UNIVERSITY OF NOTTINGHAM

Discussion Papers in Economics

Discussion Paper
No. 04/09

PRICE TRANSMISSION IN IMPERFECTLY COMPETITIVE VERTICAL MARKETS

by Tim Lloyd, Steve McCorriston, Wyn Morgan and Tony Rayner

May 2004

DP 04/09
ISSN 1360-2438

UNIVERSITY OF NOTTINGHAM

Discussion Papers in Economics

Discussion Paper
No. 04/09

PRICE TRANSMISSION IN IMPERFECTLY COMPETITIVE VERTICAL MARKETS

by Tim Lloyd, Steve McCorriston, Wyn Morgan and Tony Rayner

Tim Lloyd and Wyn Morgan are Senior Lecturers, Tony Rayner is Emeritus Professor, all in the School of Economics, University of Nottingham, and Steve McCorriston is Professor, School of Business and Economics, University of Exeter

May 2004

Price Transmission in Imperfectly Competitive Vertical Markets

Abstract

This paper focuses on price transmission in a vertically-related set-up where the retail stage may exercise oligopoly and/or oligopsony power, an issue addressed by the UK anti-trust authority investigation of the food retailing sector. From a theoretical perspective, we set out simple tests that relate to the way in which market power may affect the transmission of shocks between retail and farm prices. Using price data for the UK beef market over the 1990s, the empirical results confirm the presence of market power with oligopoly rather than oligopsony being the dominant characteristic of the UK food retailing sector.

INTRODUCTION

Growing concern about the degree of competition in UK food retailing culminated in an extensive official inquiry by the UK's anti-trust authority, the Competition Commission in 2000. Attention was drawn to the presence of large national multiple retail chains that dominated the market, with the 5-firm concentration ratio in UK food retailing being around 67% (Dobson Consulting, 1999). In this light, the potential for market power abuse, with respect to both upstream suppliers and downstream consumers was apparent and a focus of media attention. The inquiry investigated 52 practices routinely employed by the food retailing multiples of which 29 were found to be acting against the public interest. Of these, 27 were related to the impact on upstream suppliers and two related to the impact on consumers (Competition Commission, 2000).

In arriving at these results, the Competition Commission undertook an analysis of price transmission in specific food markets, particularly the markets for fresh meat, which had been greatly affected by the Bovine Spongiform Encephalopathy (BSE) crisis during the 1990s. Apart from the obvious concern with human health, the concern addressed by the Competition Commission was that the BSE crisis had a differential effect on UK retailers and farmers. Specifically, it was argued that while the BSE crisis reduced the consumption and price of beef at all levels in the vertical chain, the decline in beef prices at the retail level was substantially less than that faced at the producer level, resulting in a significant increase in the retail:producer price margin and that this differential effect was due to market power exercised by food retailing firms. [1]

The principal that in the presence of oligopoly that prices should adjust differentially to changes in costs (or, in parallel with the public finance literature, changes in policy such as taxes) is one that has been addressed in the industrial organisation literature. It is well-known from Seade's (Seade 1985) seminal work that, under fairly reasonable assumptions relating to the curvature of the demand function, that an increase in costs will not be fully reflected in a commensurate change in prices. Other papers that have

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

addressed this issue include Dixit (1986) and Stern (1987) among others. Empirical work has been relatively more limited though Fuerstein (2002) has addressed this issue in relation to the incidence of costs in the German coffee market while Bettendorf and Verboven (2000) have addressed the same issue with respect to the Dutch coffee market. Borenstein *et al*. (1997) focussed on price adjustment in a vertically-related market applied to the US gasoline market though their emphasis was more on detecting evidence of asymmetric price adjustment.[2]

This paper adds to this literature in a number of ways. First, the focus is on demand shifts and how the adjustment in retail prices may differ from the adjustment of prices in upstream sectors when one of the stages in the vertical chain is characterised by market power. As noted by Quirmbach (1988), the incidence of demand side shifts may differ from cost shifts. The focus on demand side shifts allow us to conduct an empirically-meaningful exercise as the UK food sector was characterised by the BSE crisis in the 1990s, thus allowing the use of data on an obvious demand shifter in order to identify the presence of market power. Second, in order to interpret the evidence of price adjustment that we report, we set out a theoretical model of price transmission in the presence of demand shocks where the food retailing sector is characterised by oligopoly and/or oligopsony power. The presence of each source of distortion is therefore consistent with the concerns highlighted by the UK Competition Commission in their investigation of the food retailing sector. Moreover, it is likely that, due to the nature of our demand shifter, consumers changed their consumption patterns and switched their consumption to substitute meats. We show in our formal framework that if this substitution effect existed, it would only have an effect on price transmission between the vertical stages if market power (specifically oligopoly power) was exercised by food retailers. If the food retailing sector was competitive, the switch into substitutes would have no effect on vertical price transmission. While the theoretical framework sets out the way in which market power may impact on price transmission, we use data for the UK meat market for the 1990s to test whether the pattern of vertical price adjustment, consistent with the presence of market power, is present in the data. Moreover, depending on the nature

[2] Related to the cost incidence issue has been empirical studies on tax incidence in the presence of imperfect competition but this avenue of research has been relatively limited. See, for example, Delipalla and O'Donnell (2001) for a recent example.

of price transmission in response to a demand shock, we are able to assess whether oligopoly or oligopsony was the dominant feature of food retailing in the 1990s.

