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Forecasting marketing margins in the Australian pig industry*

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Abstract

The apparent divergence between producer and retail prices in the presence of a marketing chain is a common facet in agricultural industries. There is evidence to suggest that changes in producer prices are not passed on fully to changes in retail price, especially in the situation where producer prices are in decline. In the presence of market power reductions in producer prices are not reflected in reductions in retail prices but increases in producer prices are immediately reflected in increases in retail prices. Asymmetric price transmission will result from situations where firms are facing different elasticities for their inputs and outputs. This paper looks at the Australian meat industry, in particular pigmeat, and attempts to identify whether the presence of marketing margins results in asymmetric price transmission between producer and retail prices. Error correction models suggest that the speed of adjustment of retail prices to changes in producer prices is very slow, indicating that market power in terms of intertemporal price averaging exists. When close substitutes, such as beef, chicken, and lamb are taken into consideration it seems that retail prices of pork are sensitive to changes in those retail prices, specifically changes in cattle prices. This implies that pork is competitive with beef at the retail level, indicating horizontal competition exists but not vertical.

Keywords: Australian Meat Industry, Asymmetric Price Transmission, Market Power, Vector Error Correction Models, Impulse-Response Functions, Speed of Adjustment.

JEL Classification: C22, C32, C53, L22, Q13

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1. Introduction

In this paper the apparent divergence between retail prices and producer prices due to the presence of a marketing chain is examined in detail. The apparent divergence between producer and retail prices in the presence of a marketing chain is a common facet in agricultural industries. There is evidence to suggest that changes in producer prices are not passed on fully to changes in retail price, especially in the situation where producer prices are in decline. Both Hahn and Duewer [13] and von Cramon-Taubadel [6] show that in the presence of market power reductions in producer prices are not reflected in reductions in retail prices but increases in producer prices are immediately reflected in increases in retail prices. Asymmetric price transmission will result from situations where firms are facing different elasticities for their inputs and outputs. In situations where firms are able to exert market power, an increase in input price will be transferred rapidly to their output price but a decrease in input price will not be transferred as rapidly to their output price. To account for asymmetry in a dynamic, simultaneous equation setting Section 2 looks at the formation of a VEC model of producer and retail prices taking into consideration the effect of a marketing chain driving a wedge between producer and retail prices. To take into account the possibility of spatial and temporal price averaging Section 3 looks at the Australian retail meat sector and attempts to estimate the dynamic short and long run interactions between the different meat products. Finally Section 4 summarises the results of the paper.

2. A VEC model of producer-to-retail marketing margin

Many different modelling techniques have been used to estimate asymmetric price transmission. For example, Heien [16] used a markup pricing model where the difference between producer and retail prices was a constant markup term incorporating fixed marketing costs. In contrast, Hahn and Duewer [13] develop an endogenous switching model to capture the asymmetry of price transmission which they then optimize via a linear programming approach. However, von Cramon-Taubadel [6] takes an econometric approach using an error correction model (ECM) to capture the speed and degree of adjustment of retail prices to a change in producer prices.

In testing a market for asymmetric price transmission particular attention needs to be paid to the frequency of the data [4],[5]. As the frequency of the data is reduced the asymmetric properties of price transmission will be obscured by the symmetry of the long-run equilibrium. Both [5] and [6] find that the data frequency needs to be higher than that required by market agents to complete transactions and that an appropriate frequency is weekly data. Even with weekly data von Cramon-Taubadel [6, Table 2] finds that the regression coefficients in the symmetric and asymmetric case are very similar although he does conclude that there is significant asymmetry in price transmission. Impulse-response functions calculated by von Cramon-Taubadel indicate that equilibrium is restored within one quarter, indicating that a frequency lower than that will fail to pick up the asymmetric price transmission, at least for the northern German pork market.

In the Australian pig industry context, while weekly prices are available for producer prices, retail prices with a high frequency are difficult to come by. Official ABS statistics only detail quarterly retail prices, thus exploring the asymmetric nature of price transmission in the Australian pig industry is hampered by the inadequacies of the data. Data limitations constrain us to only analyse the case of symmetric price transmission as an indication of market power. If the price transmission between producer and retail prices is slow, the implication is, therefore, that market power is being exerted as competitive pressure to rapidly adjust price is missing.

Hahn [12] suggests that there exists simultaneous equation bias between retail and producer price formation, a problem that von Cramon-Taubadel [6] skirts around by testing for weak exogeneity between prices. The formation of a Vector Error Correction (VEC) model solves this problem, by explicitly taking into consideration the simultaneous nature of price formation. In this section a Vector Error Correction of the producer-retail price margin is formulated in an attempt to explore the nature of the divergence between the two prices.

