A Note on Price Levelling and Price Averaging in Sydney Retail Vegetable Price Spreads

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For tomatoes, potatoes, carrots and onions in the Sydney market, the degree of variability of the retail price is substantially lower than the degree of variability of the wholesale price. The objective here is to investigate whether fresh vegetable retailers in the Sydney market practice price levelling and price averaging. 2SLS and 3SLS procedures were used to estimate a system of price spread equations for the four vegetables using quarterly data from 1980 to 1990. In the preferred 3SLS estimates price levelling was confirmed for potatoes and carrots. Price levelling was not evident in the tomatoes and onions equations, with price transmission influenced more by markup pricing policies for these vegetables. No evidence of price-averaging behaviour was found for any of the vegetables examined.

1. Introduction

Vegetables are an important yet variable component of the Australian diet. Per capita consumption of all vegetables is currently around 140 kg/year but in the past has varied from 125 kg in 1982/83 to almost 143 kg only two years later (ABS 1990a, BAE 1985). Movements in per capita consumption can be attributed to the variability of domestic commercial vegetable production, which represents some 90 per cent of total vegetables available for human consumption, and to the growth in imports of processed vegetable products.

There are two sectors of the Australian vegetable industry, fresh and processed. There have been significant structural changes in the processed sector of the industry, including a declining number of vegetable enterprises (ABS 1990c), increasing use of vertical integration and contracting arrangements for inputs (IAC 1986), and increasing concentration in vegetable processing firms (IAC 1986). These developments have all served to stabilise throughput of vegetable processing firms, prices paid to growers and charged to retailers (and probably also prices charged to consumers).

In the fresh sector of the industry, few such integration and/or contracting arrangements exist and wholesale prices vary substantially. Together with fluctuating availabilities, this would be expected to induce substantial short-run shifts in the mix of fresh vegetables consumed.

However there is *prima facie* evidence that retailers attempt to mask at least some of this variability in prices by adopting price levelling practices. Price levelling is defined as the practice of holding output prices relatively stable in the face of fluctuating input prices. Price levelling is a common feature in fresh meat retailing (Griffith 1974, Griffith *et al.* 1991, Naughtin and Quilkey 1979), a market sector with many of the same characteristics as the fresh vegetable retail market. Retailers may aim to set relatively stable retail prices because they believe consumers prefer more stable prices, and/or because there are considerable costs involved in changing prices and informing their consumers of these changes. That retailers are able to exert some control over price may be due to retailers offering other services such as advice, delivery, extra cutting, etc., which influence the purchase decision. Once comparison shoppers in particular are attracted to a store, retailers will attempt to retain their custom by keeping prices relatively stable. Consumers are also conscious of their own costs in searching for a better price. Additionally, where products are storable, retailers may be able to keep prices stable by meeting demand fluctuations out of stocks.

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The evidence of price levelling is seen in Table 1. For four of the major fresh vegetables (potatoes, tomatoes, carrots, and onions, which together account for some two-thirds of total vegetable consumption) (ABARE 1990, Table 163) the degree of variability of the retail price as measured by the coefficient of variation is lower than the degree of variability of the wholesale price. Additionally, the price spread or marketing margin between the wholesale and retail prices is more variable than either the wholesale or retail price in all cases. This suggests that variations in the price spread are used to dampen the impact of fluctuations in wholesale prices on retail prices. Another interesting observation from Table 1 is the size of the spread for the different vegetables, especially in comparison to their respective wholesale prices.

Whether retailers practise price levelling or not has important implications for fresh vegetable producers. Following Parish (1967), price levelling (derived demand curve Df in Figure 1) does indeed result in *more stable* retail prices (Pr to PR as supply shifts from s to S) and more stable throughput (q to Q) than would otherwise be the case (derived demand curve D'f for a constant margin, P'r to P'R, q' to Q'). The corollary however is that price levelling results in *less stable* wholesale prices (Pf to PF, compared with P'f to P'F) and, by implication, farmgate prices, since wholesale and farm prices typically differ only by a fixed transport cost and a small percentage agents' commission. Hence, establishing whether price levelling is typical pricing behaviour by fresh vegetable retailers can have some important policy implications at the farm level because farm price variability is exacerbated.

