HOW IMPORTANT IS PRICE LEADERSHIP IN THE UK FRESH FRUIT AND VEGETABLE MARKET?

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ABSTRACT
The purpose of this paper is to analyse whether price leadership is present in the market for selected fresh fruits and vegetable and whether it plays any role in the pricing decisions of two major retailers in the UK: Tesco and Sainsbury's. This is done using weekly price data for six products sold in the supermarkets. The empirical methodology used in the paper consisted of three consecutive steps: first, a statistical analysis of the properties of the prices; second, a causality analysis of the series using Granger causality tests with the purpose of investigating the existence of price leadership; third, modelling the interrelationships of both supermarket prices by means of vector autoregressive models (VARs) for each product and simulating the retailers' interaction using impulse-response functions. Except in the case of tomatoes, where Tesco appears as the leader since 2001, the other results are mixed, probably reflecting the changes in the marketing of fruit and vegetables market during the period of study.

Keywords: supermarket pricing, perishable products, fruits and vegetables.

1. INTRODUCTION

As it is well known in economics, under perfect competition, the price of a product tends to change due to variations in the supply conditions (e.g., changes in the production cost, distribution costs, seasonality) and/or demand conditions (e.g., changes in preferences). However, when the number of suppliers in the market is reduced (and especially if the firms have market power) the pricing of products becomes more complicated as it may respond not only to the aforementioned economic forces, but also to strategic behaviour by the firms, namely price responses that take into account the behaviour of other firms operating in the market.

Supermarkets in the UK have substantively increased their presence in the retail market and now account for approximately 80 per cent of the total market. Their emergence as a force in the UK market for fruit and vegetable products since the 1990s has been well documented as well as major changes in the way they have been marketed (e.g., Fearne and Hughes, 2000; Hingley et al., 2006).

The increasing market share of supermarkets and allegations of non-competitive practices has led to several investigations by the UK Competition Commission (e.g., 2000, 2008, Wilson, 2003, Cooper, 2003, Wynne, 2008) to determine whether they were exercising market power along the supply chain (i.e., with respect to suppliers and consumers).

The evidence collected from the different analyses into whether or not supermarkets exercise market power has so far been inconclusive. If something has emerged from those reports (e.g., UK Competition Commission, 2000) is the fact that economic models do not seem to fit either the behaviour of supermarkets or the way they compete in the market place. However, despite this disappointing result, some stylised facts arose from the Competition Commission investigation including the fact that that supermarkets do consider prices set by their competitors as the principal driver in their own pricing (Competition Commission 2000, pp.135). As pointed out by Lloyd (2008) whether a firm operates a policy whose aim is to offer persistently low prices on a wide range of products or the more traditional policy reliant on discounts on a relatively narrow range of core products, the fact is that all major retailers routinely undertake detailed monitoring of competitor pricing, either via covert price collection or through market research companies who provide and process Electronic Point of Sale (EPOS) data on their behalf. Price surveys are typically conducted on a weekly basis and cover the entire products range.

The purpose of this paper is to analyse whether price leadership is present in the market for selected fresh fruits and vegetable and whether it plays any role in the pricing decisions of two main retailers in the UK: Tesco and Sainsbury's. Fruit and vegetables are chosen for analysis because they are they are a less complex line of products, in the sense that they are perishable, with short shelf duration and their supply chains comprise fewer agents. In addition it is an interesting category which has seen a mix of concentration but also fierce competition and innovation in the retail market over the past 15 years.

As regards the structure of the paper, in the next section, a brief overview of the price leadership literature is provided, followed by the empirical work. Finally, conclusions are presented.

2. PRICE LEADERSHIP

Price leadership models have a long tradition in industrial organisation economics. Many economists such as Forchheimer (1908), Nichol (1930), Stigler (1947), Markham (1951), Lanzillotti (1957) and Bain (1960), Ono (1982), Rotemberg and Saloner (1990), Cooper (1996) have described various types of price leadership models. These models can be classified, as proposed by Scherer and Ross' (1990), into three types: dominant, collusive, and barometric price leadership.

