# A Further Investigation into the Relationship between Producer, Wholesaler and Retailer Prices of Beef, Pork and Lamb

**A Report prepared for the Department of Environment, Food and Rural Affairs**

**by**

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# EXECUTIVE SUMMARY

This paper reports the results of an investigation into the relationship between the retailer, wholesaler and producer prices for beef, pork and lamb over the period January 1990 to December 2000 and is a follow-up to an earlier report by the same authors (Lloyd *et al*, 1999).

The premise of this follow-up report was to consider the relationship between prices in the meat marketing system for beef, pork and lamb following the conclusion of the Competition Commission's enquiry into the UK food retailing sector. Specifically, there was the issue of whether the relationships between prices at various stages in the meat marketing chains that were identified in the previous report continued to hold. Being based on data covering the period January 1990 to December 1998, it was clear that the previous report would have little to say about the relationship between prices in each marketing chain following the conclusion of the Competition Commission's investigation. With two additional years of monthly data, we are now in a position to address this issue more thoroughly. As a result, an analysis of structural change in price transmission forms a significant component of the new report.

## Principal Results

Table 1 gives an overview of the results but here we can summarise the main results of this report as follows:

1. **Price transmission is higher in the long-run than in the short-run for all species**

   Allowing for lags in adjustment, price transmission is higher in the long-run than in the short-run. This indicates that UK meat markets are highly integrated.

2. **Price Transmission is incomplete or 'imperfect' in the short –run**

   Price signals are not transmitted instantaneously along the marketing chain. In general, one-quarter to one-third of a price change is transmitted to other levels of the chain one month following the change. So-called 'sticky prices' arise in many markets and may be due to a number of factors such as the nature of contracts at different stages of the chain, market structure or simply menu cost effects.

3. **The adjustment period is around 4 months**

   Results show that adjustment period before the price impact is fully reflected in the long-run change varies according to species which might arise from the specific characteristics of each meat marketing chain and/or different production schedules associated with each, particularly lamb which contains a larger seasonal component.

4. **There is evidence of asymmetric price adjustment between retail and producer prices in the beef and lamb sectors but not in the pork sector.**

   Retail prices are found to respond quicker to price increases than price declines in the beef and lamb sectors. There is no evidence of such asymmetry in the pork sector.

5. **BSE and other food scares appear to have played a marked role in the determination of meat prices at all marketing levels in the 1990s**

   Meat markets in the UK have been significantly affected by the BSE crisis and other food scares particularly from the mid-1990s onwards. This was an event which affected the demand for meat and correspondingly prices in each marketing chain. We have investigated this issue. The measure used to account for the BSE crisis was the Press Stories Index which was found to impact negatively on the price of beef and positively on the price of pork at all marketing levels. Lamb appears to give mixed results in that while producer and retailer prices rise with the index, wholesaler prices fall, a feature that might reflect the quality of wholesale price data. Moreover, the impact of meat scares was greater on producer prices than retail prices in all three sectors.

6. **Structural Breaks**

   We also investigated the possibility of structural breaks in the price data. There are two potential structural breaks: the announcement of the potential link between BSE and variant CJD in 1996 and the investigation by the Office of Fair Trading and subsequently the Competition Commission into the food retailing sector from 1998 onwards. The evidence suggests that structural breaks can be detected mainly for the 1998 onwards period.

7. **There is some evidence of levelling in price behaviour but no strong evidence of averaging in the setting of retail prices.**

**Table 1: Summary of Key Results**

| | **Beef** | | **Pork** | | **Lamb** | |
|---|---|---|---|---|---|---|
| Long run Price Transmission (Producer to Retailer) | Higher than short-run impact | | Higher than short-run impact | | Higher than short-run impact | |
| Short run Price Transmission (Producer to Retailer) | Imperfect | | Imperfect | | Imperfect | |
| Adjustment period | 3 months | | 4 months | | 6 months | |
| Levelling | Retail<br>Wholesale<br>Producer | Yes<br>Yes<br>No | Retail<br>Wholesale<br>Producer | Yes<br>Yes<br>No | Retailer<br>Wholesaler<br>Producer | Yes<br>Yes<br>No |
| Averaging | Retail<br>Wholesale<br>Producer | No<br>No<br>No | Retail<br>Wholesale<br>Producer | No<br>No<br>No | Retail<br>Wholesale<br>Producer | No<br>No<br>No |
| Asymmetry | Yes (Retail only) | | No | | Yes (Retail only) | |
| Structural Break (1998) | Yes | | Yes | | Yes | |
| Structural Break (1996) | No | | No | | Yes | |

## Comparison with Previous Study

### (a) Technical Innovation

This report differs from the previous one in terms of the methodology used. The testing of the price relationships here is undertaken using all three prices together in a single "triplet" model. In the previous report, three separate "pair-wise" models were estimated for each meat market. The advantage of using the triplet is that it avoids the problems of resolving apparent inconsistencies between the pair-wise model results (i.e. comparing retailer-wholesaler and wholesaler-producer with those for the retailer-producer) and also allows a sharper focus on the producer-retailer relationship.

This new methodology also allows us to investigate the impact of shocks to each marketing chain on prices using impulse response analysis. The most obvious shock to have affected meat markets in the 1990s was the BSE crisis. The testing of the price relationships here is undertaken using all three prices together in a single "triplet" model. In the previous report, three separate "pair-wise" models were estimated for each meat market. The advantage of using the triplet is that it avoids the problems of resolving apparent inconsistencies between the pair-wise model results (i.e. comparing retailer-wholesaler and wholesaler-producer with those for the retailer-producer) and also allows a sharper focus on the producer-retailer relationship.

### (b) Comparison of Results

Table A1 in the Appendix provides a direct comparison of the results in this report with those of the last report. Specifically the following points arise:

1. Direct price transmission between the producer and retailer levels is considerably higher in the long-run compared to the short-run when holding other factors constant, a result that is consistent with the last report and is indicative of a highly integrated market. The testing of the price relationships here is undertaken using all three prices together in a single "triplet" model. In the previous report, three separate "pair-wise" models were estimated for each meat market. The advantage of using the triplet is that it avoids the problems of resolving apparent inconsistencies between the pair-wise model results (i.e. comparing retailer-wholesaler and wholesaler-producer with those for the retailer-producer) and also allows a sharper focus on the producer-retailer relationship.

2. The impact of shocks to the system are relatively strong although the extent of this impact will be influenced not just by the characteristics of each marketing but also by the characteristics of the environment of the 1990-2000 period as captured by the press stories index. These are new findings based on the use of a recently developed method of generalised impulse response analysis that can explore the dynamic response of prices to changes in other variables, which was not generally available at the time of carrying out the previous research. With impulse response analysis both short and long run responses are incorporated within the same unified framework and hence a more complete picture of price response is established. This allows us to ask a different question to the issue of price transmission in the marketing chain keeping all other factors constant. Specifically, we find that the press stories index has a marked effect on prices at all levels particularly in the beef marketing chain. Consequently, the casual

observation that meat markets would have been affected by the BSE crisis is confirmed by the impulse response analysis. The investigation of this effect was not possible using the methodology of the previous report.

3. We find strong evidence of a structural break in the relationships between prices in the meat marketing chains in the period June 1998 to December 2000 which show that there appears to be some evidence of a change in pricing behaviour in both beef and pork markets. However, the results from the lamb market are indicative of a change arising from the continuing effects of the BSE crisis rather than from any other source. These apparent changes coincide with the period of the Competition Commission report into activities of UK supermarkets but cannot necessarily be attributed to the effects of this investigation alone. With the up-dated data set we are now able to explore the issue of structural breaks in greater depth than in the previous report. In addition, we employ rolling least squares as well as dummy variables to explore structural breaks in the data. Rolling least squares estimates the price transmission coefficients based on a rolling sample of 24 observations across the sample period. In doing so, the technique provides a more systematic method of highlighting where significant changes in behaviour have occurred than a simple dummy would provide.

4. The evidence on asymmetric price adjustment is somewhat mixed with asymmetric price adjustment being found between some stages in the marketing chain but not in others. The results concerning asymmetry at the retail level are not conclusive. In the beef and lamb markets, retail prices do respond asymmetrically whereas retail pork prices do not. These results are at variance

with those reported in the previous report. The results presented here may be due to either the methodology applied or to the longer data series used. It is more likely that it is the latter since, as discussed above, there is evidence of structural change in the data that may have had an impact on some of the characteristics of the price relationships being investigated.

5. There is also evidence of 'levelling behaviour' at the retail and wholesaling sectors for all three markets. This is consistent with the findings of the previous report.

6. There is no evidence of 'averaging behaviour' in any of the markets considered. This is consistent with the findings of the previous report.

## 1. STRUCTURE OF THE REPORT

The structure of this report is as follows: Section 2 briefly discusses the data used in this report. A summary of the behaviour of prices in all three markets is provided together with a discussion of the behaviour of spreads over the 1990-2000 period. We also report briefly on the results from pre-testing the data. Section 3 presents a discussion of the methodology applied in this report while Section 4 reports the results of the analysis. Section 5 provides a summary and principal conclusions and suggests some issues where further research is required.

## 2. DATA AND CONVENTIONS USED

All the data used in the analysis were provided by DEFRA. The price series for beef, pork and lamb at the retail, wholesale and producer levels are monthly for the period January 1990 to December 2000. Prices are measured in pence per kilogram (p/kg), have been deflated by the retail price index (December 1999 base) and are expressed in 'carcass weight equivalents' to facilitate comparison between retail, wholesale and producer levels of the marketing chain. A discussion of the construction of the data series has been prepared by DEFRA and accompanied the previous report as a separate data appendix. As such, the details on the construction of the data series are not repeated here.

Figures 1 to 3 show how the prices for all three levels in all three meat markets have developed over time. Notable features of the data include the following. The general trend in beef and pork prices is downwards over the 1990-2000 period whereas in lamb prices appear to rise until 1996 where after they fall. Whilst pork and beef prices exhibit decline in excess of 25%, this is not so for lamb, whose price at the

beginning and end of the period are comparable. Lamb also exhibits a seasonal pattern not present in the other meats and unlike the price of beef, which shows a marked drop following the BSE/vCJD announcement in March 1996, the prices of other meats respond positively. The timing of the announcement clearly seems to act as a watershed for price determination in all the markets, although change in price behaviour is also apparent during the autumn of 1998, a period that is coincident with the initiation of the Competition Commission's Supermarket Inquiry.