Prices received at the farm/wholesale level are extremely variable from month to month and year to year (NSW Agriculture & Fisheries 1990). This variability is often big news in the rural press. For example on 9 August 1990, it was reported that, because of floods in vegetable growing areas, prices

Table 1: Means, Standard Deviations and Coefficients of Variation of Vegetable Prices and Spreads, (c/kg), Sydney Market, 1980-1990*

Item	Mean	St.Deviation	COV+ (%)
Potato:			
Retail price	69.3	23.2	33.5
Wholesale price	43.6	16.8	38.5
Price spread	25.7	16.9	65.8
Tomato:			
Retail price	199.9	56.2	28.1
Wholesale price	44.1	14.0	31.7
Price spread	155.9	50.0	32.1
Carrot:			
Retail price	102.9	40.8	39.6
Wholesale price	34.8	15.8	45.4
Price spread	68.1	35.1	51.6
Onion:			
Retail price	93.1	38.9	41.8
Wholesale price	40.0	20.3	50.8
Price spread	53.0	28.8	55.4

+ COV = (St. Deviation/Mean) x 100
* See Appendix 1 for definitions.

at Flemington markets virtually doubled for some lines as supplies dwindled, while at the same time weather damage slashed the value of other lines by over $25 million (Anon 1990). A year later in June 1991, cauliflowers were averaging only $3.20 / carton while in the previous March they were fetching from $10-$16/carton. Broccoli had slipped from $12-$16 /carton in March to between $2.50-$7 /carton (Middlebrook and Jones 1991). Finally, on 18 July 1991 it was stated that "Fresh potato prices in NSW are now about $100/tonne, down up to 90pc on the "wet-year" prices of 1989 and 1990." (McNamara 1991). As shown in Table 1, retail prices do not vary to the same extent as wholesale prices.

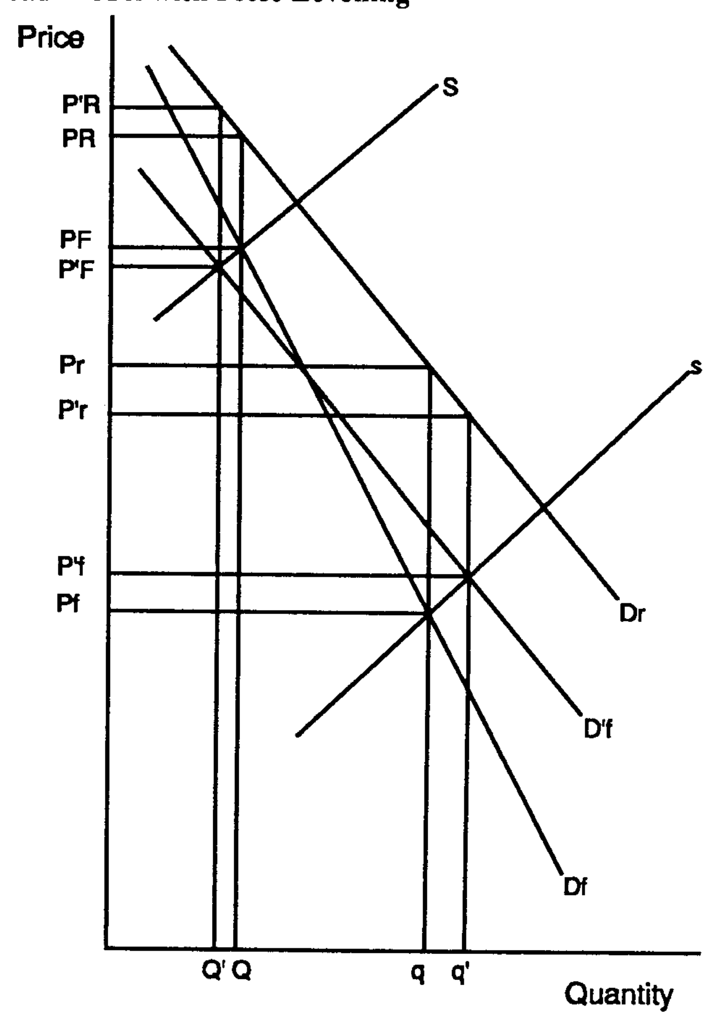
Another pricing practice which fresh vegetable retailers may use is price averaging. Price averaging is defined as the practice of holding the price spread of one product low while increasing the price spreads of other, related products. This may be relevant because most, if not all, vegetable retailers, supermarkets or speciality fruiterers are multiproduct firms selling a wide range of fresh vegetables. Hence they may be concerned more with the average margin over all input prices than with the margin on each individual product.