The paper is organised as follows. In section 1, we set out the theoretical framework which identifies the likely impact of a demand shift on price transmission between stages if market power characterises the food retailing sector. In section 2, we outline our econometric strategy. While much of this relates to the application of standard time series econometrics, we also outline a means of decomposing the potential impact of substitutes on price transmission between vertical stages which, as we have noted, will be relevant in the context of price transmission in imperfectly competitive markets. In section 3, we provide details on the data used while in section 4 we report the results. In section 5, we summarise and conclude.

1. VERTICAL PRICE TRANSMISSION WITH MARKET POWER

We characterise a vertically-related market with the competitive upstream stage supplying the product to the imperfectly competitive downstream retiling stage. We assume that the stages are linked by a quasi-fixed fixed proportions technology as in Rodgers and Sexton (1994).[3] [4] Reflecting the Competition Commission's concerns, the exercise of market power may reflect oligopoly and/or oligopsony power.[4] The shock to the market comes via a demand shift that directly affects the retailing stage. This shock represents one of the dominant feature of the UK meat market over the 1990s.

We begin with a retail demand function for the processed product given by:

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

where R is the retail price and X is the demand shifter. The supply function of the agricultural raw material is given by (in inverse form):

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

[3]This simplifies the algebra and is consistent with the data used in the empirical analysis. Incorporating a variable proportions technology has little bearing on the theoretical results.

[4] Previous research, largely relating to the US, has confirmed the presence of market power in the food sector though this research has largely on food processing rather than retailing sectors. See, for example, Azzam and Pagoulatos (1990) and Bhuyan and Lopez (1997).

where A is the quantity of the agricultural raw material.

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

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

where C_i is other costs and $Q_i = A_i / a$ where a is the input:output coefficient. The first order condition for profit maximisation is given by:

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

or, in elasticity form:

$$R(1 - \frac{\theta_i}{\eta}) = M_i + aP(1 + \mu_i \varepsilon) \tag{5}$$

where η is the absolute value of the market price elasticity of demand for the processed product, θ_i is the conjectural elasticity of firm i in the processed market, $M_i\,(= \partial C_i / \partial Q_i)$ is the marginal cost of firm i, ε is the inverse of the price elasticity of supply of the agricultural raw material and μ_i is the conjectural elasticity of firm i in the raw material market.[5]

Using market shares as weights $(s_i = Q_i / Q)$ and summing over all firms, gives:

$$R(1 - \frac{\theta}{\eta}) = M + aP(1 + \mu\varepsilon) \tag{6}$$

where θ and μ are industry level market power parameters and M is the industry-level marginal cost. Equation (6) can usefully be re-written as:

$$R = \lambda[M + aP(1 + \mu\varepsilon)] \tag{7}$$

where $\lambda = \eta/(\eta - \theta)$.

Differentiating (7) with respect to an exogenous change in the demand function written in logarithmic form gives:

$$d\ln R = -\delta d\ln R + \psi\phi d\ln X + \frac{\alpha(1 + \varepsilon\mu(1 + \gamma))}{1 + \alpha\varepsilon\mu} d\ln P \tag{8}$$

[5] The distinction between oligopoly and oligopsony power is somewhat arbitrary when considering the impact on upstream suppliers as the ‘horizontal’ conjecture will still impact on quantities sold and prices received by upstream suppliers.

where, $\delta = \omega\theta/(\eta - \theta)$, $\omega = \partial \ln \eta / \partial \ln R$, $\psi = (-\theta/\eta - \theta)\varsigma$, $\varsigma = \partial \ln \eta / \partial \ln Q \big| R$, $\phi = \partial \ln Q / \partial \ln X$, $\gamma = \partial \ln \varepsilon / \partial \ln P$ and $\alpha = aP/(M + aP)$.

Noting from (1) and (2) that:

$$d \ln P = \varepsilon d \ln Q = -\varepsilon\eta d \ln R + \varepsilon\varphi d \ln X \tag{9}$$

equation (8) can be re-written as:

$$d \ln R = -\delta d \ln R + \psi d \ln X - \frac{\alpha\varepsilon\eta B}{D} d \ln R + \frac{\alpha\varepsilon B}{D} d \ln X \tag{10}$$

where, $B = (1 + \mu\varepsilon(1 + \gamma))$ and $D = 1 + \alpha\varepsilon\mu$.