**Figure 1: Beef Prices (Jan 1990 – Dec 2000)**

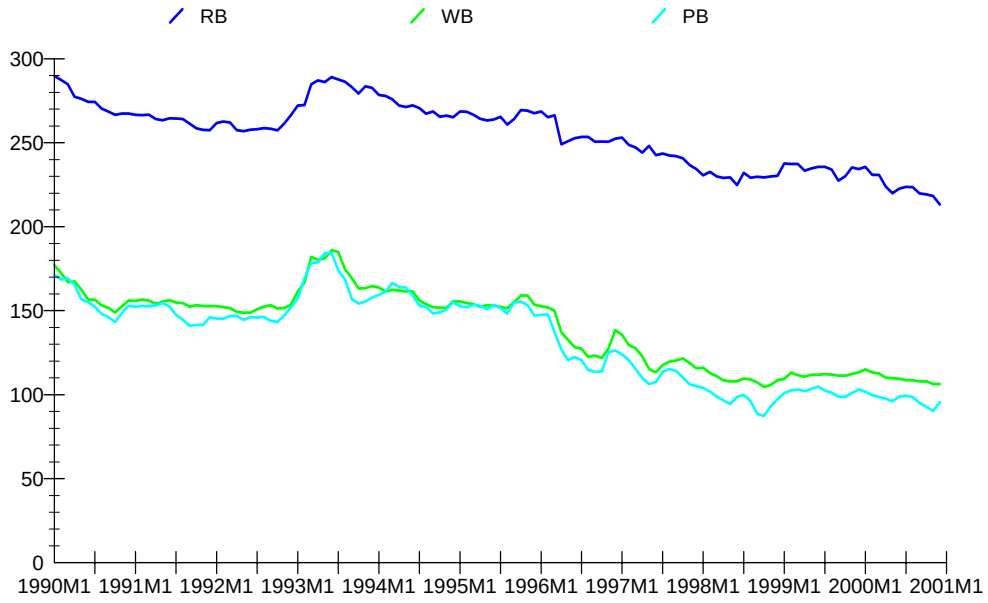


**Figure 2: Pork Prices (Jan 1990 – Dec 2000)**

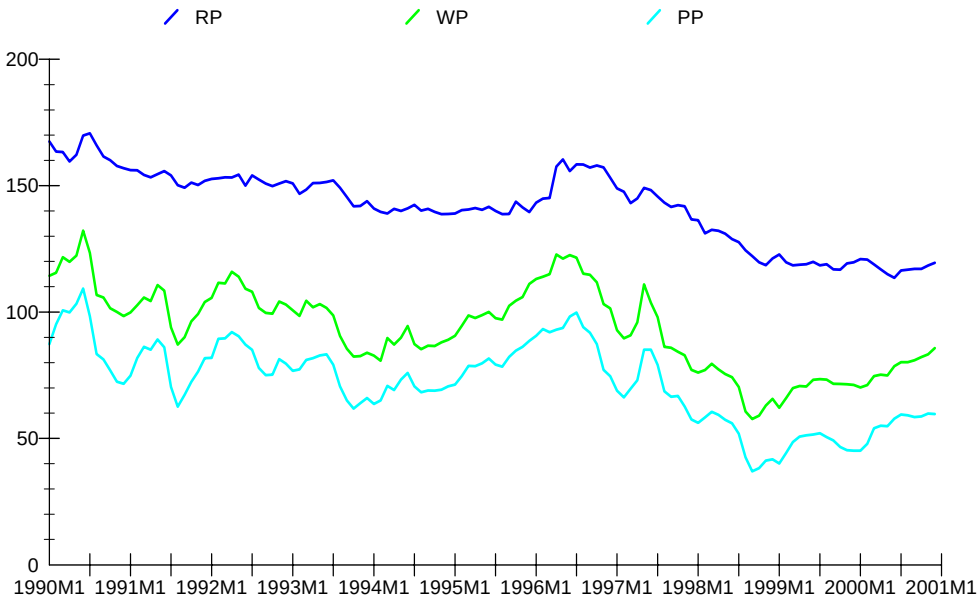
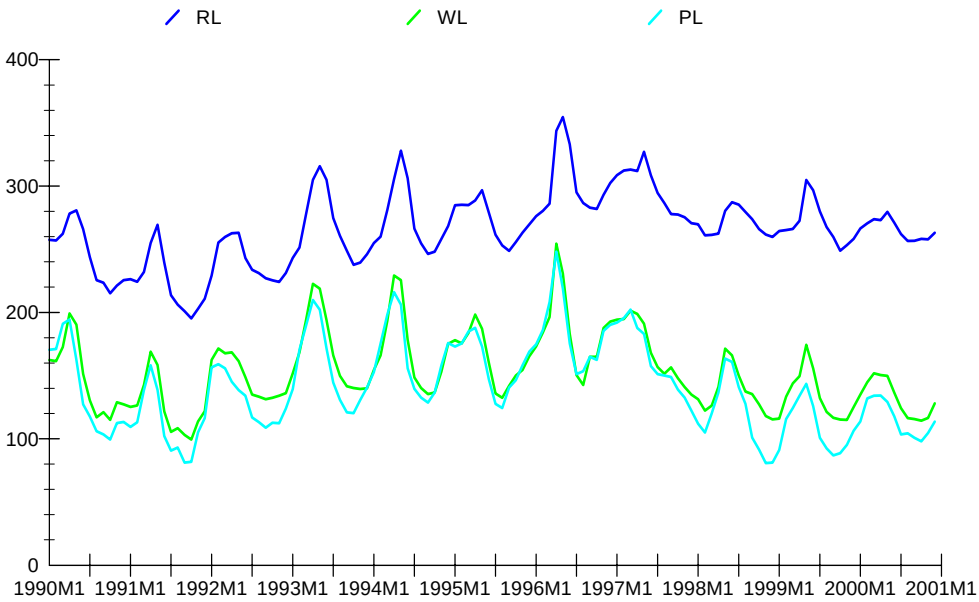



**Figure 3: Lamb Prices (Jan 1990 – Dec 2000)**



Figures 4 to 6 show that there have been three distinct phases in the marketing spreads during the 1990s: namely, 1900-1996, 1996-1998 and 1998 onwards. Overall, the marketing spreads tend fall in the first phase, rise strongly during the second and fall sharply in the third. For example, the beef data reveal that the 25% rise in the spread that occurred between 1996 and 1999 had all but vanished by the end of 2000, at which point the spread was at the same level as it was at the start of the decade.

**Figure 4: Beef Marketing Spreads (Jan 1990 – Dec 2000)**

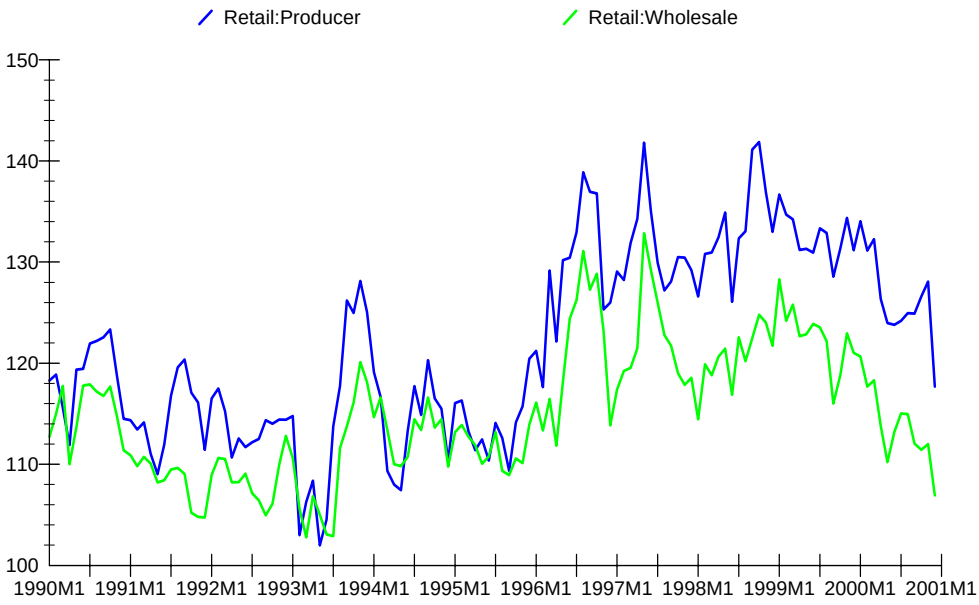


**Figure 5: Pork Marketing Spreads (Jan 1990 – Dec 2000)**

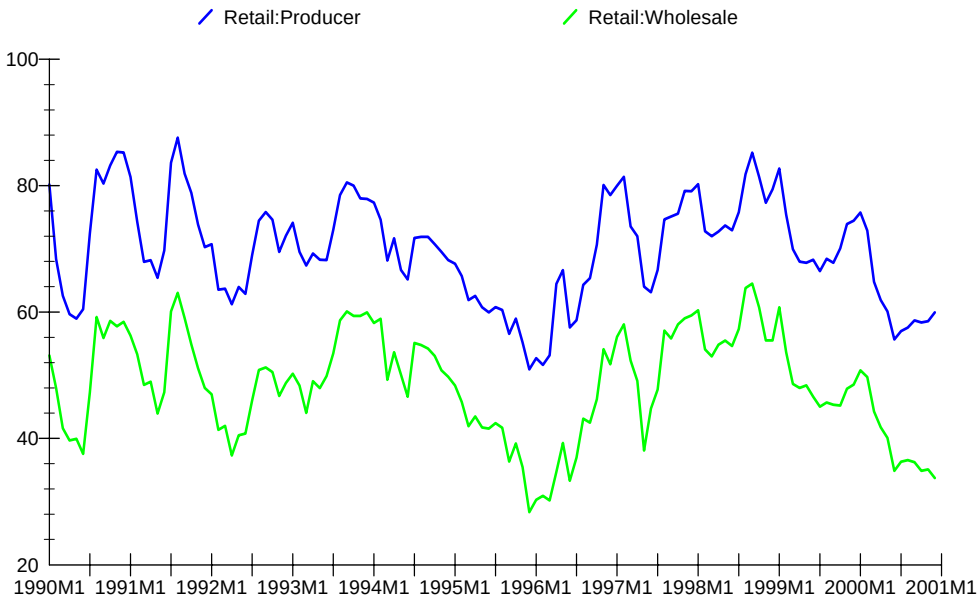
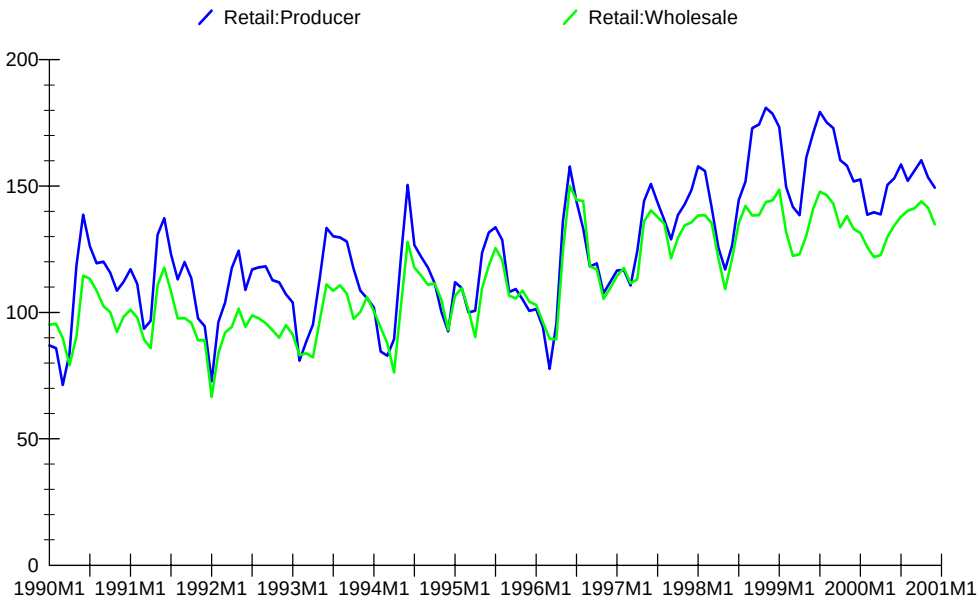



**Figure 6: Lamb Marketing Spreads (Jan 1990 – Dec 2000)**



While the graphical representations give an initial casual indication of how the data lie, more systematic and rigorous pre-testing of the data has to occur before estimation can begin. The technical appendix of the previous report provided a summary of the measures used to test for the time series properties of the data, and in particular, whether the data series were 'co-integrated'. This is not repeated here, and suffice to say that the conclusions from pre-testing are the same as in the previous report. Specifically, all the data series are 'non-stationary', and thus require co-integration methods to avoid the problem of 'spurious regression', as discussed in the first report.