The objective of this short paper is to investigate whether fresh vegetable retailers in the Sydney market practice price levelling and price averaging in their short term commercial decision-making. Some evidence of retail price rigidity is available in United States vegetable markets (Ward 1982), but no examination of this issue has been undertaken using Australian data.

Data and Methods

A typical short-run wholesale - retail price spread

Figure 1: Price Spread Model with Price Levelling



or marketing margin model is as follows (Griffith *et al.* 1991)[1]:

(1) $PS_i = f(PW_i, LPW_i, PS_j, PS_k, PS_l, Q_i, MC_i, LPS_i)$

where i,j,k,l are subscripts denoting various products (here potatoes, tomatoes, carrots, onions respectively);

PS_i is the price spread of the ith product defined as the retail price of i minus the wholesale price of i on equivalent weight terms;

PW_i is the wholesale price of the ith produc;

LPW_i is the wholesale price of the ith product lagged one or more periods;

Q_i is the throughput of the ith product at the retail level;

MC_i is the cost of marketing the ith product at the retail level; and

LPS_i is the price spread of the ith product lagged one period.

Depending on the periodicity of the data used, weekly, monthly or quarterly dummy variables can also be included to capture regular seasonal patterns in the price spreads.

The price-levelling hypothesis implies that the coefficient on the variable PW_i is negative and statistically significant (as wholesale price rises [falls] the wholesale-retail price spread contracts [expands]). The price spread moves in the opposite direction to the wholesale price. Typically the coefficient on the variable LPW_i is positive and significant (as the trend of wholesale price rises [falls], the price spread expands [contracts] to balance out the negative impact in the immediate period). Thus over the longer term, retail prices follow the same trend as wholesale prices. The price averaging hypothesis implies that the coefficients on the variables PS_j, PS_k, and PS_l are negative and significant (as price spreads for the jth, kth or lth product expand [contract] the price spread for the ith product contracts [expands], so that on average over all these products, normal profits are made).

The coefficients on the MC_i and LPS_i variables would be expected to be positive and significant. Higher costs should result in a larger price spread. The inclusion of the LPS_i variable is normally justified on the basis of a partial adjustment assumption. When short-period data are used, not all of the adjustments in PS_i to a change in any of the explanatory variables can be undertaken immediately, so there is some influence of the past values of PS_i in the decision to set the current value of PS_i.

The sign on the Q_i variable coefficient is not clear *apriori*. Since the relationship between Q_i and PS_i represents the supply curve for marketing services in price dependent form, it is normally expected that the coefficient on Q_i would be positive, reflecting a typical upward sloping supply curve. However, in the short run, the average variable cost curve of the retailing firm may be steeply U-shaped and Q_i may well be, in some periods at least, well below the cost minimising level. Hence reductions (increases) in Q_i may be associated on average with increases (decreases) in PS_i. The sign on the Q_i coefficient is therefore an empirical issue. It should be noted, however, that a positive coefficient on Q_i also implies price levelling (Figure 1).

Two important data limitations meant that the proposed model (1) had to be modified. First, a measure of the cost of providing vegetable retailing services specifically could not be obtained. As a proxy the wage rate for the retailing sector (ABS 1990b) was used (MC). Second, there are no retail quantity data available on the sale of fresh vegetables in Sydney on a quarterly basis, and the only quantity data available for the Sydney wholesale

