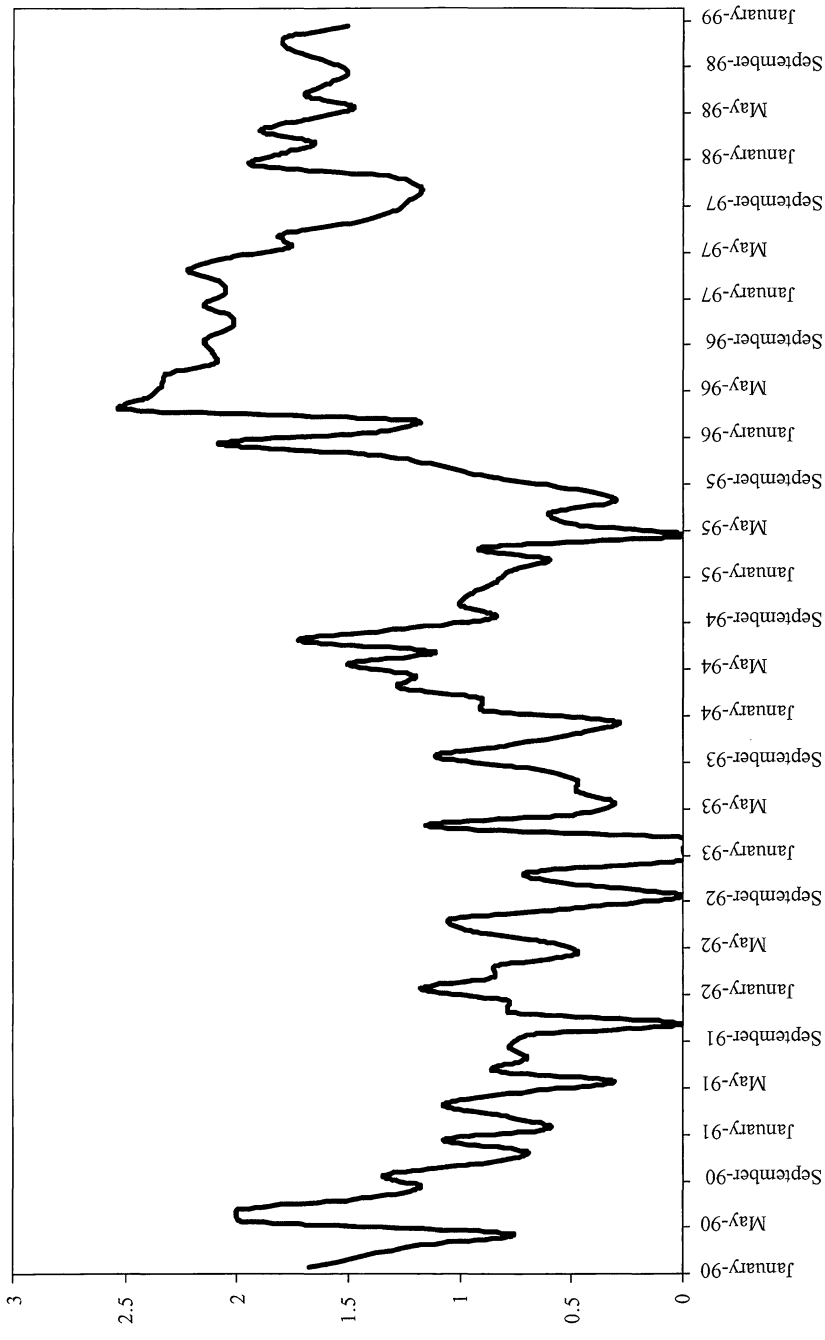

Fig. 3. The food publicity index, 1990–1998 (in logarithms).

4. Methodology

The formal analysis is conducted in a vector autoregressive (VAR) framework to exploit the properties of integration and co-integration that may exist in the data. VAR methods offer a tractable framework for the investigation of dynamic relations, particularly when the variables are co-integrated. Consider a VAR(k) model,

$$\boldsymbol{x}_t = \Pi_1 \boldsymbol{x}_{t-1} + \cdots + \Pi_k \boldsymbol{x}_{t-k} + \boldsymbol{e}_t$$
$$\boldsymbol{e}_t \sim \text{n.i.d.}(0, \Sigma) \quad (1)$$

where $\boldsymbol{x}_t$ is a $(n \times 1)$ vector of $I(1)$ variables, each Π_i $(i = 1, \ldots, k)$ is an $(n \times n)$ matrix of coefficients to be estimated using a $(t = 1, \ldots, T)$ sample of data and $\boldsymbol{e}_t$ is a $(n \times 1)$ vector of errors with a non-diagonal covariance matrix. The order (k) of the VAR is also determined by the data, and here we adopt the Schwarz Information Criterion (SIC) for this purpose.