## 3. LIVESTOCK SECTOR PRICE RELATIONSHIPS

### 3.1 Methodology

The techniques applied are state-of-the-art, incorporating recent developments in econometric theory. Specifically, as in the previous report, we adopt a vector auto-regressive (VAR) framework for modelling relationships between meat prices in the marketing chain. The VAR framework is specifically designed for the investigation of complex dynamic relationships between a set of variables and thereby allows for the knock-on and feedback effects that typically characterise variables such as prices in a marketing chain. VAR methods are particularly informative about dynamic inter-relationships, and allow concepts such as short- and long-run to be identified as well the nature of the adjustment process.

The current study employs three advances on the original (Lloyd, *et al.* 1999) study. The first is a methodological development, in that we now simultaneously incorporate price data at the retail, wholesale and producer levels when investigating price linkages between any two. In the original study, linkages were investigated using

price-pairs alone. This pair-wise approach produced three models for each meat, representing the retail:producer, the retail:wholesale and the wholesale:producer relationships. The current study yields a single, albeit considerably more complex, model for each meat that directly incorporates prices at all three stages of the marketing chain. The advantages of the triplet are principally two-fold. First, by incorporating additional information, relationships are more accurately determined. For example, in a pair-wise model the link between the retail and producer level ignores the "sub-links" between these two sectors and the intermediate wholesaling stage. Second, the use of a single model comprising the price triplet avoids the inconsistencies that inevitably arise when comparing and accounting for the results from the three pair-wise models. For example, the number of lags needed for each pairwise model may not be the same, even within the same marketing chain. Moreover, results from the retail:producer model may not be consistent with those from the retail:wholesale and wholesale:producer models. Some of these inconsistencies were noted in the discussion of the results in the previous report. The VAR model of the triplet overcomes these problems, and providing sufficiently long samples are available (as indeed they are in the current application), the approach is widely considered to be superior (Chang and Griffith 1998; Lloyd *et al.* 2001).

The second innovation introduced in this report is the use of *impulse response analysis* to describe the dynamic effects following a demand shock to the marketing chain. As in the previous report, the Press Stories Index, which is our proxy measure for the effect of BSE and similar food scares, plays a pivotal role in price determination. Indeed, the index is required in the estimation of the VAR models. For this reason, we undertake an impulse response analysis of a shock to the Press Stories

Index which takes account of the knock-on and feedback effects that characterise the inter-relationships between prices. Given the extent to which BSE affected UK meat markets in the 1990s, we consider this to be an important insight in to price relationships.

### 3.2 Model Estimation

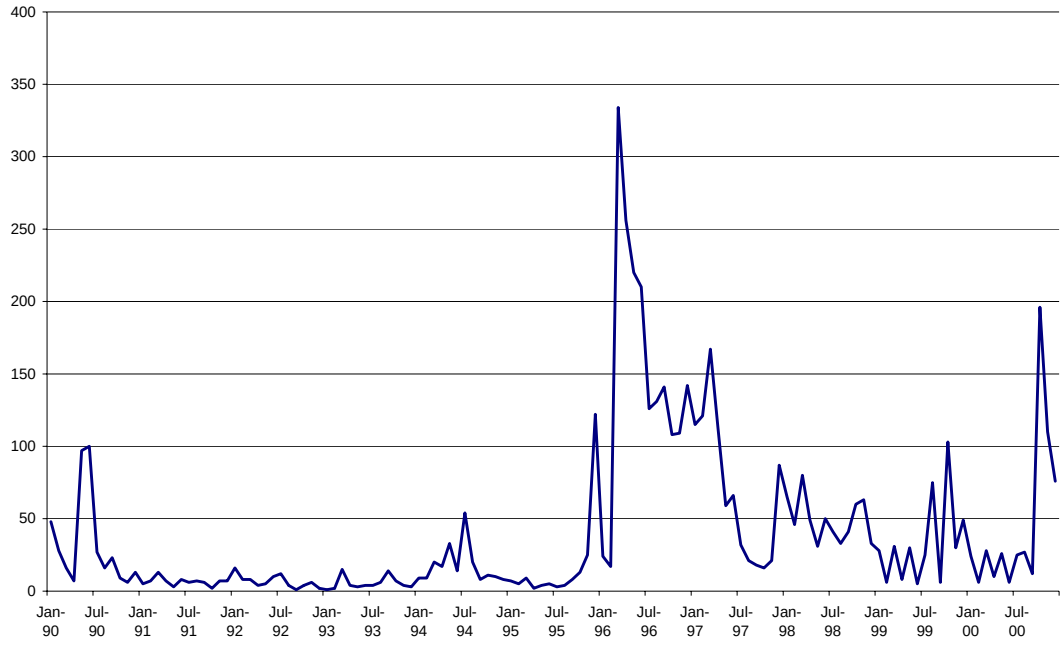
As was alluded to above modelling was carried out using a triplet (*i.e.* producer, wholesaler and retailer) of prices for each of the meats considered and in so doing allows for a more complete analysis of the short- and long -run relationships between prices. As in the original report, it was apparent that there was no evidence of co-integration (*i.e.* a long run relationship) between prices alone for any of the species considered. Furthermore, inclusion of the prices of substitute meats similarly proved unsuccessful in inducing co-integration, as was the case in the Lloyd *et al.* (1999) report.

Following our original study, attention focussed upon the role of information regarding the health and safety of meat, as measured by the Press Stories Index, illustrated in Figure 7. The index is a count of broad-sheet newspaper articles per month on the topics of food safety and human health. Reports regarding BSE dominate, although news of other food scares and abattoir hygiene are also included.

For statistical reasons, we use the log of the index rather than the index itself in the empirical analysis. Unit root testing confirms that the logarithm of the index is integrated of order one and its first difference (which corresponds to the growth rate

of the index) is stationary. As such, the logarithm of the index can be legitimately incorporated into the co-integration analysis in each of the triplet models.

**Figure 7: The Press Stories Index**




As in our earlier work, inclusion of the Press Stories Index had a marked effect on all the models. Specifically, the property of co-integration was detected with high degrees of statistical confidence, indicating that long-run relationships between the variables in the system had been detected. Following repeated rounds of refinement the final versions of the VAR models satisfied the standard checks for statistical robustness, confirming their statistical validity for further investigation. The pork and beef models were established as a VAR(2) and lamb as a VAR(3) (i.e. they included prices lagged up to two and three periods respectively).

Each basic VAR model for each meat comprises around 80 parameters. Consequently, for ease of evaluation their performance is best summarised graphically. Figures 8, 9 and 10 show the actual and fitted (or predicted) values from the estimated models along with their residuals (i.e. the difference between actual and fitted values). These clearly indicate that the models fit the data extremely well. As reported above, formal diagnostic tests have been undertaken, and confirm the adequacy of the specifications adopted. This may be inferred from casual inspection of the residuals (reported on the right hand side graphs) which are 'well behaved', in that they appear to be randomly distributed within two standard errors of the mean, a helpful summary measure traditionally used to indicate statistical robustness.