Using (9) and (10) we have:

$$d \ln R = \frac{\psi D + \alpha\varepsilon B}{D + \delta D + \alpha\varepsilon\eta B} \phi d \ln X \tag{11}$$

$$d \ln Q = \frac{D(1 + \delta - \eta\psi)}{D + \delta D + \alpha\varepsilon\eta B} \phi d \ln X \tag{12}$$

$$d \ln P = \frac{\varepsilon D(1 + \delta - \eta\psi)}{D + \delta D + \alpha\varepsilon\eta B} \phi d \ln X \tag{13}$$

where all variables are defined as above.

Using this framework, leads to the following proposition:

Proposition 1: Market power at the retail stage, either in form of oligopoly or oligopsony power, will result in a differential impact on farm level prices than on retail prices following an exogenous shift in the demand function. With oligopoly power, price transmission from retail to farm prices will increase; with oligopsony power, price transmission will decrease.

We can use (11) and (13) to show the impact of a demand shock on price transmission in the form of a 'pass-back' elasticity (ρ):

$$\rho = \frac{d \ln P / d \ln X}{d \ln R / d \ln X} = \frac{\varepsilon D(1 + \delta - \eta\psi)}{\psi D + \alpha\varepsilon B} \tag{14}$$

Consider the case of no market power (i.e. $\mu = \theta = 0$). Then (14) simplifies to:

$$\rho^c = \frac{1}{\alpha} \tag{14'}$$

where the superscript c refers to the competitive case. Specifically, if the retailing stage were competitive, the degree of price transmission between the retail and upstream stages, should reflect only the share of the upstream input in the downstream cost function. With a simple 1:1 technology, farm prices should change by the same amount as retail prices following the demand shock. In the case of oligopoly power but no oligopsony power (i.e. $\theta > 0, \mu = 0$), (14) can be re-written as:

$$\rho^{op} = \frac{\varepsilon(1+\delta-\eta\psi)}{\psi+\alpha\varepsilon} \qquad (14'')$$

where the superscript op refers to the oligopoly case. In the case of oligopsony power only (i.e. $\mu > 0, \theta = 0$), the pass-back elasticity is given by:

$$\rho^{os} = \frac{(1+\alpha\varepsilon\mu)}{\alpha(1+\varepsilon\mu(1+\gamma))} \qquad (14''')$$

where the superscript os refers to the oligopsony case.

The most straightforward way to see the impact of market power on retail and farm prices is to take representative values for the parameters in (14) and (14')-(14'''). The results are presented in Table 1. As can be seen from the table, with oligopoly in the retail sector, the price transmission elasticity increases compared to the competitive benchmark following an exogenous shift in the retail demand function. This implies that the margin between retail and farm prices widens (narrows) following a negative (positive) demand shock. With oligopsony power of retailers vis-à-vis farmers, price transmission will be expected to decrease relative to the competitive case, the implication here being that the margin between retail and farm prices will narrow (widen) following a negative (positive) shock that shifts the demand curve. The relevant issue for this paper is not to test formally for the presence of market power as captured in values for the aggregate conjectures but to ascertain what we should expect from the direction of the empirical results if one aspect of market power was to dominate the other given the concerns of the UK anti-trust authority.

Table 1: Impact of Market Structure on Price Transmission Following a Shift in the Retail Demand Function

Market Structure	Price Transmission Elasticity
Competitive	1
Oligopoly Power only	1.6
Oligopsony Power only	0.8
Both Oligopoly and Oligopsony Power	1.4

Linear demand and supply functions were assumed which implies $\omega = 1 + \eta$ and $\gamma = (1 - \varepsilon)/\varepsilon$. Values for the remaining parameters were assumed to be: $M = 0$ (which implies $\alpha = 1$), $\varepsilon = 2.5$ (which implies a supply elasticity of 0.4), $\eta = 0.4$, $\theta = \mu = 0.25$

Another means of using the price transmission model to infer the presence of market power is to identify the role of substitute products. Data shows that as beef consumption fell following the BSE crisis, consumption of other meats increased (see, for example, DTZ Pieda, 1998). The most straightforward way to capture this multi-market effect is to follow the approach of Gardner (1987, p. 64) where the elasticity of demand for a specific product is re-interpreted as a total elasticity which in a multi-market context can be expressed as:

$$\eta_i^T = \eta_i - \sum_{\substack{i \neq j \\ j=1}}^{n} \eta_{ij} \zeta_{ij} \tag{15}$$

where η_i^T is the total elasticity of good i, η_i is the partial elasticity, η_{ij} is the elasticity of substitution between product i and j and ζ_{ij} is the relationship between the prices of the substitute products ($= d \ln P_j / d \ln P_i$). Re-interpreting the absolute value of the elasticity of demand as the total elasticity of demand, the value of η in (14) and (14')-(14''') is reduced and leads to the following proposition.

Proposition 2: In the presence of oligopoly and substitute products at the retail level, the pass-back elasticity between farm and retail prices following a shock to the retail demand curve will increase. In a competitive market, the presence of substitutes following a demand shift will have no effect on vertical price transmission.