[1] A referee has asked whether price spread or retail price should be the dependent variable. These are simply two alternate ways of examining price transmission between the wholesale and retail levels of this market and both provide essentially the same information. We favour the former, however, as we are interested primarily in explaining behaviour in the marketing services sector of the market and the price spread reflects the costs of providing those services. The 2SLS model estimated in price dependent form is given in Appendix 2 for comparison. Note that all of the estimated coefficients are the same as in Table 2 except for the coefficients on the current wholesale prices, which are all exactly 1.0 larger than those in Table 2. This is due to the fact that the dependent variable in Table 2 is (retail price-wholesale price), while in the Appendix Table the dependent variable is just (retail price) - the wholesale price with its implied coefficient of 1.0 has been moved to the right hand side of the equation. The R^2 changes because there is a different absolute level of variability to be explained, but all other summary statistics are unchanged.

vegetable markets (Flemington) was a series of 33 discontinuous monthly quantities for 1983-1990 from unpublished manifests (Sydney Markets Authority, pers. comm). Hence the quantity variable had to be omitted from the analysis. Developing such quantity data series is an obvious avenue for further work.

The modified model estimated (with quarterly dummy variables) was therefore:

$$(2)\ PS_i = f(PW_i, LPW_i, PS_j, PS_k, PS_l, MC, LPS_i, D1, D2, D3)$$

To estimate this proposed model and test the price-levelling and price-averaging hypotheses, quarterly data for the period 1980(1) to 1990(1) were used (as defined in Appendix 1). No adjustment to an equivalent retail weight was considered necessary because the form of the four vegetables does not change between the wholesale and retail levels of the market, unlike meat (Griffith *et al.* 1991).

So there are four equations in the model, one for each vegetable. Since the equation for each vegetable contains the dependent variables of the other three equations, a simultaneous equation estimator such as two stage least squares (2SLS) or three stage least squares (3SLS) is required to achieve consistent and efficient coefficient estimates, rather than ordinary least squares (OLS). Further, it would be expected that because of the multiproduct nature of fresh vegetable retailing firms, decisions on price spreads are made jointly. Thus there is the probability of contemporaneous correlations across the error terms of the four equations, and they may be regarded as a system of equations. Hence 3SLS would be preferred to 2SLS methods as 3SLS takes these cross-equation error structures into account.

3. Results

Checking the correlation coefficients for the variables in model (2) it was found that there is relatively high correlation (0.82) between the tomato spread and the carrot spread. This suggests multicollinearity and may have implications for estimation of price-averaging behaviour in those equations where both these variables appear. All other correlation coefficients are less than 0.6.

Results from 2SLS and 3SLS estimates are reported in Tables 2 and 3, respectively. Under each of the estimated regression coefficients are the standard errors in (.) and the estimated short-run elasticities at the means in [.]. Elasticity values are given where the estimated coefficients exceed their standard errors. The Durbin-Watson and Durbin H statistics are included where appropriate. The first equation (i) in each set is the fully specified model (2), while the second (ii) is the final preferred specification. In Table 3 a third set of results (iii) are given for equations excluding the other price spread variables (see below).

Some general features of the results are apparent. First, across all the vegetables and both estimation methods, no consistent evidence was found of significant seasonal variation in price spreads not already explained by the other explanatory variables. In the 2SLS full carrot equations the seasonal dummies did show some significance, but the coefficients were substantially smaller in the 3SLS equation. In the preferred equations no seasonal dummies were included.

Second, the lagged dependent variables were excluded from all but the onion equation because of possible multicollinearity with the cost variable. We preferred to include the cost variable, as it should be a major determinant of the price of marketing services.

Third, given our knowledge about the correlations between the carrot and tomato spreads, only one of these, if any, was included in any one preferred equation.

Fourth, the estimates are reasonably consistent across the two estimators. The exception is the carrot equation, where the estimates of the preferred equations change markedly between 2SLS and 3SLS.

The variance-covariance matrix of 2SLS residuals suggests that 3SLS would provide more efficient estimates and this is confirmed by comparison of the relative standard errors in Tables 2 and 3, with those of the 3SLS estimates being smaller in all cases.