**Figure 8: (a) Actual and Fitted Values and (b) Residuals from the Beef Model**

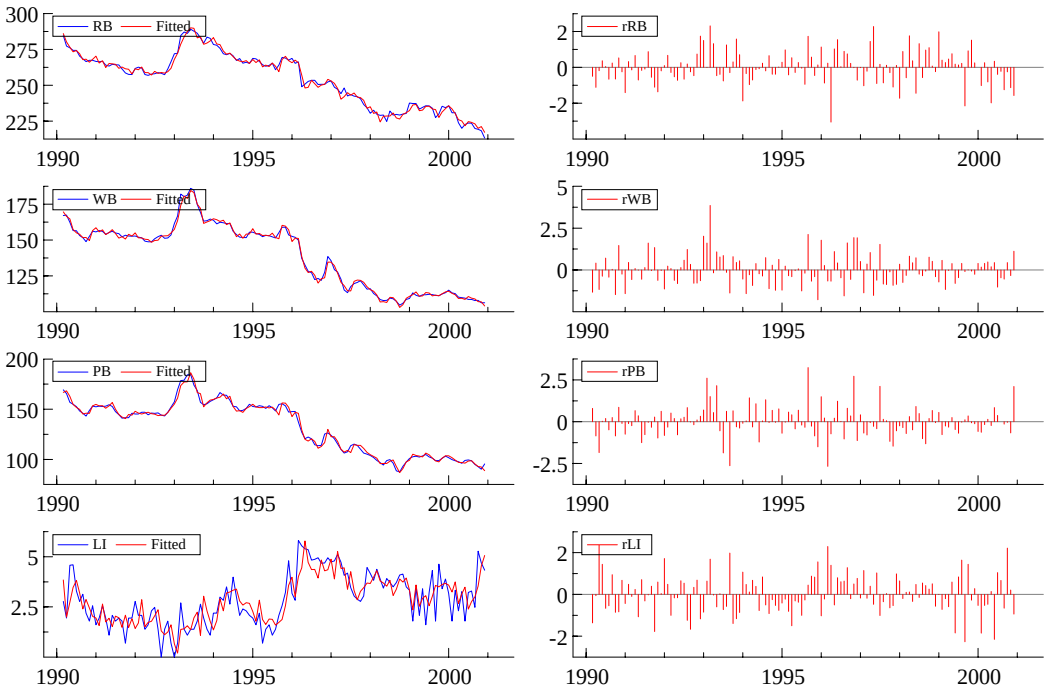


**Figure 9: (a) Actual and Fitted Values and (b) Residuals from the Pork Model**

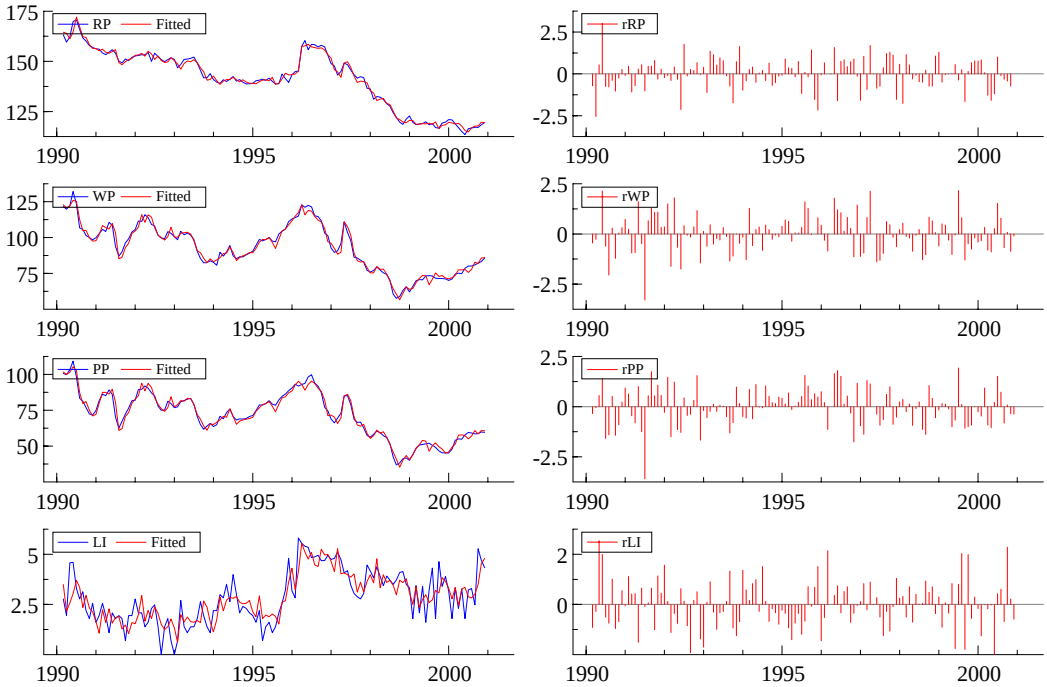
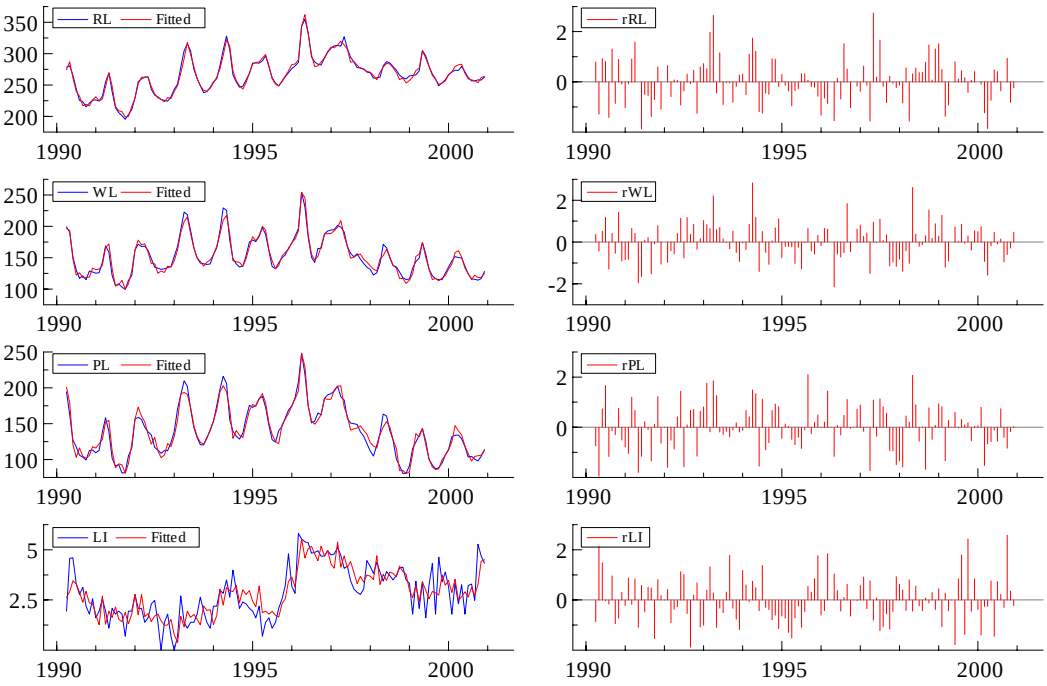



**Figure 10: (a) Actual and Fitted Values and (b) Residuals from the Lamb Model**



## 4. Empirical Analyses of Price Relationships

### 4.1 Price Transmission

To be consistent with the original study we investigate the issue of price transmission using the same statistical measures. Specifically, price transmission is defined as 'the estimated change in (say) retail prices associated with a unit change in (say) producer prices, all other variables in the system kept constant.' This measure, which is the standard metric of price transmission analysis, is the statistical analogue of a laboratory-style experiment, in that the response of a price at one marketing level is measured following a change of known magnitude in the price at another marketing stage, all other variables being held constant.

Recognising that the response to a price change may take time to occur, we evaluate the degree of price transmission in the month following the change (which we call *short-run price transmission*) and after all dynamic adjustment has taken place (which we call *long-run price transmission*). Note that as a measure of the long-run response to a price change, it does not estimate the average response but the change that may be expected to result after all the dynamics have worked their way through, keeping other factors constant. These definitions and conventions are exactly the same as those used in the previous report, and as a result we present a comparison of results using the original and updated samples.

*The Theory of Price Transmission*

Of particular interest is the notion of complete or so-called 'perfect' price transmission. This is the benchmark that we would expect to prevail in perfectly competitive markets with no uncertainty or adjustment costs. It occurs when (say)

retail prices fall by 10p/kg following a 10p/kg fall in producer prices, *i.e.* there is a one-for-one change in the prices. In this special case of 'perfect' price transmission, the price transmission coefficient is unity. It should be recognised however that a number of factors can cause price transmission to be less than perfect. Characteristics of the marketing chain play an particularly important role in determining the degree of price transmission. For example, the availability of substitutes, the presence of increasing or decreasing returns to scale in the industry cost functions and the degree of market power in downstream sectors all affect the degree of price transmission and thus the magnitude of the transmission coefficient.

Recent research on the price transmission issue has identified the factors that are likely to determine the response of price changes throughout the food chain in response to shocks from various sources. Theoretical research has shown that a number of characteristics of the marketing chain will play a role in determining the degree of price transmission. For example, the nature of the production process that links the various sectors matters in this regard. Intuitively, if retailers (and other downstream processors) can vary the proportion of the agricultural input in the final product purchased by consumers in response to a price change, it is likely that they will substitute one input for another according to their relative prices. As a consequence, price transmission will be less than one-for-one since the proportion of the each input will have altered following the price change. In the theoretical literature this is called variable (rather than fixed) proportions production technology. This however is not the only factor to cause a departure from the 'perfect' price transmission case. The elasticities of the retail demand and farm supply schedules can also impact upon price transmission, as does the returns to scale that characterises the

cost curve of the downstream sectors. Market power also plays a role. Other factors being equal, a high level of market power in any part of the marketing chain will serve to reduce the impact of cost changes on downstream prices, and thus lower the degree of price transmission between producer and retailer. If market power mattered, then retail prices rising by less than the rise in producer prices would result in a widening of the price spread. However, since the same result occurs in the presence of variable proportions technology and decreasing returns to scale, it is not generally straightforward in practice to attribute cause and effect, particularly so when working with a reduced form model (i.e. one that contains only prices). Nevertheless, any differential in the response of prices throughout the marketing chain will imply a narrowing or widening in the price spreads.

*Price Adjustment*

Given the 'special case' nature of perfect price transmission it is also pertinent to evaluate whether the long run effect of a price change differs from that observed in the short run. A difference will occur if there are constraints on price adjustment in the short run reflecting the nature of contracts with suppliers, the role of inventories and so-called 'menu costs'. For example, retailers may be reluctant to alter their prices at the check-out even if producer prices change frequently, since to do so would involve an additional cost associated with physically re-pricing the product. Moreover, retailers may attempt to moderate price fluctuations if they believe that consumers prefer price stability. Similarly, contracting supplies at a fixed price is an attempt to lock-in price stability, irrespective of market movements.

*Empirical Results*

Table 2 summarises the results for price transmission in the retail:producer relationship in the models for beef, pork and lamb.[1] Results show that in the long run price transmission is generally high. Point estimates suggest that, other things remaining constant, a 10p/kg change in the producer price of beef is associated with a 9p/kg change in the retail price of beef. For pork and lamb, the retail response to a 10p/kg change in producer prices is 8.5p/kg and 7.0 p/kg respectively. Hypothesis testing suggest that the estimates for beef and pork are compatible with perfect price transmission at conventional levels of statistical confidence, although this is not the case for lamb. Whilst the literal interpretation of this test is to suggest perfect price transmission in the beef and pork sectors during the sample period, there is strong evidence, that we report in section 4.4, to suggest that price relationships have been subject to structural change. In effect, this response over the entire sample period is a mixture of two distinct sub-periods, and thus estimates based upon the 1990-2000 sample may give a misleading impression of price transmission in either of the sub-periods.

**Table 2: Short- and Long-Run Price Transmission Between Producer-Retail Prices**

| | **Beef** | **Pork** | **Lamb** |
|---|---|---|---|
| **Short Run** | 4.6 | 1.5 | 2.4 |
| **Long Run** | 9.0 | 8.5 | 7.0 |
| **Adjustment Period** | 3 months | 4 months | 6 months |

[1] Results are qualitatively unchanged if it is the Retail-Wholesaler relationship that is examined.

Table 2 also reports relatively low levels of price transmission in the short-run (i.e. the month following the price change). Specifically, a 10p/kg change to the producer price of beef is associated with a 4.6p/kg change at the retail level, other factors remaining constant. A similar 10p/kg change in the producer prices of pork and lamb are associated with a 1.5 p/kg and 2.4p/kg changes at the retail level in the short run. Clearly, further adjustment takes place in the following months until the dynamic impacts dissipate and prices stabilise at new levels. Overall, the results indicate that price transmission in the short-run is relatively low, being between one-quarter and one-half of the long-run response.

Given that we make the distinction between short and long-run price transmission, it is pertinent to ask how long does it take for adjustment to occur? In other words, what is the length of time required for a given shock in retail (producer) prices to be completely incorporated in to producer (retail) prices. Estimates of the adjustment period generated by the models is also reported in Table 2. In the beef sector, adjustment takes around 3 months; for pork it is 4 months and for lamb it is 6 months. Accounting for differences in the length of adjustment lags between species is invariably conjectural since it involves a host of economic and statistical factors. For example, if adjustment lags are due to contracting arrangements, then differences in contracts across the species will be reflected in different lag lengths. Furthermore, highly non-linear adjustment may be poorly approximated in the linear models used here. Alternatively, the relatively long adjustment period for lamb may simply reflect the strong seasonality present in the lamb prices. Nevertheless, all results point to the incomplete of imperfect nature of price transmission in the short run. As alluded to

above, where price adjustment in the short-run is low, this reflects characteristics of the marketing chain, including the role of contracts, market structure, inventories, uncertainty and menu costs. In the long run, many of these factors become less important and hence price transmission in the long run is generally higher than the short-run impact.

In sum, these results indicate that for all meats the marketing chain is a highly integrated one. However, rigidities in the price transmission relationship clearly exists since the short-run response is far below the long-run effect. In short, high levels of price transmission characterises the long-run but not the short-run.

*Comparison with the Previous Study*

Table A1 summarises the results of this and the previous study. The following points emerge from a comparison of price transmission estimates using the original and current samples.

1. In both samples price transmission in the long run is high, although numerically less than that implied by 'perfect' price transmission.
2. In both samples, price transmission in the short-run is low and less than the long–run response.
3. Numerical values of each measure of price transmission differ between the two samples. This also applies to the estimates of the adjustment lags in price transmission.

Thus comparison points to some fundamental regularities in the price transmission process (namely that rigidities are more apparent in the short rather than long run), but

that the price relationships themselves may have changed with the addition of data for 1999 and 2000. Whilst some difference is to be expected owing to natural sample variation, the extent of the changes observed is at least indicative of a more systematic influence. For example, for beef, estimates of both short- and long-run price transmission grow by over 20% with the addition of the new data. Once again, the evidence points to the presence of structural change in the price transmission relationships, and consequently a more rigorous investigation is undertaken in to this issue in section 4.4.

### 4.2 Simulating the Effects of Health Shocks on Prices

Throughout the 1990s, BSE and other food scares have had a marked impact on the UK meat market. The Ministerial announcement of 20 March 1996, in which Stephen Dorrell raised the possibility of a link between BSE in cattle and variant Cruezfeldt Jakob Disease (vCJD) in humans, had a marked impact on meat prices in the months that followed. Whilst the immediate impact of the shock is clearly visible in Figures 1, 2 and 3 (the retail price of beef fell 7% while those of pork and lamb rose by 9% and 20% respectively), the longer term ramifications are perhaps less clear. This is the issue to which we now turn.

As discussed in Section 3, the Press Stories Index, which is the measure we use to proxy for the media coverage of BSE and similar food scares, has a played a pivotal role in the econometric modelling of meat price formation during the 1990s. In both the original and current study, the index represents the ‘missing link’ in the analysis of price transmission. Specifically, it induces the statistical property of ‘co-integration’

among each triplet of meat prices. In other words, without the Press Stories Index, retail prices do not form a long-run relationship with either wholesale or producer prices. Whilst the issue is primarily a technical one, suffice to say that in the absence of co-integration, numerical results and statistical inference are invalidated, seriously undermining the practical usefulness of them.