To see the effect of reducing the elasticity of demand in the pass-back elasticity, consider once again equations (14')-(14'''). It is clear from this that changing the elasticity of demand will only matter in the presence of oligopoly power (mainly because the change in the elasticity of demand changes the elasticity of the firms' aggregate mark-up.) The role of substitutes does not matter in either the competitive or oligopsony cases (see equations (14') and (14''')). As above, the easiest way to infer the impact of the role of inter-related markets is to choose representative values for the parameters and derive the value of (14''). The result of this is reported in Table 2 where we have chosen alternative values for η keeping the value for the remaining parameters as in the previous example.

Table 2: The Effect on Price Transmission with Inter-related Markets following a Shock to the Retail Demand Function

(Total) Elasticity of Demand	Pass-Back Elasticity with Oligopoly
$\eta = 0.3$	2
$\eta = 0.4$	1.6
$\eta = 0.5$	1.4

Values are derived using (14'') with all parameters values the same as in Table 1 except for alternative values for η. Linear functional form was also assumed.

It is clear from the above that the impact of introducing links between substitute markets is to reduce the value of the total elasticity which in turn increases the differential effect on farm and retail prices following a shock to the retail demand curve. Relating this to the econometric framework reported below, we endeavour to decompose the effects of the demand shift into the direct and indirect effects. If the latter are sufficiently ‘strong’, this will also be indicative of market (specifically oligopoly) power in the food retailing sector.

To sum up, what we would expect from the empirical results is that if oligopoly (oligopsony) power is the dominant characteristic of the UK food retailing sector, then farm level prices will fall by more (less) than retail prices following a shock to the retail demand curve. In addition, in the presence of substitutes at the retail level, the price depressing effect of the demand shock should be exacerbated and that the indirect effect of substitutes on vertical price transmission to be an important influence. This would provide confirmation of oligopoly being the dominant feature of the UK food retailing sector over the period studied. We explore these issues in the remainder of the paper using the data from the UK beef market covering the 1990s.

2. ECONOMETRIC METHODOLOGY

We couch the empirical analysis in a vector autoregressive (VAR) framework to exploit the non-stationarity and co-integration that may exist between the variables (specifically prices at the retail and farm levels) within the theoretical model. Thus, consider a VAR(p) model:

$$\mathbf{x}_t = \mathbf{\Phi}_1 \mathbf{x}_{t-1} + \mathbf{\Phi}_2 \mathbf{x}_{t-2} + \ldots + \mathbf{\Phi}_p \mathbf{x}_{t-p} + \mathbf{\Psi} \mathbf{w}_t + \boldsymbol{\varepsilon}_t \tag{16}$$

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

Providing there is at least one co-integrating (equilibrium) relationship between the variables, we may re-parameterise (16) in error correction form given by:

$$\Delta\mathbf{x}_t = \boldsymbol{\alpha}\boldsymbol{\beta}'\mathbf{x}_{t-p} + \sum_{i=1}^{p-1} \mathbf{\Gamma}_i \Delta\mathbf{x}_{t-i} + \mathbf{\Psi}\mathbf{w}_t + \boldsymbol{\varepsilon}_t \tag{17}$$

Of key interest is the $(n\times r)$ matrix of co-integrating vectors, $\boldsymbol{\beta}$, that quantify the co-integrating relationships between the variables in the system and the $(n\times r)$ matrix of error correction coefficients, $\boldsymbol{\alpha}$, whose elements load deviations from this equilibrium (*i.e.* $\boldsymbol{\beta}' \mathbf{x}_{t-k}$) into $\Delta\mathbf{x}_t$, for correction. The short-run effects of shocks on $\Delta\mathbf{x}_t$, are estimated by the $\mathbf{\Gamma}_i$ coefficients in (17) which allow for differences between short and long run responses.

In terms of the vertical market for beef, the coefficients in $\boldsymbol{\beta}$ quantify the linkages that bind prices together in the long run. As set out in section 2 above, we posit these linkages represent the price transmission relationship both between substitute meats at the retail level and between producer and retailers of beef. However, as Lütkephol and Riemers (1992) make clear, the coefficients of these vectors may be difficult to interpret when the variables in the system are characterised by strong knock-on and feedback effects, since they represent partial derivatives predicated on the *ceteris paribus* assumption. Where the variables are inter-related, as in a vertical market, impulse response analysis, which takes account of these interactions, provides a tractable solution since it delivers time profiles of the effect of hypothetical shocks to $\boldsymbol{\varepsilon}_t$ on the level of $\mathbf{x}_t$, thereby taking into account the knock-on and feedback effects that characterise the variables in a dynamical system such as (16). Furthermore, the *generalised impulse response function* (Pesaran and Shin, 1998) is particularly attractive for dynamic simulation since, unlike the orthogonalised impulse response function (Sims, 1980), it is invariant to the ordering of the variables in the VAR, and is thus unique.