Table 2: 2SLS Results for the Vegetable Wholesale-Retail Price Spread Equations

Vegetable		C	Whole-sale Price	Lagged W'sale Price	Cost	Potato Spread	Tomato Spread	Carrot Spread	Onion Spread	Lagged Dept Variable	D1	D2	D3	DW DH
Potato	(i)	-0.028	-0.916	0.709	-0.002	-	0.231	0.003	0.234	0.389	0.064	0.025	0.039	-
		(0.183)	(0.440)	(0.278)	(0.008)		(0.310)	(0.300)	(0.703)	(0.267)	(0.088)	(0.167)	(0.187)	n.a.
			[-1.54]	[1.17]										
	(ii)	0.009	-0.847	0.551	0.002			0.217						1.57
		(0.131)	(0.192)	(0.167)	(0.002)			(0.147)						-
			[-1.42]	[0.91]	[0.74]			[0.57]						
Tomato	(i)	0.159	0.758	-0.200	0.010	-0.616	-	0.799	-0.506	0.113	-0.024	-0.242	-0.182	-
		(0.364)	(0.423)	(0.613)	(0.007)	(0.803)		(0.605)	(0.818)	(0.324)	(0.179)	(0.267)	(0.224)	n.a.
			[0.22]		[0.63]			[0.35]						
	(ii)	0.208	0.707		0.004			0.994						1.79
		(0.287)	(0.340)		(0.004)			(0.272)						-
			[0.20]		[0.25]			[0.44]						

(Table 2 cont.)

Vegetable	C	Whole-sale Price	Lagged W'sale Price	Cost	Potato Spread	Tomato Spread	Carrot Spread	Onion Spread	Lagged Dept Variable	D1	D2	D3	DW DH
Carrot (i)	-0.055 (0.208)	-0.786 (0.287) [-0.39]	0.891 (0.568) [0.45]	0.003 (0.004)	-0.598 (0.479) [-0.23]	0.187 (0.226)	-	-0.099 (0.644)	0.716 (0.279)	-0.101 (0.125)	-0.270 (0.162)	-0.247 (0.157)	- n.a.
(ii)	-0.315 (0.172)	-0.563 (0.294) [-0.28]	0.727 (0.431) [0.36]		1.248 (0.437) [0.48]	0.394 (0.184) [0.90]							1.98 -
Onion (i)	-0.048 (0.309)	0.161 (0.228)	0.118 (0.277)	0.007 (0.006) [1.30]	0.039 (0.598)	-0.242 (0.287)	0.218 (0.416)	-	0.182 (0.225)	-0.080 (0.144)	-0.111 (0.169)	-0.149 (0.173)	- n.a.
(ii)	-0.192 (0.241)	0.207 (0.209) [0.16]		0.005 (0.003) [0.93]					0.260 (0.160)				- n.a.

Table 3: 3SLS Results for the Vegetable Wholesale-Retail Price Spread Equations

Vegetable		C	Whole-sale Price	Lagged W'sale Price	Cost	Potato Spread	Tomato Spread	Carrot Spread	Onion Spread	Lagged Dept Variable	D1	D2	D3	DW DH
Potato	(i)	-0.018 (0.112)	-0.854 (0.199) [-1.43]	0.672 (0.164) [1.11]	-0.0004 (0.002)	-	-0.123 (0.086) [-0.74]	0.072 (0.167)	0.116 (0.157)	0.361 (0.176)	0.057 (0.051)	-0.002 (0.058)	0.013 (0.056)	- n.a.
	(ii)	0.029 (0.111)	-0.818 (0.161) [-1.37]	0.504 (0.147) [0.84]	0.002 (0.001) [0.74]			0.289 (0.091) [0.76]						1.69 -
	(iii)	-0.032 (0.110)	-0.717 (0.146) [-1.20]	0.741 (0.163) [1.23]	0.002 (0.002) [0.74]					0.373 (0.179)	0.040 (0.051)	-0.065 (0.051)	-0.052 (0.050)	- n.a.
Tomato	(i)	0.290 (0.294)	0.640 (0.311) [0.18]	-0.100 (0.379)	0.007 (0.004) [0.44]	0.220 (0.416)	-	1.450 (0.352) [0.64]	-1.037 (0.380) [-0.35]	-0.025 (0.143)	-0.059 (0.131)	-0.065 (0.151)	-0.051 (0.139)	- 1.19
	(ii)	0.488 (0.132)	0.458 (0.231) [0.13]					1.282 (0.117) [0.56]						1.67 -
	(iii)	-0.144 (0.346)	0.523 (0.359) [0.15]	0.479 (0.355) [0.14]	0.014 (0.004) [0.88]					0.070 (0.133)	-0.078 (0.158)	-0.317 (0.156)	-0.265 (0.154)	- 0.78

(Table 3 cont.)