The dominant type describes industries in which a firm (the leader), having the largest market share, establishes its price leadership position with the other minor firms being followers. The collusive type is similar to the dominant type, but with a group of firms exercising the leadership in term of setting prices which are followed by other minor firms. In these two cases (dominant and collusive) the price level is rather more monopolistic than competitive. In contract in the barometric type the price is set around the competitive level. Within the price leadership models, the barometric type is considered as a benign form of price leadership, where the leader's advantage comes from its higher efficiency in getting relevant information for pricing the products.

Despite the fact that a leader-follower setting is inherently dynamic, with a firm (i.e., the follower) responding to the signals given by another firm (i.e., the leader), the economic literature is relatively scant in terms of the actual dynamics when analysing data. From an empirical perspective Lloyd (2008) introduces the concepts of tactical and strategic price leadership, which are associated with causality observed in the price data. Tactical leadership occurs when the prices of a firm is found to cause (in the Granger sense) the prices of another firm (Granger, 1969). Strategic leadership occurs when the price of a firm affects or determines in the long term the price of the other firm. Note that these two types can match the collusive or dominant leadership concepts found in the literature.

In the case of barometric price leadership, the literature provides more empirical clues about what might be observed in the data. Thus, according to Ono (1982), it can be characterised by: occasional switching between firms in the role of price leader; the occurrence of upward price leadership only in response to increased industry costs or demand; occasional and sometimes substantial time lags in the price response of follower firms and; occasional rejection by the rest of the market of price changes initiated by the price leader.

3. EMPIRICAL WORK

The empirical methodology used in this paper consisted of three consecutive steps: the first step was to analyse the statistical properties of the prices, particularly to test the stationarity of the series (i.e., the presence of unit roots). As the series were found stationary in levels, the next step of the empirical work consisted of a causality analysis of the series using Granger causality tests (considering two separate periods and applying them recursively) with the purpose of investigating the existence of price leadership. The final step consisted of modelling the interrelationships of the prices in both supermarkets for each product by means of vector autoregressive models (VARs) and simulating the retailers' interaction using the impulse-response functions (Hamilton, 1994, Alvarez-De-Toledo et al., 2008).

3.1. Data

The data used consisted of two sets of prices: retail and wholesale prices (as indicative of costs). They were collected from the magazine Grower (Nexus Media Limited), a weekly British magazine specialising in horticulture, from their section 'supermarket price guide' for two supermarkets: J. Sainsbury and Tesco.

The prices published by the Grower were collected by the Market Intelligence Services (MIS), which is a market research company with experience in monitoring retail prices at the major supermarkets, convenience stores and discounters around the UK. The company has an experienced team of collectors who visit the stores and collect the prices independently.

The sample available for this study consisted of 10 years of weekly basis price data covering from July 1996 to March 2007, i.e., approximately 559 observations for tomatoes, Bramley's apples, white cabbages, cucumbers, iceberg lettuce and round lettuce. It should be noted that although MIS collects the data, which comprises a range of prices for each product within the week, the magazine Grower only publishes only the modal prices.

Wholesale prices were also collected from the Grower, however, the source was the UK Department for Environment, Food and Rural Affairs (Defra) and they correspond to the weekly UK average for several markets for produce class 1.

3.2. Data statistical analysis

Table 1 presents descriptive statistics for the price series. Note that the highest variation in the data (measured by the coefficient of variation, i.e., ratio of standard deviation to the mean) corresponded to wholesale tomato prices (approximately 39 per cent). In all cases, the variation in retail prices was below that of the wholesale prices.

Table 1 also presents results concerning the stationarity of the price series (i.e., whether they possess a unit root). This is important for two reasons: first, to avoid obtaining results based on models that reflect spurious correlations, and second, because these results indicate the methodology to follow (i.e., vector autoregressive models, VARs if the series are stationary or vector error correction models, VECs, is the series are non-stationary, Hamilton, 1994). As show by Table 1 all the series are stationary in levels.