Decomposition Effects

In order to evaluate the impact of imperfect competition on price transmission, we need to take into account of the presence of substitute goods at the retail level if we suspect the presence of oligopoly. As such we can think about the impact of a demand shift (the BSE crisis) being due to a direct effect (consumers reduce consumption of beef due to the food scare) and an indirect effect (consumers switch into substitute meats). Each if these effects will matter for price transmission if oligopoly characterises the food retailing sector.[6] To decompose these effects, we rely on alternative specifications of the impulse response functions. Expressing the VAR in its moving average [MA(∞)] representation:

$$\mathbf{x}_{\mathrm{t}} = \boldsymbol{\varepsilon}_t + \mathbf{A}_1\boldsymbol{\varepsilon}_{t-1} + \mathbf{A}_2\boldsymbol{\varepsilon}_{t-2} + \ldots + \sum_{i=0}^{\infty}\mathbf{A}_i\boldsymbol{\Psi}\mathbf{w}_{t-i} \qquad (18)$$

where the ($m \times m$) coefficient matrices $\mathbf{A}_i$ are obtained according to:

$$\mathbf{A}_i = \boldsymbol{\Phi}_1\mathbf{A}_{i-1} + \boldsymbol{\Phi}_2\mathbf{A}_{i-2} + \ldots + \boldsymbol{\Phi}_p A_{i-p} \qquad i = 1,2,\ldots,$$

[6] To clarify, each of these effects will impact on retail and farm prices but a differential effect will arise only in the presence of market power and oligopoly will be the dominant characteristic if the effect of substitutes matters.

with $\mathbf{A}_0 = \mathbf{I}_m$ and $\mathbf{A}_i = \mathbf{0}$ for $i < 0$. In this moving average representation of the model:

$$\mathbf{A}_n = \frac{\partial \mathbf{x}_{t+n}}{\partial \boldsymbol{\varepsilon}_t'}$$

comprises coefficients that measure the effects *n* periods after a system-wide shock to the disturbances on each variable in the system. Specifically, the ij^{th} element of the $\mathbf{A}_n$ matrix defines the effect of a one unit increase in the j^{th} variable's disturbance at time *t* (ε_{jt}) on the i^{th} variable at time $t+n$, ($x_{i,t+n}$), holding all other disturbances at all dates constant. A plot of the ij^{th} element of $\mathbf{A}_n$, i.e.,

$$\frac{\partial x_{i,t+n}}{\partial \varepsilon_{jt}} \tag{19}$$

as a function of n is the *impulse response function* {$\varphi_{i,j}(n)$}. However, the *ceteris paribus* clause upon which (19) is predicated, denies the dynamic interaction that the VAR attempts to capture. Indeed, (19) assumes that the disturbances in (16) are uncorrelated and thus that Σ is diagonal. Given that a shock to ε_{jt} may simultaneously perturb all other variables, and in turn $\mathbf{x}_{t+n}$, the total effect of the shock is the quantity of interest. Focussing on $x_{i,t+n}$, the net effect of these interactions is given by:

$$\frac{dx_{i,t+n}}{d\varepsilon_{jt}} = \frac{\partial x_{i,t+n}}{\partial \varepsilon_{1t}}\delta_1 + \frac{\partial x_{i,t+n}}{\partial \varepsilon_{2t}}\delta_2 + \ldots + \frac{\partial x_{i,t+n}}{\partial \varepsilon_{mt}}\delta_m \tag{20}$$

where $(\delta_1, \delta_2, \ldots, \delta_m) = \boldsymbol{\delta}$ defines the extent to which the shock to ε_{jt} contemporaneously 'impacts' on all other variables.

The *generalised impulse response function* offers a measure of (20) that, unlike the orthogonalised impulse response function of Sims is invariant to the ordering of the variables in the VAR. The impulse response function {$\varphi_{i,j}(n)$} and the generalised impulse response function {$\varphi^g_{i,j}(n)$} provide a basis for comparison of the relative size of the direct and indirect effects of shocks. Specifically, we can derive:

$$\iota_n = \frac{\varphi_{i,j}(n)}{\varphi^g_{i,j}(n)} \tag{21}$$

which measures the relative importance of direct to total effects on variable i, n periods following a unit shock to variable j.

3. DATA

We use data on retail and farm prices for beef and retail prices for substitute meats. The data are supplied by the UK's Department of Environment, Food and Rural Affairs (DEFRA) and cover the period January 1990 to December 2001. All beef prices are measured in pence per kilogram (p/kg) and are expressed in 'carcass weight equivalents' to allow direct comparison between the different levels of the marketing chain. In addition, all prices have been deflated by the retail price index (December 1999 base).[7] Reflecting the characteristics of this market over the 1990s, the demand shifter we employ is an index of media coverage about the health and safety of beef. It is based on a count of newspaper articles per month. It covers the same period as the price data and as such begins before, and ends after, the BSE crisis in the UK.