To investigate the impact of media shocks (as proxied by the Press Stories Index) on prices throughout each marketing chain, we use a recently developed technique of generalised impulse response analysis (Pesaran and Shin, 1998). This method, which develops the techniques originally proposed in a seminal paper by Sims (1980), utilises the coefficients estimated in the price transmission model to produce so-called *impulse response functions*. Each impulse response function describes the dynamic response of one variable in the system following a shock to another, allowing for inter-relationships between variables in the system.

The principal advantages of the impulse response analysis method are two-fold. First, it provides a time path (on a monthly basis given the data used here) for each variable in the system that traces the effect or response following a shock to one of the other variables in the system. This facilitates evaluation of the system-wide effects of a shock. Furthermore, impulse response functions not only describe the 'short' and 'long-run' effects but the response at all intervening periods. Second, this technique takes into account the knock-on and feedback effects between variables that occur as a shock to one of the variables reverberates through the system. This differs from the more usual *ceteris paribus* measures which, by assumption, keep all other factors constant following a shock. For example, in the current application, the impulse

response functions take into account the dynamic effect on prices at retail, wholesale and producer levels following a shock to the Press Stories Index. Given that prices are likely to be interdependent the technique is clearly attractive. Thus the estimated response of, say, retail prices following a shock to the index will embody the knock-on effects through wholesale prices in addition to any feedback effects that characterise the relationships between the price triplet and press stories index. The impulse response function thus delivers an estimate of the net effect on variables in the system following a shock and by doing so more accurately simulates what one might observe in the real world in response to that shock. The levelling-off of the impulse response function indicates the long-run effect of the media shock.

Note that in the simulations that follow, the models are calibrated to evaluate the effect of a 'typical' shock to the Press Stories Index. 'Typical' in this instance is defined statistically as a shock of one standard error in magnitude, and may be interpreted as a shock with a size that would be expected to occur about one-third of the time.[2] It should be kept in mind that given the predominance of stories relating to BSE, the impact of the Press Index Stories on the beef sector, is likely to be different to that of pork and lamb, which are its substitutes in consumption. Consequently, our *a priori* expectations are that beef prices should fall and pork and lamb prices rise following a shock to the index. Of course, it may also be the case that the impact of meat scares would be to reduce demand for all meats and thus depress meat prices in some or all of the meat markets considered. Furthermore, given that price transmission coefficients are generally close to but less than unity, it is expected that

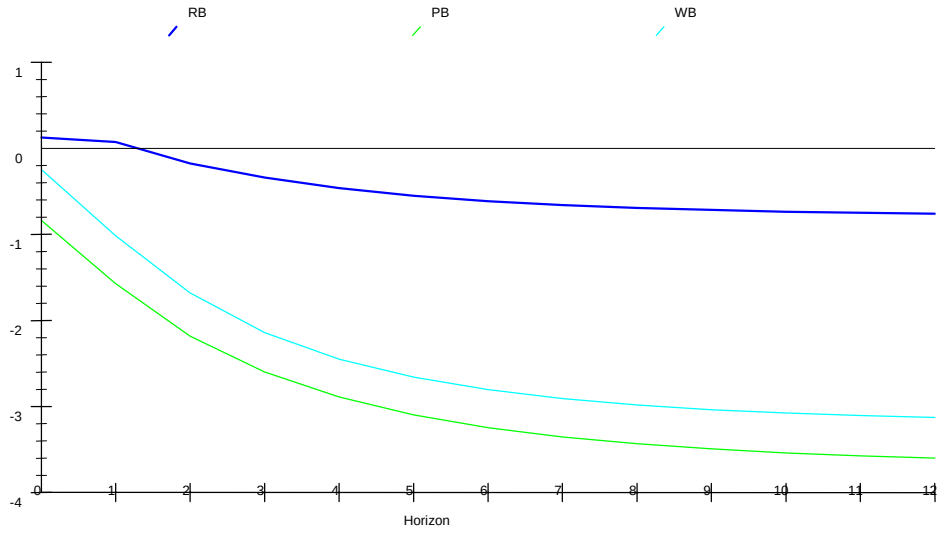
[2] Given that the index is measured in natural logarithms (and therefore measures the *proportional change* in the newspaper count), it is impossible mathematically to work back to the *absolute number* of newspaper articles implied by this shock.

the effect at the retail level while not be the same as that observed at the wholesale or producer levels.

*Empirical Results*

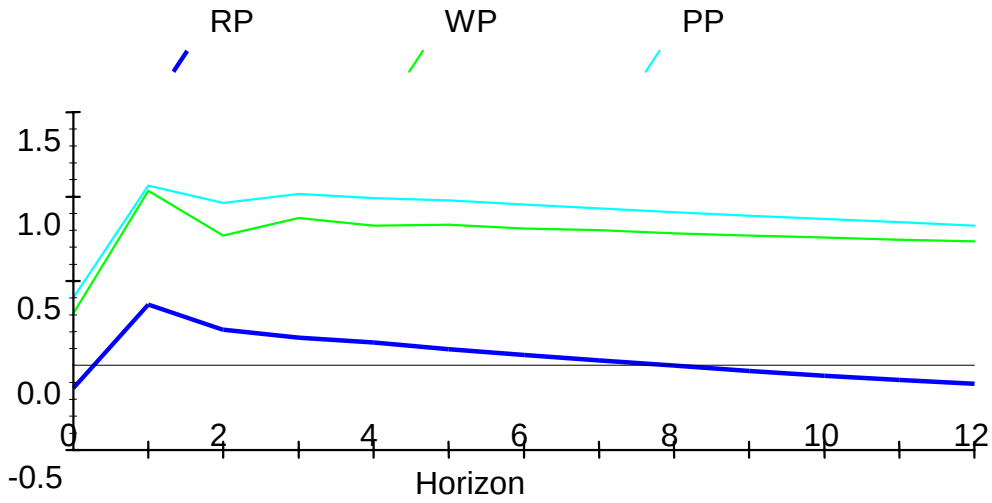
Figure 11 shows the profile of a typical shock to the Press Stories Index on beef prices allowing for the knock-on and feedback effects within the system. As can be seen, heightened media interest in food and safety issues of meat lower beef prices at all marketing levels. However, prices fall by varying amounts, producer, wholesaler and retailer prices falling by 3.6p/kg, 3.1p/kg and 0.8p/kg respectively. In other words, producer prices are four and half times more responsive to changes in the index than retail prices. As a result, demand shocks of this sort have the tendency to lead to a widening of the price spread, a result that is consistent with the numerical estimates of price transmission in Table 2.

**Figure 11: Simulated Effect of a Typical Shock to the Press Stories Index on Beef Prices (p/kg)**



For pork, the same demand shock triggers an initial increase in prices at all three marketing levels, which persists for producers and wholesalers, leaving them around 1p/kg higher as a result of the increased media coverage, although there is no discernible long-run impact at the retail level. As a result widening of the price spread is a consequence of demand shocks, and as for beef, arises from the less than complete transmission of prices between stage in the marketing chain (Table 2).

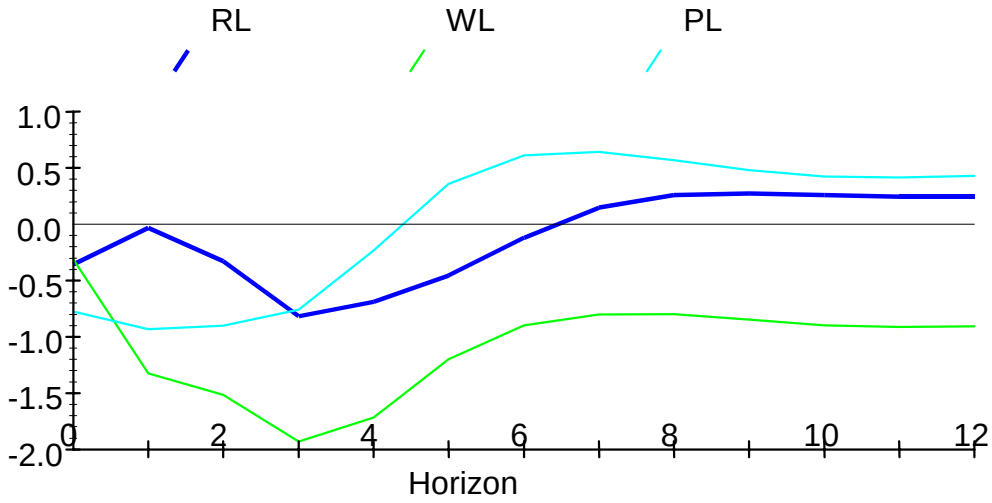
**Figure 12: Simulated Effect of a Typical Shock to the Press Stories Index on Pork Prices (p/kg)**




The simulated response of lamb prices to the shock to the Press Stories Index is different to the other meats. However, it resembles beef in the 'short-run' insofar as prices initially fall following the heightened media coverage of health and safety issues. In the longer term, producer and retail prices rise, although to a level barely above their starting point. Oddly, wholesale prices remain depressed following the shock, falling to 1p/kg below their starting point. Whilst this is puzzling, it may simply reflect the quality of the wholesale price data for lamb. However, as far as the

price spread between retail and wholesale prices is concerned, the results suggest that there is no permanent (long-run) widening in the price spread following a demand shock.

**Figure 13: Simulated Effect of a Typical Shock to the Press Stories Index on Lamb Prices (p/kg)**




In sum, the simulation results indicate that the three meats behave in different ways. Whereas beef prices fall following a shock, pork prices generally rise. The response of lamb is somewhat of the hybrid, in that in the short term the response is akin to beef whereas in the longer term it is more like pork. As such, the results suggest that the principal effects of press coverage of meat health and safety fall negatively upon beef, both in the short and long-run, indicative of a switch out of beef consumption. Given that stories about BSE predominate in the Press Stories Index (and in media coverage in general), it is not surprising that the negative effects on beef prices are both greater in magnitude and more long-lasting than appears to be the case for lamb. The price of

pork, (and to a lesser extent lamb) is indicative of substitution as consumers switch out of beef consumption in to alternatives.

The fact that lamb prices respond to media shocks in a way that pork prices do not, may say something about consumers' perceptions of the meats. In particular, one may speculate that as in other respects, beef and lamb are more closely associated with respect to media coverage of health and safety than are pork and beef.

Another corollary of the results is that price spreads in the pork and beef sectors widen in the face of heightened media interest in food safety. This reflects the nature of price transmission at each stage of the marketing chain. It is clear that producer prices are more responsive than retail prices even in the long-run when the adjustment costs have worked their way through the marketing system. However, given the many potential determinants of price transmission, the reduced form nature of the model that has been estimated here, it is not possible to attribute the differential causes of the price changes to any specific factors.

### 4.3 Asymmetry in Price Transmission

In the preceding section it has been assumed that price transmission is symmetrical, in that the response to a change in a variable is the same, irrespective of whether the initial price change was positive or negative. What is of further interest is whether the size of response is dependent on the direction of the change in the other variable. In other words, is there any evidence of asymmetry in the response of one variable to a change in another variable? For example, do retailer prices change more when

producer prices rise than when producer prices fall? The implications of asymmetry if evident are also worth noting. If retail prices respond more to producer price increases than price declines then this implies that price setting behaviour is different from the behaviour of prices at the farm gate. With a producer price decrease, retailers may not pass-through this decline to consumers at least initially. This would in turn cause an increase in their margins, at least in the short-run. However, they will be more willing to re-coup an increase in their costs when producer prices are rising thus maintaining their margins when costs increase. Taken together, the existence of asymmetry implies some differences in price setting behaviour and relates to the distinction between 'flex and fix-price' markets that is well-known in the agricultural economics literature.