Table 1: Descriptive statistics of the variables used within the analysis

	Units	Mean	St. Dev.	Min	Max	Skewness	Kurtosis	Season 1/	Unit roots 2/
J. Sainsbury retail price of tomato	p/kg.	118.8	21.9	77.0	199.0	1.0	4.6		I(0)
Tesco retail price of tomato	p/kg.	117.8	21.2	77.0	199.0	1.1	5.0		I(0)
Wholesale price of tomato - class 1	p/kg.	74.6	29.1	29.2	206.5	1.5	5.7	No in winter	I(0)
J. Sainsbury retail price of Bramley's apple	p/kg.	131.5	20.0	77.0	169.0	-0.5	2.7		I(0)
Tesco retail price of Bramley's apple	p/kg.	124.2	16.7	86.0	152.0	-0.6	2.0		I(0)
Wholesale price of Bramley's apple - class 1	p/kg.	56.0	14.6	19.0	135.9	1.6	6.8	All year	I(0)
J. Sainsbury retail price of white cabbage	p/kg.	55.8	9.1	35.0	89.0	1.8	7.2		I(0)
Tesco retail price of white cabbage	p/kg.	51.3	9.1	33.0	86.0	0.7	4.6		I(0)
Wholesale price of white cabbage - class 1	p/kg.	24.7	6.4	16.0	50.3	1.5	5.6	All year	I(0)
J. Sainsbury retail price of cucumber	p/unit	59.0	14.0	35.0	99.0	1.0	3.8		I(0)
Tesco retail price of cucumber	p/unit	56.7	13.4	35.0	99.0	1.1	4.2		I(0)
Wholesale price of cucumber - class 1	p/unit	34.1	9.8	17.0	81.7	1.5	6.8	No in winter	I(0)
J. Sainsbury retail price of Iceberg lettuce	p/head	60.0	14.6	29.0	129.0	0.9	4.6		I(0)
Tesco retail price of Iceberg lettuce	p/head	58.7	14.0	29.0	119.0	1.0	4.7		I(0)
Wholesale price of Iceberg lettuce - class 1	p/head	30.6	10.1	10.1	85.2	1.9	9.1	No in winter	I(0)
J. Sainsbury retail price of Round lettuce	p/head	35.7	6.7	19.0	49.0	-0.4	2.7		I(0)
Tesco retail price of Round lettuce	p/head	33.1	6.7	19.0	49.0	0.0	2.9		I(0)
Wholesale price of Round lettuce - class 1	p/head	23.4	6.2	11.9	53.8	0.9	5.1	All in year	I(0)

Notes:

1/ Indicates whether the fruit or vegetable is produced all the year.

2/ Augmented Dickey Fuller test of the null hypothesis that the series has a unit root. I(0) indicates that the series is stationary in levels. The tests were carried out at 1 per cent significance.

3.3. Granger causality analysis

To test the presence of price leadership we used Granger's test of causality (Granger, 1969) as in Lloyd (2008). Table 2 presents Granger causality tests for each product, for the entire sample and splitting the sample into two periods, namely, July 1996 to December 2000 and January 2000 to March 2007. The two periods considered were approximately based on the emergence of supermarkets as a major force in the UK retail market (Hingley et al., 2006). The level of significance chosen for rejecting causality was 1 per cent.

As shown in Table 2, the results indicate significant changes in causality across products between the two periods, therefore, it is expected that the results for the entire sample are masking part of the competition story between the retailers. Thus, in the case of tomatoes the entire sample indicates causality from Tesco to Sainsbury; however, this only reflects the result arising from the second sample period.

With respect to Bramley's apples, the entire sample test indicates causality from Sainsbury to Tesco, although the two sub sample tests indicate that there is no causality. For white cabbage the sub-samples tests indicate double causality, although the entire sample test shows that the causality goes from Sainsbury to Tesco. In the cases of cucumbers, Iceberg and Round lettuce the entire sample test indicates double causality despite the fact that the sub-samples tests indicate causality in only one direction.