Vegetable	C	Whole-sale Price	Lagged W'sale Price	Cost	Potato Spread	Tomato Spread	Carrot Spread	Onion Spread	Lagged Dept Variable	D1	D2	D3	DW DH
Carrot (i)	-0.175 (0.173)	0.389 (0.182) [-0.19]	0.315 (0.208) [0.16]	-0.002 (0.003)	-0.383 (0.241) [-0.15]	0.429 (0.108) [0.98]	-	0.641 (0.146) [0.49]	0.244 (0.122)	0.016 (0.081)	-0.075 (0.090)	-0.071 (0.086)	- 1.84
(ii)	-0.386 (0.103)	-0.157 (0.162) [-0.08]	0.074 (0.181)		0.280 (0.145) [0.11]	0.655 (0.072) [1.50]							1.67 -
(iii)	-0.118 (0.196)	-0.641 (0.206) [-0.33]	0.833 (0.199) [0.42]	0.006 (0.002) [0.90]					0.490 (0.109)	-0.121 (0.090)	-0.260 (0.088)	-0.251 (0.089)	- 1.20
Onion (i)	0.203 (0.248)	0.166 (0.153) [0.13]	-0.046 (0.146)	0.003 (0.004)	0.335 (0.300) [0.17]	-0.464 (0.172) [-1.39]	0.871 (0.239) [1.14]	-	0.146 (0.120)	-0.094 (0.116)	-0.025 (0.123)	-0.039 (0.123)	- 0.78
(ii)	-0.188 (0.228)	0.187 (0.196) [0.14]		0.005 (0.003) [0.93]					0.239 (0.150)				- 1.20
(iii)	-0.073 (0.236)	0.367 (0.201) [0.27]	-0.023 (0.205)	0.004 (0.003) [0.70]					0.366 (0.148)	-0.104 (0.110)	-0.126 (0.111)	-0.181 (0.110)	- 0.19

Looking at the preferred equation estimates in Table 3, the coefficients on the current wholesale price in the potato and carrot equations are negative and statistically significant. This confirms the practice of price levelling in the marketing chain for these two vegetables - as the wholesale price rises (falls), the price spread contracts (expands), so that the retail price remains relatively stable compared to changes in the wholesale price. The estimated elasticity value is about -1.4 for potatoes so that there is an over-reaction to the change in the wholesale price and the retail price actually moves in the opposite direction to the wholesale price. For carrots the elasticity is very low so there is only a minor effect on the stability of the retail carrot price. These price levelling results can be compared with those of Ward (1982) who found short-run retail price rigidities in United States vegetable marketing. For these two vegetables as well, the coefficients on the lagged wholesale price are positive, and for potatoes, statistically significant with an elasticity of about one. This suggest some longer-run but only partial compensation for the negative response in the immediate period.

For tomatoes and onions, the coefficients on the wholesale price variable are positive, although not significant for onions, so there is no evidence of price levelling behaviour and price transmission is more by way of a direct markup on wholesale price. In both cases the response is very inelastic.

The coefficients on other price spreads included in the preferred potato, tomato and carrot equations are all positive. The elasticities range from 0.56 to 1.50. This confirms that there is no price averaging for these vegetables. Rather there are complementary relationships between the price spreads, as suggested by the positive and, in some cases, large correlation coefficients between them. A possible explanation may be that all the vegetables are likely to be similarly affected by exogenous shocks, such as climatic extremes, so that all their prices will move together to a certain extent. Alternatively, carrots and potatoes may be regarded as close complements in hot-cooked meals while carrots and tomatoes may be regarded as close complements in salads. The elasticities suggest that the carrot spread has a strong effect on both the potato and tomato spreads; the tomato spread has a dominant influence on the carrot spread; and the potato spread has only a minor impact on the carrot spread. In the preferred onion equation there was no influence of other spreads, but the lagged dependent variable did show some significance.