*Methodological Issues*

To deal with the question of asymmetry, we return to the more specific issue of price transmission of section 4.1. Asymmetry is by its very nature a short-run phenomenon since it relates to differences in the speed and magnitude of the adjustment process following positive or negative price shocks. Significant differences between the values of the price transmission coefficients in each case would allow us to say that an asymmetric response is occurring within the price complex and whether this is in respect of the speed or magnitude of the response.

The approach we take here is to increase the number of explanatory variables such that each price now enters the model twice, once to represent a positive change and once to represent a negative change. For example, in examining the response of retail prices, we would include a variable for positive changes in producer prices and

another for negative changes in producer prices and, in the same manner, two variables for wholesale prices would be included. The test for asymmetry is then a simple comparison of the coefficients on the pairs of variables. If the coefficients are the same for a price increase and price decrease then prices are said to respond symmetrically.

Note however, that asymmetry is a two-dimensional concept to account for differences in the speed and magnitude of adjustment to positive and negative shocks. Hence, in cases where each pair of coefficients (quantifying the response to price rises and falls at time *t* -1) are both significantly different from zero, this implies symmetry in the speed of adjustment. Where one coefficient is significantly different from zero but the other coefficient is not, there is asymmetry in the *speed* of adjustment. Asymmetry in the *magnitude* of adjustment may be evaluated by a test of the hypothesis that there is equality between the two coefficients.[3] In considering the asymmetry issue, we focus on the response of prices at the retail level.

*Empirical Results*

The results are summarised in Table 3. The tests reveal that adjustment is asymmetrical in all of the meats considered, and that this occurs in both the speed and magnitude of adjustment. As indicated above, these results are based on hypothesis tests. If the size of the coefficients are compared, then point estimates from the models suggests that the response of retail prices tends to be twice as large in response

[3] Note that if there is asymmetry in the speed of adjustment (entailing that one coefficient is statistically different from zero and the other not) then by definition there is also asymmetry in the magnitude of adjustment. The converse however is not true, since both coefficients could be statistically different from zero (symmetry in speed) and statistically different from each other (asymmetry in magnitude).

to producer price increases as it is to decreases in producer prices. This is suggestive that retail prices tend to reflect price increases more readily than price decreases.

Returning to the hypothesis testing of asymmetry, it should be noted that we test hypotheses so as to be 90% confident in the outcome. The results for pork and lamb are borderline cases and opposite conclusions could be obtained had the 95% confidence level been chosen. Beef results are however robust to this consideration. As so often happens in hypothesis testing, results are sensitive to the degree of certainty that the investigator requires to draw a conclusion. However, in making an overall judgement, the evidence seems to point to the existence of asymmetric adjustment (in that retail prices tend to reflect price increases more readily than price decreases) since not only is this detected with 90% confidence in all meats, it is detected with even greater confidence for beef.

**Table 3: Adjustment of Retail Prices in Response to Producer Price Rises/Falls**

| | Beef | Pork | Lamb |
|---|---|---|---|
| Symmetric Adjustment | × | × | × |
| Asymmetry in speed of adjustment | ✓ | ✓ | ✓ |
| Asymmetry in magnitude of adjustment | ✓ | ✓ | ✓ |

*Comparison with Previous Study*

These results appear to be at variance from those reported in the earlier study where asymmetry was found for the pork sector but not for beef and lamb. The different results may be due to either the different methodology applied in this report and/or the longer period of data that is used. To investigate this issue, the tests were repeated on

the sample used in the original report. Results are the same as those obtained using the extended sample suggesting that differences arise due to the change in model specification, *i.e.* the use of the price triplet rather than the separate models of price pairs. Since the triplet models are better specified (since they embody more information on prices), the results they generate are likely to be most reliable. As a consequence, the evidence suggests that asymmetric price transmission characterises all three red meat sectors. Specifically, the response of retail prices tends to be twice as large in response to producer price increases as it is to decreases in producer prices.

### 4.4 Structural Breaks

The 1990s represent a turbulent period for the UK meat market. Not only has BSE played an important part in price determination, particularly so since the Ministerial announcement of 1996, but the market has also been the focus of attention following the Office of Fair Trading and Competition Commission's investigations of the conduct of UK Supermarkets.

The issue of structural change was also addressed in the previous report though no firm evidence of structural change was found. This may have been due to the lack of sufficient data for the latter years of the 1990s. With the expanded data set used in this report, we are able to give greater weight to the analysis of structural breaks in the data. As such, the results reported here will supersede those reported previously. In addition, we also test for structural breaks associated with the rise in the Press Stories Index in the mid-1990s.

Given that inspection of the price data in Figures 1, 2 and 3 suggests that the spring of 1996 and autumn of 1998 represent watersheds in the evolution of meat prices, we formally test for structural breaks in the price relationships at these times. In so doing, the intention is to offer statistical evidence of the effect of the BSE/vCJD Ministerial announcement in March 1996 and the period in which the Office of Fair Trading and Competition Commission investigations into competition in the UK food retailing sector on price transmission. It is important to stress, that whilst the presence of structural change may be evaluated scientifically through these methods, attribution can only be inferred. Given that (potentially at least) other factors may be responsible for the structural change, it is not possible to ascribe the cause and magnitude of the structural change to a specific effect since 'other factors' may potentially compound, counteract or solely account for the structural change that is detected.

Our investigation of structural change in the price transmission relationships involves three steps: inspection of the data; rolling least squares and formal tests for structural change. Initially, simple inspection of the data provides some indication of the possible presence or otherwise of such a break. Specifically, differences in price behaviour at different marketing levels will, *ceteris paribus*, be reflected in the price spread. This is merely indicative of structural change since all models of price relationships also contain the Press Stories Index. Naturally, movement in this variable will also affect the price spread where its impact is unequal at different parts of the marketing chain. Nevertheless, inspection of the price series and price spreads plays a key role in the detection, and subsequent discussion of possible causes of structural breaks.

However, to account for this and other limitations of graphical methods we also adopt the technique of *rolling least squares*. Technically, this involves the estimation of the long-run price transmission coefficient based on a rolling sample of 24 observations which moves sequentially through the sample of 132 observations. Since an estimate of the price transmission coefficient is produced for each (24 observation) sub-sample of data, this procedure generates 108 estimates of the price transmission coefficient which, when plotted over time, gives an informal indication of the sensitivity of the price transmission relationship to the sample used. These estimates are taken from static single OLS regression equations with a constant, the Press Stories Index and seasonal dummy variables included. If rolling least squares estimates of the price transmission coefficient cluster around a constant level, one may infer that structural change has not occurred. In other words, the relationship is invariant to the sample period selected. Alternatively, a systematic pattern to the plot of estimates points to the presence of the structural change, i.e. the relationship is sensitive to the sample period selected. Periods when the coefficient falls indicates a period in which price transmission has been impeded; a rising plot of coefficients, a period of accelerated price transmission. While natural sampling variability will play a role, this is unlikely to account for prolonged systematic change in the size of the estimates. Where structural change is discovered, it may be possible to speculate on the cause, particularly so if coincident with known exogenous events. Whilst not a formal test of structural change, rolling least squares provides a powerful diagnostic tool with clear intuitive appeal.

Finally, we test formally for a structural break using binary (dummy) variables to allow for change in both the price transmission relationship and an exogenous shift in

the intercept of the OLS price regressions. Allowing both the intercept of the regression and the price transmission coefficient to change makes it possible to isolate the precise impact of (the hypothesised) exogenous factors, although in essence change in any one of them is indicative of structural change. The joint statistical significance of the parameters on these dummy variables is indicative of a structural break.

Testing proceeds along the following lines:

1. *Structural Change during September 1998 to December 2000.* This is period during which the Office of Fair Trading and the Competition Commission was investigating the conduct of UK supermarkets. The dummy variables are constructed to 'switch on' during this period, and if their coefficients are statistically significant, this indicates structural change.[4]
2. *Structural Change during March 1996 to December 2000.* This is the period following the Ministerial announcement linking BSE to vCJD. This test compares whether the price relationships are different pre and post March 1996. As above, the dummy variables are constructed to 'switch on' during the post March 1996 period. Statistical significance of the coefficients on the dummy variables is indicative of structural change.
3. *Structural Change during March 1996 to September 1998.* Given that the period over which we test for a 'BSE-induced' effect covers the Office of Fair Trading/Competition Commission investigation era, it is possible that

[4] The tests below have also been repeated for sub-periods of the Competition Commission time frame such as the period of the Competition Commission's actual investigation (April 1999 – October 2000)

the results under Test 2 could be contaminated by structural change detected under Test 1. To remove this potential influence the sample period was shortened to exclude the investigation period. Consequently, dummy variables are constructed to 'switch on' during March 1996 and August 1998 only. Statistical significance of the coefficients on the dummy variables is indicative of structural change. Results may be compared to those obtained from Test 1 and 2 to help identify the cause of any structural change detected.

*(i) Structural Breaks in Beef Price Transmission*

With reference to beef prices, casual inspection of the data (Figures 1 and 4 above) suggests that although a small a step change in prices occurred in March/April 1996, this immediate impact was relatively small and had an impact on all marketing levels. Consequently, it is an unlikely cause of structural change in the price transmission relationship. Of more relevance is the more gradual growth in the spread up to the end of 1998 and its subsequent sharp decline. Having peaked in September 1998, the retailer-producer spread has fallen almost continually so that its current level is similar to that last seen at the end of 1995 (i.e. pre-BSE). The spread for retail-wholesale prices is at a level similar to that of the end of 1993. Whilst these results are indicative of structural change during both the BSE and Competition Commission investigation periods they may simply reflect movements in the Press Stories Index, and thus statistical methods are required to investigate the issue further.

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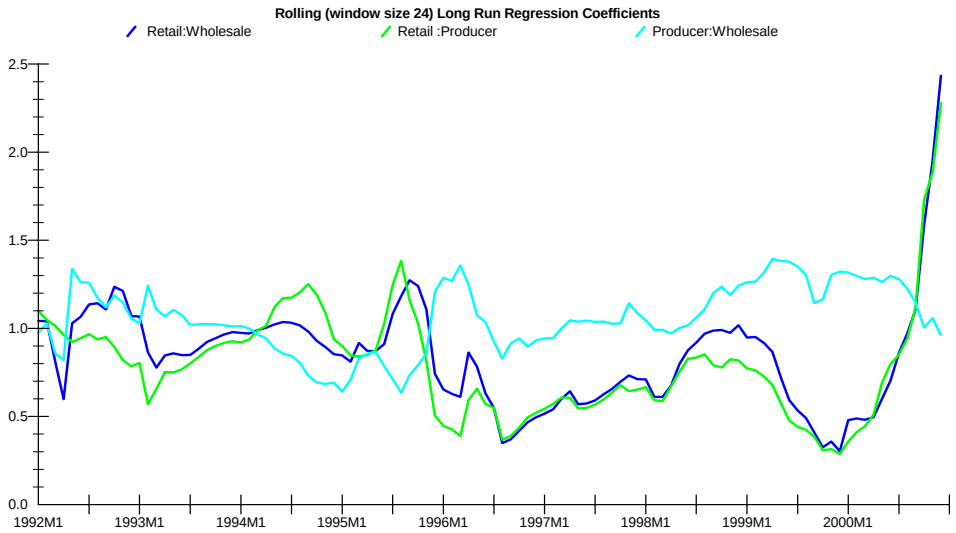
and the period during which the Competition Commission was undertaken the study (April 1999 – December 2000). Results for the sub-periods are even stronger those reported here.