Co-integration is evaluated using methods developed by Johansen (1988). Following Stock and Watson (1988), it is well known that with n variables there can be at the most $n - 1$ co-integrating relations and $n - r$ common trends in the system. Therefore, with a triplet of prices, there can be at the most two such co-integrating combinations, since if any two pairs of prices co-move (co-integrate) then so must the third. In this case, the prices share a single common trend and may be expected to co-move over time.

Given the difficulties that can be encountered interpreting the coefficients of multiple co-integrating vectors (Lütkepohl and Reimers, 1992) impulse response functions are commonly calculated to evaluate the time path of the variables in $\boldsymbol{x}_t$ to exogenous shocks in such circumstances. The simulated time paths are found by imposing a recursive structure on the moving average representation of the VAR and represent the time path of the variable i with respect to a unit shock to the variable j, s periods ago, all other variables at the time of the shock (and earlier) held constant. Since our principal interest is in the effect of health information on prices, orthogonalised impulses are adopted here given that in the current application changes in the food publicity index are likely to drive price changes and not vice versa. Given that prices at all stages of the marketing chain may respond in unison to such shocks, this orthogonalisation is advantageous since it incorporates any contemporaneous correlation in $\boldsymbol{e}_t$ arising from shocks to the food publicity index.

Table 1
Co-integration test results

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

[a] Denotes rejection of H_0 at the 5% significance level.
[b] Denotes rejection of H_0 at the 1% significance level. Critical values (CV) are those tabulated by Osterwald-Lenum (1992).

5. Results

As an initial step, Eq. (1) is estimated for the price triplet (R_t, W_t and P_t). An unrestricted VAR(12) model, augmented by four impulse dummy variables [3] gives a good approximation, such that residuals conform to the stated assumptions of $\boldsymbol{e}_t$ in (1).

Given that prices are $I(1)$, the model is examined for the presence of co-integration implied by the co-movement of prices apparent in Fig. 1. Panel (a) of Table 1 reports the co-integration test statistics for this model.