Some may argue that because the price-averaging null hypothesis was not rejected, none of the other price spread variables should be retained. While this is not what the authors believe, the 3SLS full model has been re-estimated as a Zellner system with the other price spread variables excluded. These results are reported as the third set of results for each vegetable in Table 3. The only equation which changes materially is the carrots equation where the price levelling effect becomes more pronounced and cost becomes significant.

The cost of supplying retail market services for vegetables did enter the potato and onion preferred equations with a positive coefficient as expected, and these coefficients were statistically significant. The elasticity values were 0.74 for potatoes and close to one for onions. Onions are not closely related to the other vegetables through their price spreads, so the spread for onions is determined very much by a cost-plus pricing policy. These cost variables were insignificant in the preferred tomato and carrot equations. This result reinforces those from meat price spread studies where the cost variable tends not to influence greatly short-run price spread behaviour (Griffith *et al.* 1991).

Finally, it should be noted that the overall explanatory power of these equations is quite low. In the OLS versions of these equations, some 70 per cent of the variation in the tomato and carrot price spreads can be explained, but for potatoes this drops to 50 per cent and for onions it drops further to only about 25 per cent. The missing throughput variable may explain the wide disparity in the degrees of explanatory power.

4. Summary and Conclusions

This study has been motivated by two factors. First, fresh vegetable producers in New South Wales have seen the prices received for their produce fluctuate substantially from season to season and from month to month. Second, a cursory examination of the prices of tomatoes, potatoes, carrots and onions at different market levels suggests that the degree of variability in the retail price of these vegetables is considerably less than that in the wholesale price. Both factors suggest the presence of price-levelling behaviour in fresh vegetable price transmission, as this leads to relatively stable retail prices but relatively unstable wholesale and farmgate prices.

2SLS and 3SLS procedures were used to estimate a system of price spread equations for these four vegetables sold in the Sydney market, using quarterly data from 1980 to 1990. In the preferred 3SLS estimates price levelling was confirmed for potatoes and carrots. Price levelling was not evident in the tomatoes and onions equations, with price transmission being influenced more by markup pricing policies for these vegetables. Hence, it is concluded that for potatoes and carrots, the variability of prices evident at the wholesale level and, by extension, at the farm level, is due at least partly to the pricing practices adopted by fresh vegetable retailers. For these products then, fresh vegetable retailers in the Sydney market behave commercially in a similar fashion to Sydney fresh meat retailers (Griffith *et al.* 1991).

No evidence of price-averaging behaviour was found for any of the vegetables examined. Again, this is consistent with the behaviour of fresh meat retailers in Sydney.

Some areas for further work include examination of the role of quantity fluctuations in short run vegetable pricing patterns, and investigation of the possible impacts of alternative models of price spread behaviour.

References

ANON. (1990),"Hawkesbury losses $25.5m", *The Land*, 9 August, p.160.

AUSTRALIAN BUREAU OF STATISTICS (ABS) (1990a), *Apparent Consumption of Foodstuffs and Nutrients, Australia*, Cat. No. 4306.0, AGPS, Canberra.

AUSTRALIAN BUREAU OF STATISTICS (ABS) (1990b), *Award Rates of Pay Indexes, Australia, March*, Cat. No. 6312.0, AGPS, Canberra.

AUSTRALIAN BUREAU OF STATISTICS (ABS) (1990c), *Agricultural Land Use and Selected Inputs, Australia*, Cat. No. 7411.0, AGPS, Canberra.

AUSTRALIAN BUREAU OF STATISTICS (ABS) (1990d), *Annual Average Retail Prices, Australia*, Cat. No. 6403.0, AGPS, Canberra.

AUSTRALIAN BUREAU OF AGRICULTURAL AND RESOURCE ECONOMICS (ABARE) (1990), *Commodity Statistical Bulletin*, AGPS, Canberra.

BUREAU OF AGRICULTURAL ECONOMICS (BAE) (1985), *Vegetable Growing Industries: A BAE Submission to IAC*, AGPS, Canberra.