Due to the fact that the results from Table 2 were not conclusive as regards of the causality, we decided to run the Granger test recursively (i.e., estimating the test by adding consecutively each observation). The results of the tests (i.e., the value of the F tests) are presented graphically in Figure 1 (solid lines) together with their p-values (dashed lines) in panels a to f.

The recursive Granger tests allow us to complement Lloyd's (2008) analysis and postulate that if one observes unidirectional causality from one retailer to the other, then it can be considered a case of tactical price leadership, whilst if the causality changes over time from one retailer to the other, it can be considered a case of barometric price leadership based on Ono (1982).

The results of the recursive tests help to understand the findings of the two period tests. As shown in the different panels of figure 1, the causality is not constant over time, although the most common case after year 2000 is the presence of double causality and not of a leader-follower relationship.

After 2000 two cases seem to favour the tactical price leadership model: tomatoes and Bramley's apples. For tomatoes (panel a), the figure indicates lack of causality (i.e., no relation at all between both prices) for the period before 2001; however, since 2001 the causality from Tesco to Sainsbury becomes stronger with the additional data points, showing Tesco as a clear "tactical leader" in that market.

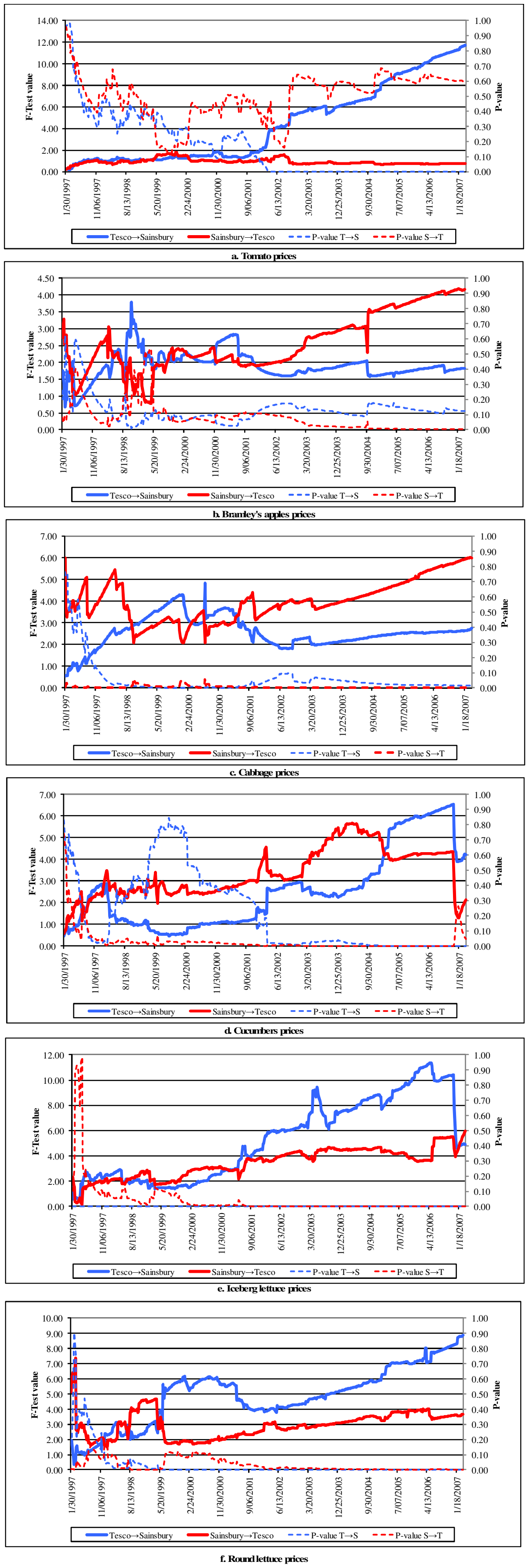

Figure 1: Recursive Granger Causality Tests between J. Sainsbury and Tesco Prices (F tests and P-values).