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

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

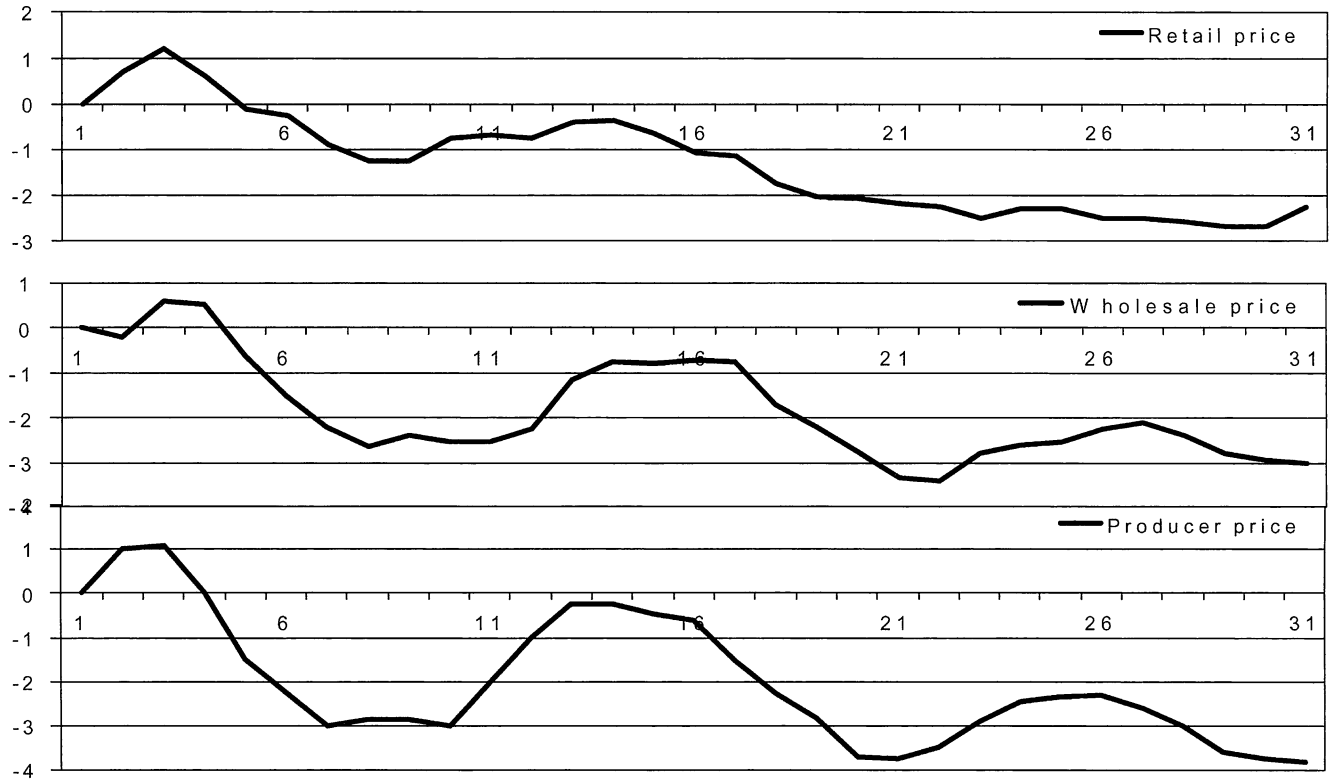

Fig. 4. Response of beef prices to a 1% shock in the food publicity index.

sion, the impact of BSE and related health concerns on price movements.

Augmenting the price transmission model with (the natural logarithm of) the food publicity index i_t has a marked effect on inference. As the results in Panel (b) of Table 1 show, evidence in favour of co-integration is now much stronger: the trace and maximal eigenvalue test statistics now reject the null of no co-integration at the 1% significance level. Moreover, both tests suggest the presence of three co-integrating vectors, a result consistent with pair-wise co-movement (in combination with the food scares variable).[4] The clear conclusion of the co-integration analysis is that the food publicity index plays a key role in the long-run evolution of the UK beef prices and that once the effect of the index is taken into account, prices co-move in a manner consistent with market integration.

The above result begs a number of questions, not least those relating to the precise role that the food publicity index plays in price formation. To investigate this issue, Fig. 4 shows the orthogonalised impulse response functions of the three beef prices to a unit (1%) shock in the food publicity index. These indicate that the heightened publicity regarding food safety initially increases beef prices at all stages of the marketing chain, but that thereafter, they fall. The long-run effect is negative on all beef prices, with the estimates suggesting that retail, wholesale and producer prices fall by 1.70, 2.25 and 3.0 pence/kg, respectively. This corresponds to a food publicity elasticity of around 1.4.[5]

As an adjunct to these results, forecast error decompositions may also be calculated. These estimate the proportion of the total variance of each of the prices that is due to an orthogonalised shock measured at specific intervals following this shock (Hamilton, 1994). The results suggest that the effects on prices stabilise some 30 months following a shock to the index which accounts for approximately 6, 11 and 61% of the variation in the retail, wholesale and producer prices, respectively.

[4] Using the finite sample correction to the asymptotic critical values suggested by Reimers (1992) does not change this conclusion, although the *P*-values of the test are correspondingly larger. Specifically, whilst the null of no cointegration cannot be rejected at the 10% level in panel (a), it is rejected in panel (b) at this level.

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

The results demonstrate two features: (1) That the UK beef prices were responsive to the public's awareness of food safety issues (principally BSE) in the 1990s but (2) that the impact was not common across stages in the marketing chain. This second point suggests that price spreads also move systematically in response to publicity about the safety of food. Shocks to the food publicity index cause the wholesale–producer price spreads to expand more than the retail–wholesale price spreads. Moreover, the difference between retail and producer prices, the measure that receives most attention in the public debate on this issue, rises by an even larger amount in response to BSE publicity. Specifically, a 1% increase in the food publicity index induces a 0.5 pence/kg increase in the retail–wholesale spread, 0.75 pence/kg increase in the wholesale–producer spread and thus a 1.25 pence/kg increase in the retail–producer spread. Given that the media interest has generally risen over the sample period, price spreads are observed to rise over time.