Since the experience of BSE accumulates over time, we do not use the index as a demand shifter as a simple count of media stories. Rather, to capture the effect of 'memory', we model this media index as:

$$s_t = (1-\lambda)i_t + \lambda s_{t-1} \tag{22}$$

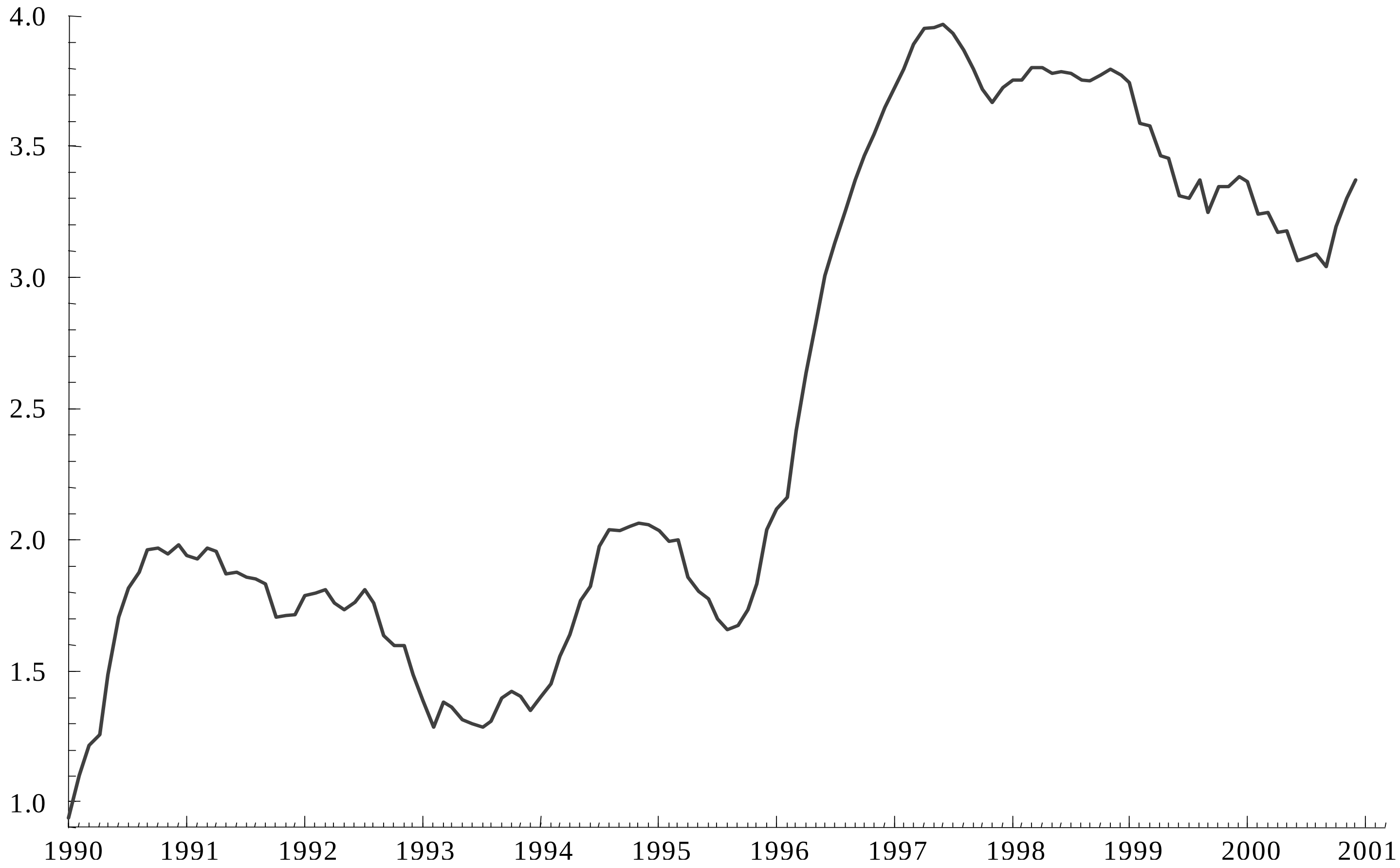
where s_t is the log of the stock of media information and i_t is the monthly publicity count. In the context of equation (22), the optimal value of λ is estimated at 0.93, implying a long but imperfect memory of the food scare.[8] The estimated habituation rate, $(1-\lambda)$, of 7% may be interpreted as the estimated rate at which media information is discounted or 'forgotten' from the stock of news. In other words, this suggests that half the stories are "forgotten" within approximately ten months. This measure which we call the meat scares index is plotted in Figure 1. This is the demand shifter used to identify the price transmission effect and the role of market power in determining the direction and magnitude of this effect.

---

[7] Details of the construction and transformation of the price series can be found in MAFF (1999).

[8] Details of the methods and results of the grid search over λ are available on request

Figure 1: The Meat Scares Index 1990-2001



4. EMPIRICAL RESULTS

The results in Table 3 confirm that the retail prices of beef, pork, lamb and chicken (RB_t, RP_t, RL_t and RC_t respectively), the producer price of beef (PB_t) and the Meat Scares Index (s_t) are all integrated of order one, I(1).