Seasonal unit root tests undertaken by Purcell and Harrison [28] using quarterly data suggest that prior to 1990 prices and quantities were stationary but the introduction of imports resulted in a structural break with producer prices becoming non-stationary. We use the same dataset as Purcell and Harrison in this analysis.

Phillips-Perron [26] and ADF unit root tests [7], [8] were carried out for the dataset variables over the period 1984:1 to 1998:8[1]. The results are presented in Table 2.1 (See Figure 2.1). The results are interesting, and for the main part confirm the unit root tests carried out on the same variables using a quarterly frequency (See Purcell and Harrison [28]). The main differences are in the identification of a unit root process in saleyard prices for baconers, domestic production, and imports. Purcell and Harrison [28] identified saleyard prices for baconers having a unit root process post 1990, the introduction of imports, and being stationary prior to 1990. Using monthly data the ADF test suggests that saleyard prices for baconers follows a stationary, $I(0)$, process whereas the Phillips-Perron test indicates that baconer prices follows a unit root process. The Phillips-Perron test is for a null of a unit root is not significant at the 5% significance level but at the 10% level the test rejects a unit-root process. The conflict in the test results, and the borderline critical values suggests that saleyard prices for baconers follows a fractional or seasonal unit root process. The import price for pigmeat from Canada appears to also follow a fractional or seasonal unit-root process, as the results of the Phillips-Perron and ADF tests are conflicting, and import volumes are stationary. Using DHF tests [9], [22], [23] Purcell and Harrison [28] identified import prices and volumes as following a $SI_4(0,1)$ process whereas HEGY tests [18] carried out by the Institute for Research into International Competitiveness (IRIC) [19] suggested that import prices follow a semi-annual unit-root process and import volumes follow a normal unit-root process. Domestic production of pigmeat appears to be stationary ($p < 0.001$), which is surprising given the unit-root process found by both Purcell and Harrison and IRIC using quarterly data.

It is normally assumed that stationary variables cannot be including in an ECM, since the ECM requires that the variables be integrated of the same or higher order. However, Hansen and Juselius [15, p. 1] point out that all that is required is that two of the variables in the ECM are non-stationary. Stationary (and near-integrated variables) often play an important role in the long-run equilibrium relationship and should be included in the ECM.

As a first step the order of lags to be incorporated into the model needs to be taken

[1]The results were the same for the tests carried out on pre-1990 and post-1990 samples and for log versus level variables. In the ADF tests, except for import volumes and values, which had an augmented lag length of 2, the rest of the variables had an augmented lag length of 4. In the Phillips-Perron test the Newy-West statistic suggested a truncation lag of 3 for all variables.