Table 2: Granger causality tests for different samples

Product	Causality	Entire sample			Jul-96 - Dec-00			Jan-00 - Mar-07		
		Obs.	F test	Signif.1/	Obs.	F test	Signif.1/	Obs.	F test	Signif.1/
Tomato	Tesco → Sainsbury	553	11.7	*	228	1.7		325	18.7	*
	Sainsbury → Tesco		0.8			1.1			1.9	
Bramley's apples	Tesco → Sainsbury	553	1.4		228	2.4		325	0.4	
	Sainsbury → Tesco		3.1	*		1.4			1.4	
White cabbage	Tesco → Sainsbury	553	2.8		228	3.6	*	325	3.6	*
	Sainsbury → Tesco		6.0	*		3.0	*		4.6	*
Cucumbers	Tesco → Sainsbury	536	6.5	*	228	1.1		308	12.1	*
	Sainsbury → Tesco		4.4	*		2.5			2.6	
Iceberg lettuce	Tesco → Sainsbury	536	10.4	*	228	2.8		308	10.8	*
	Sainsbury → Tesco		5.5	*		3.0	*		2.8	
Round lettuce	Tesco → Sainsbury	553	8.9	*	228	5.6	*	325	5.2	*
	Sainsbury → Tesco		3.7	*		2.1			1.6	

Notes:
1/ "*" denotes that the null hypothesis is rejected at 1 per cent of significance. "→" indicates the direction of the tested causality.

The results from Bramley's apple prices (panel b) show the opposite situation and since about 2003 Sainsbury becomes the tactical leader. Note, however, that the situation is not as strong as for tomatoes.

The other products reflect stories of double causality but with different starting periods, namely: cabbage since 1998, cucumbers since 2003, iceberg lettuce since 2000 and round lettuce since 2001. Before these years the situation portrayed in the figures is more complex, with sudden changes in leader/follower roles, which may fit the notion of barometric leadership. Note that it is difficult to track the reasons behind these changes in roles and they might be related to all the transformations that supermarkets went through during the period under study.

The fact that in many cases the relationship between the supermarket prices is one of double causality motivated the next step in the methodology, i.e., the estimation of VARs models to study the interactions between the supermarkets in terms of pricing.

3.4. Vector autoregressive models

To study the interaction of the retailers' prices for each one of the products we proposed six VARs models. The generic structure of the VAR model for a product is presented in equation (1), where P_{1t} and P_{2t} are the prices at time period t, for supermarket 1 and 2, W_t is the wholesale price for the product, which operates as a coincident indicator (Granger causalities test found it causing retailer prices but not the opposite), the ε are error terms, which are white noise, and the α are parameters. The results of the estimation are shown in Table 3.

$$\begin{bmatrix} P_{1t} \\ P_{2t} \end{bmatrix} = \begin{bmatrix} \alpha_{10} + \alpha_{11} W_t \\ \alpha_{20} + \alpha_{21} W_t \end{bmatrix} + \begin{bmatrix} \alpha_{12} & \alpha_{13} \\ \alpha_{22} & \alpha_{23} \end{bmatrix} \begin{bmatrix} P_{1t-1} \\ P_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (1)$$

The exact structure of the models varied for each product, with some of them including trends (all of them where estimated with monthly seasonal dummies). In all t cases the relevant wholesale prices were included, being statistically significant for all products except for Round lettuce.

The number of lags in each model was selected based on the Akaike and Schwartz criteria (Hamilton, 1994). Where these two criteria failed to indicate the same optimal number of lags, a decision was taken based on the properties of the residuals, which are supposed to be independent and identically distributed. We used the Breusch–Godfrey serial correlation Lagrange multiplier test (Breusch, 1978, Godfrey, 1978) to study the presence of autocorrelation in the series, which was rejected in all the cases.

In addition, we computed the inverse roots of the autoregressive characteristic polynomial to verify whether they were within the unit circle and therefore that all the studied models were dynamically stable. The results indicated that all the models were dynamically stable.