GRIFFITH, G.R. (1974), "Sydney meat marketing margins - an econometric analysis", *Review of Marketing and Agricultural Economics* 42(4), 223-239.

GRIFFITH, G.R., W. GREEN and G.L. DUFF (1991), "Another look at price levelling and price averaging in the Sydney meat market", *Review of Marketing and Agricultural Economics* 59(2), 97-109.

INDUSTRIES ASSISTANCE COMMISSION (IAC) (1986), *Vegetables and Vegetable Products*, AGPS, Canberra.

MCNAMARA, L. (1991), "Record low returns hit potato growers", *The Land*, 18 July, p.6.

MIDDLEBROOK, T. and T. JONES (1991), "Vegetables dumped as winter glut bites", *The Land*, 20 June, p.6.

NAUGHTIN, J. and J. QUILKEY (1979), "Pricing efficiency in the retail meat market", *Australian Journal of Agricultural Economics* 23(1), 125-129.

NSW AGRICULTURE & FISHERIES (1990), *Annual Average Wholesale Prices*, Division of Marketing and Economic Services, Sydney.

PARISH, R. (1967), "Price 'levelling' and 'averaging'", *The Farm Economist* 11(5), 187-198.

WARD, R. (1982), "Asymmetry in retail, wholesale and shipping point pricing for fresh vegetables", *American Journal of Agricultural Economics* 64(2), 205-211.

Appendix 1: Data Definitions and Sources

PR_i: average quarterly retail prices of potatoes, tomatoes, carrots and onions, Sydney, \$/kg (ABS 1990d).

PW_i: average quarterly wholesale prices of potatoes, tomatoes, carrots and onions, Flemington Wholesale Markets, Sydney, \$/kg (NSW Agriculture & Fisheries 1990). Quarterly averages calculated from published monthly averages.

PS_i: average quarterly price spreads of potatoes, tomatoes, carrots and onions, Sydney, \$/kg (calculated as PR_i-PW_i).

MC: quarterly award rate of pay index, full time adult employee, retail trade, base 1985=100 (ABS 1990b, and previous forms of this index). Quarterly averages calculated from published monthly averages of weekly rates of pay.

D1: dummy variable for 1st quarter, =1 in quarter 1, =0 elsewhere.

D2: dummy variable for 2nd quarter, =1 in quarter 2, =0 elsewhere.

D3: dummy variable for 3rd quarter, =1 in quarter 3, =0 elsewhere.

LPW_i: PW_i lagged one quarter.

LPS_i: PS_i lagged one quarter.

Appendix 2: 2SLS Model with Retail Price as the Dependent Variable

Vegetable	C	Wholesale Price	Lagged W'sale Price	Cost	Potato Spread	Tomato Spread	Carrot Spread	Onion Spread	Lagged Dept Variable	D1	D2	D3	DW DH
Potato	-0.028 (0.183)	0.084 (0.440)	0.709 (0.278) [0.43]	-0.0023 (0.008)	-	0.231 (0.310)	0.003 (0.300)	0.234 (0.703)	0.389 (0.267)	0.064 (0.088)	0.025 (0.167)	0.039 (0.187)	- n.a.
Tomato	0.159 (0.364)	1.758 (0.423) [0.39]	-0.200 (0.613)	0.010 (0.007) [0.49]	-0.616 (0.803)	-	0.799 (0.605) [0.27]	-0.506 (0.818)	0.113 (0.324)	-0.024 (0.179)	-0.242 (0.267)	-0.182 (0.224)	- n.a.
Carrot	-0.055 (0.208)	0.214 (0.287)	0.891 (0.568) [0.30]	0.003 (0.004)	-0.598 (0.479) [-0.15]	0.187 (0.226)	-	-0.099 (0.644)	0.716 (0.279)	-0.101 (0.125)	-0.270 (0.162)	-0.247 (0.157)	- n.a.
Onion	-0.048 (0.309)	1.161 (0.228) [0.50]	0.118 (0.277)	0.007 (0.006) [0.74]	0.039 (0.598)	-0.242 (0.287)	0.218 (0.416)	-	0.182 (0.225)	-0.080 (0.144)	-0.111 (0.169)	-0.149 (0.173)	- n.a.