Table 3: Augmented Dickey-Fuller Test Statistics (Jan 1990– Dec 2000)

Variable	Levels (lag)	Differences (lag)	Inference
RB_t	-1.73 (0)	-10.98** (0)	RB_t ~I(1)
RP_t	-1.65 (0)	-9.87** (0)	RP_t ~I(1)
RL_t	-2.23 (3)	-7.39** (2)	RL_t ~I(1)
RC_t	-2.94(10)	-3.79**(10)	RC_t ~I(1)
PB_t	-2.47 (2)	-6.63** (0)	PB_t ~I(1)
s_t	-2.76 (7)	-5.87** (0)	s_t ~I(1)

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

Equation (16) is estimated for $p = 1,\ldots,5$ with constant, trend and seasonals. The Akaike Information Criterion selects the VAR(2) model which passes both vector (and equation)-based tests for residual auto-correlation, ARCH, and heteroscedasticity at the 5% level. Diagnostic checking points to the presence of outliers in the equations for PB_t, RP_t and RC_t around March 1996, which coincides with the Ministerial announcement linking BSE and vCJD. These are accounted for by dummy variables in the final model.

Co-integration among the variables is evaluated using Johansen's Trace test.[9] Results are reported in Table 4 and clearly indicate the presence of two co-integrating vectors at the 5% level. In the absence of additional restrictions the co-integrating relations are unidentified, and hence merely represent statistical rather than economic relationships without meaningful interpretation. However, it is likely that they

[9] Johansen's second test, maximum eigenvalue, also confirms the presence of two co-integrating vectors but given this is sensitive to departures from residual normality, and have thus been omitted.

represent the relationship between meat prices at retail level and the price transmission relationship between retail and producer prices. If so, we have a set of over-identifying restrictions, namely that producer prices are excluded from the retail relation and that the prices of substitutes are excluded from the price transmission relationship.

Table 4: Co-integration Test Statistics

H_0	Trace Statistic	5% critical values
$r=0$	130.0	94.2
$r=1$	70.5	68.5
$r=2$	39.8	47.5
$r=3$	17.0	29.7
$r=4$	4.2	15.4
$r=5$	0.8	3.8

Notes: Critical values are derived by Osterwald-Lenum

Normalising on the price of beef at retail and producer levels respectively yields:

$$RB = 0.59RP + 0.47RL + 1.10RC - 34.99s \tag{23}$$

$$PB = 1.00RB - 8.31s \tag{24}$$

which is not rejected at the 5% significance level (test of over-identifying restrictions: $\chi^2(3) = 7.34$). Consequently, although the normalisation is arbitrary, these equations may be legitimately interpreted as characterising the vertical links between retail and farm prices and the role of inter-related markets at the retail level.

Whilst the coefficients in equations (23) and (24) are informative, it should be born in mind that they represent partial derivatives and thus ignore the ‘knock-on’ and ‘feed-back’ effects that characterise the inter-relationships between the meat prices in this system. The generalised impulse response function developed by Pesaran and Shin (*op. cit.*) explicitly allows for these interactions and thus offers a convenient tool with which to investigate what might be more appropriately called ‘long run’ responses – the eventual impact that one might observe following a shock. Figure 2 shows the simulated effect of a shock of typical size (one standard error) to the meat scares index on all meat prices in the twelve months following this hypothetical shock.

Figure 2: The Simulated Dynamic Effect of Shocks to the Meat Scares Index

There are two obvious outcomes from this simulation. First, the food scare induces a differential effect on beef prices at the retail and farm stages. Specifically, the farm gate price of beef falls by two and a half times more than the fall experienced at the retail level. Taking the mean values for retail and farm level beef prices and that a one standard error shock to the index represents approximately 6 per cent of the value of the index, the elasticities of prices at both levels with respect to the index can be derived. Specifically, the elasticity of retail beef prices with respect to shock to the meat scares index is -0.063% and the comparable elasticity for producer prices is -0.275%. In turn, this implies a pass-back elasticity (ρ) of around 4.4, twice that implied by the estimates provided in (24) above. Moreover, these figures imply that a doubling of the meat scares index would lower retail beef prices by 12.6 per cent and producer prices by 55 per cent. Taken together, the empirical results are consistent with the predominance of oligopoly at the retail level in determining the impact of the demand shift on the price transmission elasticity.

Second, the demand shifter causes the retail price of beef to fall and the prices of other retail meats to rise in a manner consistent with substitution as is evident from Figure 2. As noted above, the role of substitutes also affects the degree of price transmission when oligopoly power is present. Using (21) it is possible to estimate the proportions of the total impact on retail beef prices emanating from the direct and indirect effect of the demand shock. Recall that the direct effect is the impact of the shift of the demand function and the indirect effect being the impact of consumers' ability to switch into substitute meats. The results of the decomposition show that the availability of substitutes was to exacerbate the decline in beef prices. Specifically, while the direct effect of the food scare accounts for around 40 per cent of the decline in retail beef prices, around 60 per cent was due to the switch to substitute meats. The implication of the results from this decomposition that price transmission was exacerbated by the ease with which consumers were able to substitute out of the consumption of beef and that this effect is consistent with oligopoly being the dominant feature of the food retailing sector with respect to upstream suppliers.