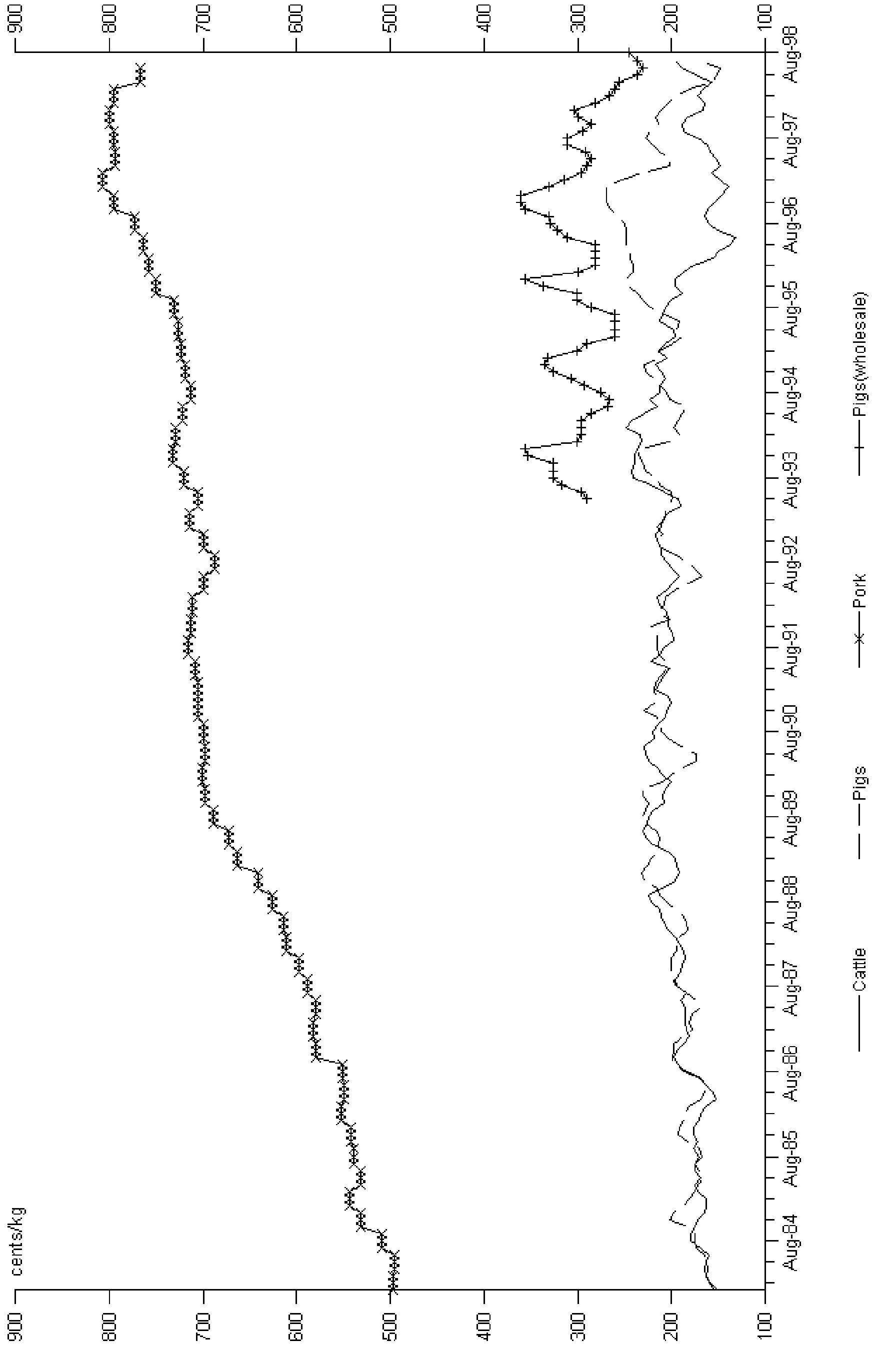

Figure 2.1: Australian pig industry producer, wholesale and retail prices

Table 2.1: Pig industry dataset and unit root tests

	Phillips-Perron	ADF
Saleyard price for baconers (¢/kg) (SPM)[1]	I(1)	I(0)
Saleyard price for beef cattle (¢/kg) (SBFM)[1]	I(1)	I(1)
Retail price for pork (¢/kg) (RPM)[1]	I(1)	I(1)
Wholesale price for pork leg (¢/kg) (WPM)[27]	I(1)	I(1)
Imports of pigmeat from Canada (kg) (CAMVM)[3]	I(0)	I(0)
Price of imports from Canada (¢/kg) (CAMPM)[3]	I(0)	I(1)
Domestic production of pigmeat (kg) (PPDM)[2]	I(0)	I(0)

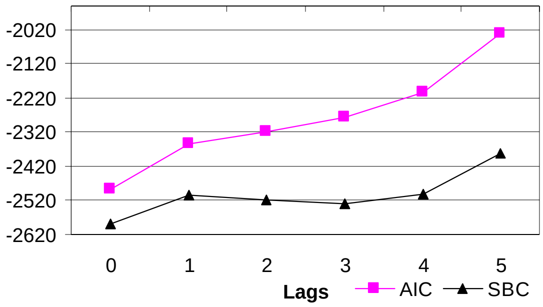

Figure 2.2: Lag length determination for monthly marketing margin model

into account. A VAR(5) model with SPM, SBFM, RPM, WPM, PPRODM, CANVM, CANPM (See Table 2.1) as endogenous variables and a constant, time trend, 1^{st} to 11^{th} seasonal dummies, and a structural break dummy for 1997:11 was regressed over the period 1993:10 to 1998:6 and the AIC and SBC calculated for each order of lags (See Figure 2.2).

The results indicate that the SBC selects a VAR(1) whereas the AIC does not reach a maximum level over the lag lengths estimated. In consideration that the SBC is a consistent model selector and the AIC over parameterises the model lag length selection a VAR(2) was considered to be the more appropriate model lag length.

The model is estimated for monthly data from 1993:7 to 1998:6 and includes as endogenous $I(1)$ variables the wholesale price for bone-in leg meat (WPM), the retail price for pork (RPM), the saleyard price for baconers (SPM), and domestic production of pigmeat (PPRODM). In addition the saleyard price for cattle (SBFM), import volumes (CANVM) (in kgs), and import prices (CANPM) are treated as exogenous $I(1)$ variables. The $I(0)$ variables are the 1^{st} to 11^{th} seasonal dummies and a dummy variable for the change in import protocol in 1997:11.