The next step was to use the estimated models to compute both the impulse-response functions and the variance decomposition for each product (i.e., the effect of a shock in one of the prices in one of the supermarkets on the variance of the price of the same product in the other supermarket). To do this we used the Cholesky decomposition of the error matrix with the series ordered according to their causality (using Granger causality tests) due to the fact that one should expect correlation between the error terms of the VAR equations. The impulse-response functions are not presented in the paper but they are available from the authors.

Table 4 presents six sub-tables, one for each VAR model. Within each sub-table the top panel indicates the decomposition of the variance of the "exogenous" variable and the lower panel presents the decomposition of the variance of the "affected" variable.

To aid interpretation of Table 4, let us concentrate on the case of tomatoes. As the VAR system in the first period responds to a shock in the Tesco price, the variance of this price is only explained by its own shock and not by feedback from the Sainsbury price (see upper panel). However, for the Sainsbury price, 54.9 per cent of its variance is explained by Tesco's price shock and 45.1 per cent by its own price. It is interesting to note that whilst a significant part of the variance in Sainsbury's tomato price is explained by Tesco, the opposite is not true.

Based on the variance decomposition it is possible to classify the results into three cases: first, when a shock in a supermarket price affects the other supermarket price but only a small feedback is received from it (e.g., tomatoes, cucumber, and Iceberg lettuce); second, when the feedback is relatively small for both supermarkets (e.g., Bramley's apple, white cabbage); and third, an intermediate case, when the feedback received from the reacting supermarket is more significant (e.g., Round lettuce).

The first of the mentioned cases could indicate some sort of clear leader follower situation. The second one would be one of "related to some degree but independent", whilst the third case would represent a higher degree of interaction between the supermarkets.

3.5. Conclusions

The purpose of this paper has been to identify the presence of price leadership using data for selected fruits and vegetables from two supermarkets: Tesco and Sainsbury. Except in the case of tomatoes, where Tesco appears as the leader since 2001, the other results are mixed, probably reflecting the changes that have occurred in the fruit and vegetables market during the period of study.