5. SUMMARY AND CONCLUSIONS

This paper has focussed on the potential presence of market power in the UK food retailing sector, an issue that has drawn recent attention from the UK anti-trust authority. Specifically, it was motivated by the public concerns raised about the differential impact of price adjustment on retailers and producers, the concern being that prices at the farm gate fell by more than retail prices in the wake of the BSE crisis. In this paper we have shown formally how imperfect competition is likely to result in a differential effect on prices at different stages of vertical chain following a shift in the retail demand function. We have also shown, given that the beef market is tied to substitutes, how the presence of substitutes can also have an impact on price adjustment in the presence of market power.

The results are consistent with the concerns addressed by the Competition Commission. Following a demand shift as captured by the food scare index, if oligopoly power at the retail level exists, farm level prices will be expected to fall by more than retail prices. The results show that, empirically, this effect is large with the price effect at the farm level following the BSE scare to be more than double that occurring at the retail level. Moreover, the availability of substitutes also has non-trivial impact particularly on price adjustment at the retail level. Taken together, the empirical results are consistent with the theory of price transmission in the presence of market power. Specifically, the results are consistent with oligopoly being the dominant feature of the UK food retailing sector. As such, although the Competition Commission concluded that there was no discernible abuse of market power vis-à-vis consumers, the results reported here confirm that the concern in relation to the impact of market power on upstream suppliers was warranted.

REFERENCES

Azzam, A. and E. Pagoulatos (1990) 'Testing Oligopolistic and Oligopsonistic Behaviour: An Application to the US Meat Packing Industry', *Journal of Agricultural Economics*, 41, 362-370.

Bettendorf, L. and F. Verboven (2000) 'Incomplete Transmission of Coffee Bean Prices: Evidence from the Dutch Coffee market' *European Review of Agricultural Economics*, 27, 1-16.

Borenstein, S., C. Cameron and R. Gilbert (1997) 'Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes?' *Quarterly Journal of Economics*, 112, 305-339.

Bhuyan, S. and R.A. Lopez (1997) 'Oligopoly Power in the Food and Tobacco Industries', *American Journal of Agricultural Economics*, 79, 1035-1043.

Competition Commission. (2000) *Report on the Supply of Groceries from Multiple Stores in the United Kingdom* (3 Volumes).CM 4842. London HMSO.

Delipalla, S. and O. O'Donnell (2001) 'Estimating Tax Incidence, Market Power and Market Conduct: The European Cigarette Industry' *International Journal of Industrial Organisation,* 19, 885-908.

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.

Dixit, A.K. (1986) 'Comparative Statics for Oligopoly' *International Economic Review*, 27, 1-16.

Dobson Consulting. (1999) *Buyer Power and its Impact on Competition in the Food Retail Distribution Sector of the European Union* Report prepared for the European Commission. Brussels.

Gardner, B.L. (1987) *The Economics of Agricultural Policies*. Macmillan, New York.

Johansen, S. (1988) 'Statistical Analysis of Co-integrating Vectors' *Journal of Economic Dynamics and Control*, 12, 231-254.

Lütkepohl, H. and Reimers, H.E. (1992) 'Impulse Response Analysis of Co-integrated Systems', *Journal of Economic Dynamics and Control*, 16, 53-78.

MAFF (1999), "A Report of an Investigation into the Relationship Between Producer, Wholesale and Retail Prices of Beef, Lamb and Pork", Ministry of Agriculture, Fisheries and Food, HMSO, London.

MacKinnon, J.G. (1991) 'Critical Values for Co-integration Tests' in R.F. Engle and C.W.J.Granger (eds.) *Long-Run Relationships*. Oxford University Press, Oxford.

Osterwald-Lenum, M. (1992) ‘A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Co-integration Rank Test Statistics’, *Oxford Bulletin of Economics and Statistics,* 56, 461-472.

Pesaran, H. and Shin, Y. (1998) 'Generalised Impulse Response Analysis in Linear Multivariate Models'. Economics Letters, 58, 17-29.

Quirmbach, H.C. (1988) ‘Comparative Statics for Oligopoly: Demand Side Effects’ *International Economic Review*, 29, 451-459.

Rogers, R.T and R. J. Sexton (1994) 'Assessing the Importance of Oligopsony Power in Agricultural Markets' *American Journal of Agricultural Economics* 76, 1143-1150.

Seade, J. (1985) 'Profitable Cost Increases and the Shifting of Taxation: Equilibrium Responses of Markets in Oligopoly'. University of Warwick Discussion Paper, No. 260.

Sims, C. (1980) ‘Macroeconomics and Reality’ *Econometrica*, 48, 1-48.

Stern, N. (1987) ‘The Effects of Taxation, Price Control and Government Contracts in Oligopoly and Monopolistic Competition’ *Journal of Public Economics*, 32, 133-158.