The Johansen maximum-likelihood test for cointegration [20], [21] is carried out on a VAR(2) with unrestricted intercepts and no trends and the results indicate that the hypothesis of two cointegrating vectors is not rejected (See Table 2.2) Tests of over indentifying restrictions on the cointegrating vectors indicates that in the first vector a positive long run relationship exists between producer and wholesale prices and domestic production with import prices playing a significant role in raising prices. In the second cointegrating vector a long run relationship exists between producer

Table 2.2: Johansen ML test for Cointegration

H_0	H_1	Max-Eigenvalue	$LR_{Crit,0.05}$	Trace	$LR_{Crit,0.05}$
$r = 0$	$r = 1$	77.0265	40.0600	141.1725	86.3000
$r \leq 1$	$r = 2$	35.8601	33.8100	64.1459	60.5400
$r \leq 2$	$r = 3$	22.8040	26.9500	28.2858	38.5000
$r \leq 3$	$r = 4$	5.4819	19.6200	5.4819	19.6200

Table 2.3: Cointegrating vectors

CI vector	β_1	β_2	$\bar{\beta}_1 \left(S_{\bar{\beta}_1}\right)$	$\bar{\beta}_2 \left(S_{\bar{\beta}_2}\right)$
WPM	0.0026696	−0.0089313	0.41225	−3.0124
$PPRODM$	0.1709×10^{-3}	0.2978×10^{-4}	0.027378(0.0036825)	0
RPM	0.9889×10^{-3}	0.8577×10^{-3}	0	0
SPM	0.0064756	0.0029649	1.0	1.0
$SBFM$	0.0013550	−0.0092884	0	−2.8995(0.85070)
$CANVM$	-0.1431×10^{-6}	0.1424×10^{-6}	0	0
$CANPM$	0.0010493	0.0022368	0.19143(.078741)	0.75927(.26131)

CI matrix = $[\beta_1, \beta_2]$, Restricted CI matrix = $[\bar{\beta}_1, \bar{\beta}_2]$

and wholesale prices along with cattle prices and import prices (See Table 2.3). The positive relationship between domestic prices and import prices is perhaps indicative of the price capping effect of imports; as import prices decline domestic prices have to fall in order to compete. It appears that import volumes have no role to play in the determination of the long-run equilibrium in the domestic market, at least in the short (monthly frequency) run. The VEC model based on the restricted cointegrating vectors is presented in Tables 2.4 and 2.5.

The results indicate that producer prices are significantly affected by short run changes in cattle prices, with every $\$1/kg$ increase in the price of cattle results in around a $28¢/kg$ fall in the saleyard price for baconers. Import volumes also appear to have significant short run effects with every 1000 tonnes of imports resulting in producer prices falling by around $13¢/kg$. Long-run effects do not appear to play an important role in producer price formation in this model framework, as the From the non-significant structural break term it appears that on a monthly basis the fall in producer prices after November 1997 could not be attributed to factors other than changes in factors already modelled in the equation, although the relatively low R^2 of 69% indicates that the model is not a very good fit of the data generating process (DGP). The equation for producer prices did not suffer from any serial correlation or heteroscedasticity.

Retail prices are not significantly affected by the variables in the regression model, indicating that the DGP for retail prices is influenced by other factors. The structural break parameter is borderline on being significant, and indicates that import protocols may have decreased retail price by around $5.32¢/kg$. Long-run effects embedded in the cointegrating vectors do not appear to play a great role in the determination of retail prices The R^2 for the equation for retail prices is only 56%, indicating that the equation is not a very good fit of the DGP and that changes in retail prices are explained by factors other than producer prices and production for instance. The equation for retail prices exhibits significant heteroscedasticity.