Table 3: Bivariate VAR models for each product 1/ 2/

Tomato (1)			Bramley's apple (2)			White cabbage (3)			Cucumber (4)			Iceberg lettuce (5)			Round lettuce (6)		
	R11	R21		R12	R22		R13	R23		R14	R24		R15	R25		R16	R26
R11(-1)	0.316	0.147	R12(-1)	0.688	0.008	R13(-1)	0.699	-0.072	R14(-1)	0.579	0.200	R15(-1)	0.479	0.245	R16(-1)	0.842	0.202
	(0.068)	(0.067)		(0.045)	(0.043)		(0.044)	(0.039)		(0.047)	(0.051)		(0.076)	(0.073)		(0.047)	(0.063)
	[4.640]	[2.196]		[15.271]	[0.188]		[15.948]	[-1.839]		[12.333]	[3.937]		[6.323]	[3.356]		[18.064]	[3.207]
R21(-1)	0.520	0.645	R12(-2)	0.190	0.137	R13(-2)	0.033	0.154	R24(-1)	0.223	0.561	R15(-2)	0.065	0.073	R16(-2)	-0.052	-0.115
	(0.071)	(0.070)		(0.055)	(0.053)		(0.054)	(0.048)		(0.047)	(0.051)		(0.082)	(0.079)		(0.044)	(0.060)
	[7.355]	[9.259]		[3.467]	[2.597]		[0.616]	[3.201]		[4.727]	[11.002]		[0.799]	[0.926]		[-1.168]	[-1.915]
Intercept	8.890	12.429	R12(-3)	-0.057	-0.085	R13(-3)	0.082	0.006	Intercept	2.845	2.114	R15(-3)	-0.039	-0.297	R26(-1)	0.141	0.710
	(2.420)	(2.382)		(0.056)	(0.053)		(0.044)	(0.039)		(1.279)	(1.385)		(0.076)	(0.073)		(0.034)	(0.045)
	[3.673]	[5.217]		[-1.027]	[-1.599]		[1.870]	[0.149]		[2.225]	[1.526]		[-0.509]	[-4.061]		[4.198]	[15.674]
W1	0.141	0.155	R12(-4)	-0.033	-0.004	R23(-1)	0.129	0.702	W4	0.207	0.287	R25(-1)	0.292	0.499	R26(-2)	0.020	0.122
	(0.018)	(0.018)		(0.053)	(0.051)		(0.049)	(0.044)		(0.031)	(0.033)		(0.078)	(0.075)		(0.035)	(0.047)
	[7.761]	[8.668]		[-0.618]	[-0.081]		[2.622]	[16.059]		[6.759]	[8.676]		[3.768]	[6.670]		[0.575]	[2.593]
			R12(-5)	0.105	-0.026	R23(-2)	-0.120	0.022	Trend	0.006	0.002	R25(-2)	-0.019	-0.050	Intercept	1.722	2.011
				(0.044)	(0.042)		(0.059)	(0.052)		(0.002)	(0.002)		(0.083)	(0.081)		(0.465)	(0.628)
				[2.398]	[-0.615]		[-2.039]	[0.412]		[3.114]	[1.118]		[-0.222]	[-0.619]		[3.700]	[3.200]
			R22(-1)	0.080	0.710	R23(-3)	0.009	0.109				R25(-3)	-0.029	0.211	W6	0.0002	0.0002
				(0.045)	(0.043)		(0.048)	(0.043)					(0.079)	(0.076)		(0.001)	(0.001)
				[1.767]	[16.407]		[0.189]	[2.567]					[-0.365]	[2.781]		[0.249]	[0.168]
			R22(-2)	-0.033	-0.090	Intercept	6.674	3.634				Intercept	5.499	8.420	Trend	0.002	0.002
				(0.054)	(0.052)		(1.543)	(1.375)					(1.942)	(1.875)		(0.001)	(0.001)
				[-0.598]	[-1.725]		[4.326]	[2.644]					[2.831]	[4.490]		[2.647]	[1.919]
			R22(-3)	-0.005	0.150	W3	0.147	0.012				W5	0.281	0.292			
				(0.054)	(0.052)		(0.037)	(0.033)					(0.044)	(0.043)			
				[-0.099]	[2.886]		[3.925]	[0.354]					[6.369]	[6.864]			
			R22(-4)	0.020	0.047	Trend	-0.003	-0.001									
				(0.054)	(0.052)		(0.001)	(0.001)									
				[0.359]	[0.909]		[-2.305]	[-0.987]									
			R22(-5)	-0.019	0.103												
				(0.045)	(0.043)												
				[-0.412]	[2.369]												
			Intercept	3.860	3.410												
				(1.854)	(1.778)												
				[2.083]	[1.918]												
			W2	0.055	0.034												
				(0.022)	(0.021)												
				[2.570]	[1.640]												
			Trend	0.007	0.002												
				(0.002)	(0.002)												
				[3.387]	[1.290]												
Observations	412	412		540	540		554	554		412	412		303	303		542	542
Adj. R-squared	0.84	0.84		0.93	0.91		0.74	0.79		0.83	0.80		0.73	0.71		0.93	0.87
F-statistic	725.66	695.75		643.30	472.84		201.75	262.84		501.15	401.62		119.07	107.26		1177.63	597.33
Log likelihood	-1500.15	-1493.71		-1644.92	-1622.40		-1610.98	-1547.09		-1264.36	-1297.35		-1016.42	-1005.81		-1080.68	-1243.24
Mean dependent	117.78	117.00		131.48	124.06		55.61	51.18		57.37	55.45		55.56	54.51		35.76	33.14
S.D. dependent	23.25	22.49		20.15	16.76		8.83	8.71		12.69	12.56		13.57	12.62		6.70	6.66

Notes:

1/ Standard errors are presented in parenthesis under the coefficients and t statistics are presented in brackets. All the regressions were carried by ordinary least squares.