Figure 14 summarises the results from rolling least squares and plots the price transmission coefficient between retail:producer, retail:wholesale and wholesale:producer beef prices. Whereas the coefficient between wholesale and producer price is virtually constant around unity over the period, coefficients for the relationship between retail and wholesale and retail and producer show a dramatic rise at the end of the period following a long period of gentle decline, which seems to begin around the middle of 1995. Indeed, the estimate of the price transmission coefficient using the last 24 observations (i.e. during the CC investigation period) is two and a half times larger than the historical average. This implies retail beef prices have become much more responsive to changes in wholesale and producer prices and represents *prima facie* evidence of structural change in the price transmission relationship. Since this behaviour is not apparent in the price transmission coefficient between wholesale and producer prices, it may be deduced that it is the retail marketing stage that is driving the change in the pricing behaviour.

**Figure 14: Rolling Least Squares Coefficients for Beef**



Results from formal testing using dummy variables as described for Tests 1, 2 and 3 above, are summarised in Table 3. Results for Test 1 confirm the presence of structural change in 1998 at conventional (95%) levels of confidence, as indeed would be expected given the dramatic rise in the price transmission coefficient shown in Figure 14. For example, point estimates from the model of the retail:producer relationship indicate that the price transmission coefficient doubles and intercept halves during the Competition Commission investigation period. This reflects a sharp contraction in the price spread during this period. As discussed above, whether this response is a reaction to the Competition Commission's investigation or some other factor is conjectural.[5] Note however, that since no change in the price transmission relationship is detected between wholesale and producer, the structural change must have been due solely to changes in price behaviour at the retail stage. This appears to be inconsistent with public perceptions at that time that price responsiveness at the retail level was slow. The results reported here suggest that retail price responsiveness was increasing during this period.

Results from Test 2, which compare the price relationships pre- and post-March 1996 do not suggest structural change in any of the price transmission relationships and these are corroborated by Test 3 which also do not suggest any presence of structural change in the March 1996 to August 1998 period.[6]

[5] It is worth noting that the detection of a structural break at this point does not provide *prima facie* evidence of the effect of the Competition Commission inquiry as there may be other factors causing the break to occur which coincide with this period, such as Wal-Mart's entry into the market for example. Similarly, a similar caveat is warranted in interpreting the findings relating to BSE/vCJD.

[6] Evidence of structural change is apparent at lower (85%) confidence levels of confidence, however this is likely to be due to contamination from the results of Test 1 since no evidence can be detected (at any meaningful) level of confidence using Test 3.

**Table 3: Tests for Structural Change in Beef Price Transmission**

| | Test 1<br>1998(9) to 2000(12) | Test 2<br>1996(3) to 2000(12) | Test 3<br>1996(3) to 1998(8) |
|---|---|---|---|
| Retail:Producer Relationship | ✓ | × | × |
| Retail:Wholesale Relationship | ✓ | × | × |
| Wholesale:Producer Relationship | × | × | × |

Note : Inference evaluated at the 95% confidence level.

Overall, the results for beef clearly signal the presence of a single period of structural change which was coincident with the Office of Fair Trading/Competition Commission's investigation period. Furthermore, the effect of the structural change was to enhance (by some 250%) price transmission from downstream producer and wholesalers to retailers during this period compared to the historical average. In effect, retail prices fell more than producer and wholesale prices during this period, in a manner that was uncharacteristic of the transmission process that was observed in the rest of the 1990s.

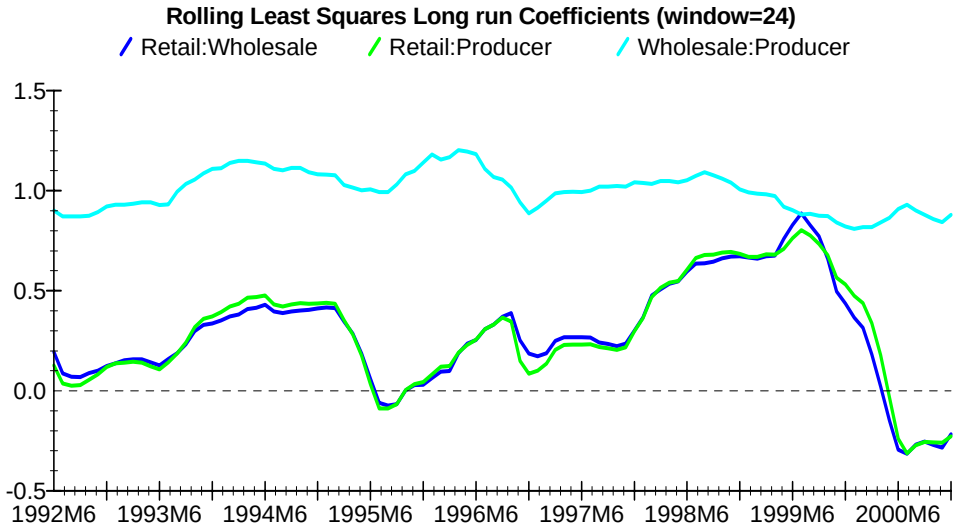
*(ii) Structural Change in Pork Price Transmission*

Conclusions regarding structural change for pork are the same as those for beef. They arise however from slightly different patterns of the raw price data. Whilst the price of pork (like beef) has been in secular decline during the 1990s it rose abruptly following the announcement of March 1996 (unlike beef). That pork prices behave differently to beef in response to BSE simply reflects the beef specific nature of the crisis among substitutes. Inspection of the graph of pork prices (Figure 2) indicates a step-up in all prices during the spring of 1996 followed by a period of decline that lasted in to the

autumn of 1998, where after retail prices stabilised but producer and wholesale prices rose. Consequently, and as with beef, retail spreads (see Figure 5) grew from a low base in 1996, peaked in autumn 1998 and have fallen since.

Applying rolling least squares to the price transmission relationships for pork, two features are apparent (Figure 15). First, while the wholesaler-producer price transmission coefficient has remained around unity, there has been a substantial change in the coefficients that link retail to wholesale/producer prices. Second, price transmission coefficients have changed abruptly in the latter part of the sample in a manner that reflects a rapidly closing spread. Again, this is much the same story as for beef. Interestingly, whereas with the narrowing of the beef spread post-1998 occurred via retail prices falling more rapidly than producer (or wholesale) prices, the same results have been achieved in pork by more radical changes in price transmission behaviour. In the pork market, the data shows that retail prices were falling in this era yet producer (and wholesale) prices were rising.. Since prices have moved in opposite directions in the latter part of the sample, the price transmission coefficients between retail:producer and retail:wholesale are actually *negative*. Hence despite an apparent difference between the rolling least squares results for beef and pork, the reality is that they are both lead to a narrowing of the retail spread since September 1998.

**Figure 15: Rolling Least Squares for Pork**




Formal statistical tests of structural change in pork price relationships are reported in Table 4. Results for Test 1 confirm the presence of structural change in the retail:producer and retail:wholesaler models but not between wholesaler and producer. As was the case for beef, the statistical evidence indicates that the structural change in price transmission observed during the Competition Commission's period of investigation arises due to changes in pricing behaviour at the retail level only. Test 3, which excludes the period of the Competition Commission's investigation, does not detect evidence of structural change in the period following the BSE/vCJD announcement. Note however, that such is the magnitude of the structural change detected in Test 1, that it contaminates the results of Test 2.

**Table 4: Tests for Structural Change in Pork Price Transmission**

| | Test 1<br>1998(8) to 2000(12) | Test 2<br>1996(3) to 2000(12) | Test 3<br>1996(3) to 1998(8) |
|---|---|---|---|
| Retail:Producer Relationship | ✓ | ✓ | × |
| Retail:Wholesale Relationship | ✓ | ✓ | × |
| Wholesale:Producer Relationship | × | × | × |

Note : Inference evaluated at the 95% confidence level.

In sum, the conclusions regarding structural change in price relationships for pork are the same as those for beef, in that they suggest that the only break in the price relationships that can be detected in the 1990s occurs around September 1998 and impacts upon retail prices only.

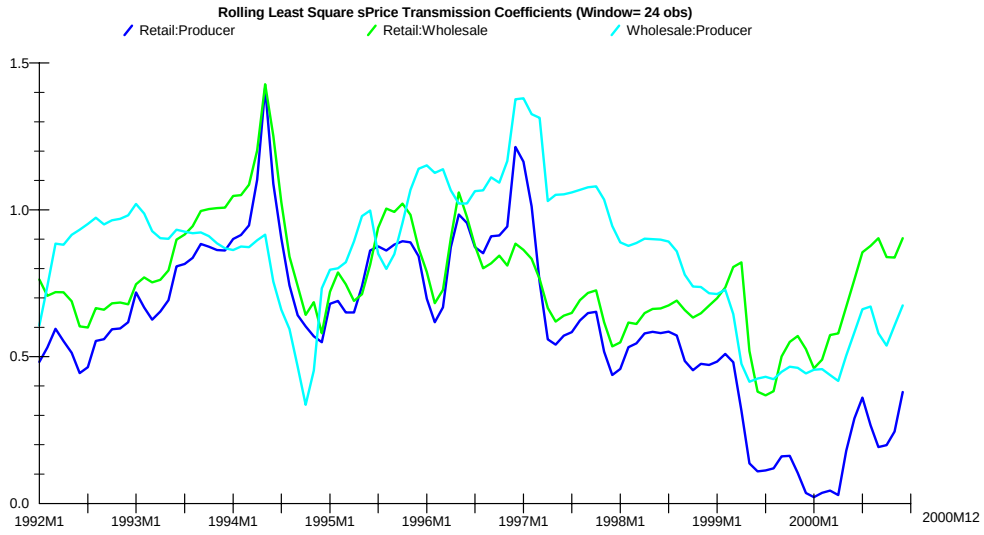
*(iii) Structural Breaks in Lamb Price Transmission*

Overall, the conclusions of the analysis for structural change are broadly similar for lamb. As noted in Section 2, the plot of lamb price data has a different appearance to beef and pork owing to a strong seasonal component. Overall however, the same three sub-periods seem to emerge for lamb, corresponding to (a) pre- spring 1996, (b) spring 1996 to autumn 1998 and (c) post autumn 1998. Inspection of the graph of lamb prices (Figure 3) indicates that all prices have been falling since the spring of 1996, as indeed has been the case for beef and pork. Whereas beef and pork prices had been falling up to this point, lamb prices had been rising and thus the 1996 downturn is all the more evident in the data. As Figure 6 reveals this is also a trigger for the growth in the retail spreads which have been arrested towards the end of the period, in a similar manner to the other products considered. Clearly, it appears as

though BSE has had an impact on lamb prices, although more sophisticated analysis is required to evaluate whether this has actually affected the transmission relationship itself.

Application of rolling least squares (Figure 16) produces a somewhat different picture to that for the beef and pork not least since there appears to be much greater variability in the estimates of price transmission. Nevertheless, all three series appear to decline following the spring of 1996 and rise towards the end of the sample. Whilst the pattern is similar to the results for beef and pork, the upturn during the period of the Competition Commission investigation is less pronounced than for the other meats.

**Figure 16: Rolling Least Squares for Lamb**




Formal tests of structural change are reported in Table 5. Results of Test 1 signal the presence of structural change in the price transmission relationship, and that price transmission is enhanced during the Competition Commission investigation period.

Whilst this mirrors the conclusions for beef and pork, the wholesale:producer relationship also appears to be affected. The numerical impact of structural change in the period is considerably smaller than that observed for beef and pork: point estimates suggest price transmission improved by around 30% (rather than the 250% for beef for example).