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

6. Conclusions

This paper has focussed on the impact of publicity, predominately concerns relating to BSE, on price transmission in the UK beef sector during the 1990s. Acknowledging the co-movement that exists between prices in the meat marketing chain, we use a co-integrating framework, the results of which show the importance of information, as embodied in a food publicity index, in price transmission. Prices at all levels have tended to decrease during the 1990s, a result that is consistent with inward shifts of the

demand function. Perhaps more interesting is that the extent of price adjustment varies between marketing stages. In particular, prices at the retail (wholesale) level decline but less so than prices at the wholesale (farm) level. While supply side shocks may also have been apparent in the UK beef sector over the 1990s due to increased regulation, the fact that widening margins are observed suggests the dominance of demand-side shifts in a market that does not correspond to a perfectly competitive model. Although the results presented in this paper do not constitute a formal test of market power, they lend support to the UK's Competition Commission investigation into the degree of market power in the food sector. A more formal test for market power in vertically integrated markets is the subject of our on-going research.

Acknowledgements

The authors acknowledge the financial assistance of the Ministry of Agriculture, Fisheries and Food of the United Kingdom. The views expressed are those of the authors and are not attributable to MAFF. We would also like to thank David Colman for useful comments on a previous version of this paper.

References

Bhuyan, S., Lopez, R.A., 1997. Oligopoly power in the food and tobacco industries. Am. J. Agric. Econ. 79, 1035–1043.

Brown, D., Schrader, L., 1990. Cholesterol information and shell egg consumption. Am. J. Agric. Econ. 72, 548–555.

Burton, M., Young, T., 1996. The impact of BSE on the demand for beef and other meats in Great Britain. Appl. Econ. 28, 687–693.

Chang, H., Griffith, G., 1998. Examining long-run relationships between Australian beef prices. Aus. J. Agric. Res. Econ. 42, 369–387.

DTZ Pieda Consulting, 1998. Economic impact of BSE on the UK economy. A report commissioned by the UK Agricultural Departments and HM Treasury, HMSO, London.

Gardner, B., 1975. The farm-retail spread in a competitive industry. Am. J. Agric. Econ. 57, 399–409.

Goodwin, B., Holt, M., 1999. Price transmission and asymmetric adjustment in the US beef sector. Am. J. Agric. Econ. 81, 630–637.

Hamilton, J.D., 1994. Time Series Analysis, Princeton University Press, Princeton.

Johansen, S., 1988. Statistical analysis of co-integration vectors. J. Econ. Dyn. Control 12 (2/3), 231–254.

Kinnucan, H.W., Xiao, H., Hsia, C.-H., Jackson, J.D., 1997. Effects of health information and generic advertising on US meat demand. Am. J. Agric. Econ. 79, 13–23.

Lütkepohl, H., Reimers, H.-E., 1992. Impulse response analysis of co integrated systems. J. Econ. Dyn. Control 16, 53–78.

Meat and Livestock Commission, 1999. Retail Price Spreads and Indicative Retail Price Margins for Beef, Pork and Lamb, MLC mimeo, Milton Keynes.

Ministry of Agriculture, Fisheries and Food, 1999. Report of an investigation into the relationship between producer, Wholesale and Retail Prices of Beef Lamb and Pork, MAFF, London.

McCorriston, S., Morgan, C.W., Rayner, A.J., 1998. Processing technology, market power and price transmission. J. Agric. Econ. 49, 185–201.

McCorriston, S., Morgan, C.W., Rayner, A.J., 1999. Market Structure, Demand Shifts and Pass-Back Elasticities. Mimeograph, School of Economics, University of Nottingham, Nottingham, UK.

Osterwald-Lenum, M., 1992. A note with quantiles of the asymptotic distribution of the maximum likelihood co-integration rank test statistics. Oxford Bull. Econ. Statist. 54, 461–472.

Reimers, H.-E., 1992. Comparisons of tests for multivariate cointegration, Statist. Papers, 33, 335–359.

Rickertsen, K., von Cramon-Taubadel, S., 2000. Nutrition, health and the demand for food — a European perspective, In: Symposium Paper presented at the XXIV IAAE Conference, Berlin, Germany.

Stock, J.M., Watson, M.W., 1988. Testing for common trends. J. Am. Statist. Assoc. 83, 1097–1107.

von Cramon-Taubadel, S., 1998. Estimating asymmetric price transmission with the error-correcting representation: an application to the German pork market. Eur. Rev. Agric. Econ. 25, 1–18.