2/ The name of the variables is as follows: Rij (e.g., R11) denotes the retail price of supermarket i (1=Sainsbury, 2= Tesco) of product j (where j is given with the heading of the regression). Wj indicates the wholesale price of product j. All the regressions included seasonal dummies (monthly), which are not presented to save space.

Table 4: Variance decomposition for each product VAR model 1/

Tomato (1)				**Bramley's apples (2)**				**White cabbage (3)**			
Variance Decomposition of R21				Variance Decomposition of R12				Variance Decomposition of R13			
Period	St dev.	R21	R11	Period	St dev.	R12	R22	Period	St dev.	R13	R23
1	9.1	100.0	0.0	1	5.2	100.0	0.0	1	4.5	100.0	0.0
4	13.5	98.8	1.2	4	7.8	99.3	0.7	4	6.4	99.2	0.8
16	14.7	98.6	1.4	16	10.3	96.8	3.2	16	7.4	99.2	0.8
Variance Decomposition of R11				Variance Decomposition of R22				Variance Decomposition of R23			
Period	St dev.	R21	R11	Period	St dev.	R12	R22	Period	St dev.	R13	R23
1	9.3	54.9	45.1	1	4.9	3.6	96.4	1	4.0	5.2	94.8
4	14.0	77.1	22.9	4	6.8	7.8	92.2	4	5.7	7.2	92.8
16	15.3	80.6	19.4	16	9.6	11.8	88.2	16	7.3	21.2	78.8
Cucumber (4)				**Iceberg lettuce (5)**				**Round lettuce (6)**			
Variance Decomposition of R14				Variance Decomposition of R15				Variance Decomposition of R16			
Period	St dev.	R14	R24	Period	St dev.	R15	R25	Period	St dev.	R16	R26
1	5.2	100.0	0.0	1	7.0	100.0	0.0	1	1.8	100.0	0.0
4	7.6	93.4	6.6	4	9.9	95.2	4.8	4	3.2	91.4	8.6
16	8.1	91.1	8.9	16	10.2	93.3	6.7	16	4.8	68.6	31.4
Variance Decomposition of R24				Variance Decomposition of R25				Variance Decomposition of R26			
Period	St dev.	R14	R24	Period	St dev.	R15	R25	Period	St dev.	R16	R26
1	5.7	29.3	70.7	1	6.8	46.6	53.4	1	2.4	9.7	90.3
4	7.8	42.9	57.1	4	9.4	59.0	41.0	4	3.8	18.6	81.4
16	8.2	46.3	53.7	16	9.7	57.5	42.5	16	5.2	24.7	75.3

Notes:
1/ The name Rij (e.g., R11) denotes the retail price of supermarket i (1=Sainsbury, 2= Tesco) of commodity j (where j is given with the heading of each variance decomposition).

The results of the recursive causality tests show that if one considers the entire sample available for each product, then one should conclude that there is no evidence of a price leadership situation in any. However, since it is possible to find leaders when considering sub-periods, then the evidence would support in most of the cases the presence of barometric price-leadership.

If instead of considering the entire sample, one considers sub-periods then, it is possible to find cases of price leadership (tactic) such as in the case of tomatoes since 2001 or in a lesser extend Bramley apples since also since 2003. All the other cases, show double causality indicating some sort interaction (e.g., by observing the other's prices) when pricing their product.

To provide a further analysis of the interrelationships between supermarkets VAR models were estimated to produce the impulse-response and the variance decomposition analyses. These analyses allowed us study the effect that movements (i.e., generated through a shock) on the price of one supermarket have on the price of the same product of the other supermarket. The results of the variance decomposition seem to indicate three cases depending on the degree of feedback received between the supermarkets' prices: the first case corresponds when a change in the price of one supermarket affects the other supermarket's price but received only small feedback from it. This was found in tomato, cucumber, and Iceberg lettuce. The second case, takes place when the feedback is relatively small for both supermarkets and this was found in the Bramley's apple and white cabbage cases. The third case, an intermediate situation, shows that the feedback received from the reacting supermarket is significant as was the case for Round lettuce.

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