Results from Test 2 indicate that the price transmission relationships for lamb pre- and post-March 1996 are statistically different. Since this may due to the effect above detected by Test 1, a more informative assessment is given by results from Test 3, which confirms structural change in the retail price relationships (although not between wholesaler and producer) between the pre March 1996 data and the March 1996 to August 1998 data. Point estimates from the models suggest that price transmission was around 25% less in the period immediate following the BSE announcement. Given that structural change is not present between wholesaler:producer price relationships, it can be inferred that this inhibition of price transmission arose due to change in retail price behaviour only.

**Table 5: Tests for Structural Change in Lamb Price Transmission**

| | Test 1<br>1998(8) to 2000(12) | Test 2<br>1996(3) to 2000(12) | Test 3<br>1996(3) to 1998(8) |
|---|---|---|---|
| Retail:Producer Relationship | ✓ | ✓ | ✓ |
| Retail:Wholesale Relationship | ✓ | ✓ | ✓ |
| Wholesale:Producer Relationship | ✓ | ✓ | ✗ |

Note : Inference evaluated at the 95% confidence level.

The results for lamb not only detect structural change during the Competition Commission investigation period (when transmission increased) but also in the period following the Ministerial announcement (when transmission fell).

Comparing results for across all the meats one common feature emerges, specifically price transmission increased, and for beef and pork markedly so, post-1998. Furthermore, the structural change detected at this time has been shown to emanate principally (although not exclusively) from the retail marketing level. Whether this is due to a 'Competition Commission effect' is conjectural since other factors, such as the introduction of the budget retailer *Wal-mart*, may be responsible either in part or in total, for the improvement in price transmission that has taken place since 1998.

Another important result to emerge from this analysis is that whilst public concern over BSE and similar food scares has played a crucial role in price formation for beef, pork and lamb, it is only in the market for the latter that evidence for 'BSE-induced' structural change in price transmission can be detected. Whilst at first sight this may be surprising, it should be remembered that the Press Stories Index (which is our proxy measure of BSE and similar health concerns) enters directly in to the model. If it were not in the models structural change would be detected in any relationship where the price spread changed systematically. However, since it is included, its impact (strictly speaking, its linear impact) will be taken in to account as part of the modelling process, and as a result dummy variables are ordinarily superfluous. The fact that the dummy variables are statistically significant in the lamb models may be due to one of two (or possibly both) explanations. The first is that the dummy

variables are detecting some non-linearity in the relationship between retail prices and the second is that other factors have intervened during this period and are inadvertently captured by the BSE dummies.

In any event, the coefficients on the dummy variables in the lamb models are consistent with the overall conclusion that price spreads increased in the 1996 to 1998 period (after which they declined), as is the case for beef and pork.

Finally, it is worth considering the structural change results from the perspective of the degree of price transmission. It is readily apparent from the results from the rolling least squares exercise that the degree of price transmission between producer and retail prices is, on average, less than one in the period prior to the structural change. For example, for the beef sector, the average for the period, as a whole, lies between 0.75 and 0.80, a result that is consistent with the previous report. However, for the period post-1998, price transmission rises. Thus we would expect that estimates of price transmission to increase in the future if this aspect of structural change continued to have an effect. For pork and lamb, the results of the impact of the structural change on the degree of price transmission seem less clear cut. However, to estimate these effects properly, this would require further data.

### 4.5 Levelling and Averaging

*Levelling*

While there is no structural model with which direct observation of levelling can be made, implications about such behaviour can be drawn from analysis of the relative variance of prices at the different stages of the chain. In effect what is being examined

is the ratio of the variances of two series because levelling reduces the peaks and troughs of a series and thus makes the series less variable. It is appropriate to assume that producers would not be expected to level prices and thus it is against producer price variance that other price series variance is measured. If the retail and wholesale prices, when allowing for differences in means, are less variable then this could be taken to be evidence of levelling behaviour.

The results for the beef market show that both wholesale and retailer prices are less volatile than producer prices suggesting that levelling behaviour is occurring. Testing the null of levelling between the price pairs in both the pork and lamb chains shows that there is also some evidence of levelling behaviour as both wholesale and retail prices are less volatile than producer prices. Evidence of price levelling was also found in the previous report.

*Averaging*

It might be expected that given the substitutability between meats in consumption that pricing behaviour at the retail and wholesale level might take into account the inter-relationships that exist. Such behaviour, where margins in the market for one meat are a reflection of spreads for meat in another, is referred to as averaging. To test for this behaviour, we introduce the spreads for other meats into an error correction model (ECM) relating to marketing spreads, where a negative coefficient is suggestive of averaging (i.e. for the beef ECM, we introduce pork and lamb spreads. If there is averaging behaviour, the coefficient on the pork and lamb spreads will be negative indicating that as margins in these other sectors rise, spreads in the beef sector fall).

For beef, the evidence for this test is not supportive of averaging at the 5% level and is only marginal at the 10% level, which could be interpreted as showing averaging is not a significant feature in the beef market.

In the pork model, the results show a strong positive relationship between the lamb spread and the prices of pork at all levels, whereas there is no relationship between beef spreads and pork prices at any level. As a result it can be concluded that averaging is not occurring. Finally, in the lamb model, results suggest that averaging is not occurring. The lack of evidence on averaging is also consistent with the results reported in the previous report.

## 5 SUMMARY AND CONCLUSIONS

The main focus for this report has been the nature and extent of price transmission in the beef, pork and lamb marketing chains over the period 1990-2000 as well as including analysis of other aspects of price relationships in these three meat sectors.

The results suggest that, in general, price transmission between producer and retailer prices is between the producer and retail prices in all the markets is higher in the long-run than in the short-run. This is indicative of a highly integrated market in spite of the lower levels of price transmission in the short-run. Specifically, the short run results suggest that price transmission takes time to occur presumably owing to menu costs, expectations formation and other behavioural characteristics of vertically related markets. These results are consistent with the conclusions of the earlier report.

The other main results from the analysis of price transmission are that the adjustment period takes between 3 and 4 months before price changes at the producer are fully reflected in changes in retail prices.

We investigate the dynamics of price transmission further using generalised impulse response analysis. The meat publicity index captures important developments in the UK meat sector over the 1990s that leads us to differentiate the analysis of prices with and without its effects. As noted in the report, this index was both necessary in specifying the underlying model and has a strong quantitative effect on the development of prices due to the feedback influences associated with it. Specifically, we used the impulse response methodology to investigate the impact of meat scares on prices in each marketing chain. The results highlighted the fact that the Press Stories Index (the proxy for the meat scares) had a considerable effect on meat prices and, perhaps most notably, the impact on prices varied by stage in the marketing chain. In the beef sector for example, the impact of the Press Stories Index was greater on producer prices than retail prices. This is in itself would cause a widening of the marketing spread in the beef chain. The impact of meat scares on pork and lamb were also explored with varying results.

Analysis of structural breaks also formed a major part of this study. Although there are several potential structural breaks in the data, the results predominately suggest that structural change may have occurred towards the end of the sample period. Given that the Office of Fair Trading and subsequently the Competition Commission undertook their investigations during autumn 1998 to winter 2000 period, we tested

for the presence of a structural break in the price transmission relationship during this period (as well as the possibility of a structural break in 1996).

While structural change was referred to in the previous report, the longer data set is clearly more helpful as it allows the effects of any change in behaviour to have had time to work through into prices and thus to be more readily apparent in the data. The results are striking and allow firm conclusions to be made. Specifically, marked changes in the price transmission relationship are detected towards the end of the period and formal testing confirms this. One possible inference of this is that the Competition Commission's investigation had an immediate regulatory effect even before its report had been published. However, care should be taken in the attribution of cause and effect since other factors cannot be discounted, such as the entry of *WalMart* into the retail market via its acquisition of ASDA.

With respect to other characteristics of price relationships, there is also evidence of levelling behaviour in all three sectors but no evidence of averaging behaviour in any of these sectors could be found. These results are entirely consistent with the previous report.

In arriving at these results and conclusions, this report has employed the recent innovation of generalised impulse response analysis, a longer data series and also a theoretically superior method to that of the earlier report. Conceptually, the VAR approach dealing with the triplet of prices is more theoretically convincing than models incorporating only the price pairs and future work on prices and marketing margins should follow this approach. This is notwithstanding the issues relating to the

meat publicity index noted above. Within this new framework, we are able to repeat the tests employed in the earlier report, with the added benefit that we are also able to address new questions pertinent to policy makers. On the whole, the main conclusions of the earlier report also hold here. The only exception to this relates to testing of asymmetry, which we now find more generally. This is due to the different method used in the current report.

Finally, it should be noted that not all aspects of price relationships have been investigated and they may deserve further attention in the future. For example, the frequency and amplitude of price adjustment over shorter periods of time are clearly important but cannot be uncovered with monthly data. Using data with higher frequency (for example, daily or weekly) would give greater insight into the pattern and economics of price adjustment that occurs in the UK meat sectors and the UK food sector more broadly. Moreover, given the important role played by the Press Stories Index in the analysis presented here due to the data period covering the BSE crisis, it may be the case that its impact on prices and price adjustment diminishes in the future as BSE becomes a more distant memory. A further issue that requires attention is the degree of price transmission in the post-Competition Commission period. In the report, we have identified a structural break around the 1998 period. This would be expected to have an impact on price behaviour if this has made meat markets (via changes in the behaviour of retailers) more competitive. For example, in the beef market this would be expected to increase the degree of price transmission. However, it is difficult to ascertain these effects with the current data that only stretches for 24 months following the structural break. If the nature of price relationships have changed permanently after this period, then this would require

further research with more recent data. Moreover, as the memory of BSE fades, the impact of meat scares would dissipate thus reducing the role of the press Stories Index on prices in each of the markets. However, this may be offset by a potential impact of foot-and-mouth disease though, given that it was not linked directly to human health, should *a priori* have less of an impact that BSE appears to have done. Nevertheless, in a marketing environment that has faced a number of external shocks in recent years, research on how price relationships are affected by such changes with up-to-date data will provide valuable information for policy-makers.

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# APPENDIX

## Table A1: Comparison of Results with Previous Report

(Previous Results in Parentheses)

| | **Beef** | | **Pork** | | **Lamb** | |
|---|---|---|---|---|---|---|
| Short run Price Transmission<br>Effect of 10p/kg change in producer prices on retail prices | 4.6<br>(3.8) | | 1.5<br>(3.5) | | 2.4<br>(3.9) | |
| Long run Price Transmission<br>Effect of 10p/kg change in producer prices on retail prices | 9.0<br>(7.3) | | 8.5<br>(8.6) | | 7.0<br>(7.8) | |
| Adjustment period | 3 months<br>(4 months) | | 4 months<br>(6 months) | | 6 months<br>(5 months) | |
| Levelling | Retail<br>Wholesale<br>Producer | Yes (Yes)<br>Yes (Yes)<br>No (Yes) | Retail<br>Wholesale<br>Producer | Yes (Yes)<br>Yes (No)<br>No (Yes) | Retailer<br>Wholesaler<br>Producer | Yes (Yes)<br>Yes (No)<br>No (Yes) |
| Averaging | Retail<br>Wholesale<br>Producer | No (No)<br>No (No)<br>No (No) | Retail<br>Wholesale<br>Producer | No (Mixed)<br>No (No)<br>No (No) | Retail<br>Wholesale<br>Producer | No (Mixed)<br>No (Mixed)<br>No(Yes) |
| Asymmetry: Retail:Producer prices | Yes (No) | | No (Yes) | | Yes (No) | |
| Structural Break (1998) | Yes (Not applicable) | | Yes (Not applicable) | | Yes (Not applicable) | |
| Structural Break (1996) | No (Not applicable) | | No (Not applicable) | | Yes (Not applicable) | |