Table 2.4: VEC representation

	ΔWPM		$\Delta PPRODM$	
	$\hat{\beta}_i$	S_{β_i}	$\hat{\beta}_i$	S_{β_i}
α_0	306.9774	92.1384[.002]	77687.6	9451.0[.000]
T	-0.86487	21796[.000]	-4.3553	22.3565[.847]
ΔWPM_t	0.10154	0.14006[.473]	23.7041	14.3669[.107]
$\Delta PPRODM_t$	0.860×10^{-3}	0.0011104[.443]	0.23671	0.11389[.045]
ΔRPM_t	-0.086225	0.31822[.788]	24.5519	32.6410[.457]
ΔSPM_t	0.34591	0.25831[.189]	49.4988	26.4959[.070]
$\Delta SBFM_t$	0.34214	0.21704[.123]	36.3242	22.2630[.111]
$\Delta CANVM_t$	-0.1733×10^{-5}	0.9293×10^{-5}[.853]	0.3100×10^{-4}	0.9532×10^{-3}[.974]
$\Delta CANPM_t$	-0.049990	0.046405[.288]	4.6714	4.7599[.333]
ECM^1_{t-1}	-0.11075	0.070738[.126]	-63.1735	7.2559[.000]
ECM^2_{t-1}	0.13902	0.032330[.000]	.23322	3.3163[.944]
M^1_t	-31.0504	7.7848[.000]	-2624.3	798.5139[.002]
M^2_t	-29.9178	10.9208[.009]	-2796.1	1120.2[.017]
M^3_t	-30.8413	11.0161[.008]	-2226.9	1130.0[.056]
M^4_t	-28.4394	9.5432[.005]	-2339.1	978.8799[.022]
M^5_t	-30.3244	10.2198[.005]	779.3292	1048.3[.462]
M^6_t	-21.9991	9.8411[.032]	-178.4178	1009.4[.861]
M^7_t	-16.3723	9.1755[.083]	-1777.3	941.1612[.067]
M^8_t	-16.3246	9.3927[.091]	-2673.5	963.4424[.009]
M^9_t	-14.2722	7.7514[.074]	-1815.6	795.0894[.028]
M^{10}_t	-7.8965	7.9653[.328]	-1863.9	817.0337[.028]
M^{11}_t	8.3452	9.3357[.377]	-1161.2	957.5982[.233]
$BREAK_{97:11}$	2.7928	6.5256[.671]	-2126.2	669.3534[.003]
R^2	0.76579		0.88849	

Table 2.5: VEC representation

	ΔSPM		ΔRPM	
	$\hat{\beta}_i$	S_{β_i}	$\hat{\beta}_i$	S_{β_i}
α_0	47.5995	60.4842[.436]	45.5634	49.0858[.359]
T	0.028505	0.14308[.843]	-0.082515	0.11611[.482]
ΔWPM_t	0.020975	0.091945[.821]	0.081860	0.074618[.280]
$\Delta PPRODM_t$	0.0010737	0.7289×10^{-3}[.149]	0.2096×10^{-3}	0.5915×10^{-3}[.725]
ΔRPM_t	0.0053036	0.20890[.980]	-0.21227	0.16953[.218]
ΔSPM_t	0.24035	0.16957[.165]	0.15155	0.13761[.278]
$\Delta SBFM_t$	-0.28434	0.14248[.053]	0.10662	0.11563[.362]
$\Delta CANVM_t$	-0.1311×10^{-4}	0.6100×10^{-5}[.038]	0.1005×10^{-5}	0.4951×10^{-5}[.840]
$\Delta CANPM_t$	0.032408	0.030462[.294]	-0.013607	0.024722[.585]
ECM^1_{t-1}	-0.054144	0.046436[.251]	-0.021866	0.037685[.565]
ECM^2_{t-1}	-0.013039	0.021223[.543]	0.017207	0.017224[.324]
M^1_t	-10.7726	5.1103[.042]	6.6713	4.1473[.116]
M^2_t	-2.0970	7.1689[.772	5.4415	5.8179[.356]
M^3_t	-2.5877	7.2315[.722]	0.43728	5.8687[.941]
M^4_t	-9.2892	6.2646[.147]	-7.1180	5.0840[.170]
M^5_t	5.9023	6.7088[.385]	0.044074	5.4445[.994]
M^6_t	5.3456	6.4602[.413]	0.35433	-5.2428[.946]
M^7_t	15.7061	6.0232[.013]	2.5541	4.8881[.604]
M^8_t	14.8160	6.1658[.021]	-3.5120	5.0039[.487]
M^9_t	8.3410	5.0884[.110]	-2.1983	4.1295[.598]
M^{10}_t	7.8074	5.2288[.144]	12.2377	4.2435[.007]
M^{11}_t	12.1480	6.1284[.055]	3.1532	4.9735[.530]
$BREAK_{97:11}$	-4.9064	4.2837[.259]	-5.3246	3.4764[.134]
R^2	0.69358		0.55794	

Changes in the wholesale price are appear to be borderline significantly affected by changes in the saleyard price for baconers with a \$1.00 increase in producer prices resulting in around a $34¢/kg$ increase in the wholesale price. Imports do not appear to play a role in short-run changes to wholesale price but the second ECM parameter is highly significant and the first borderline significant, indicating that long-run changes in domestic production, producer prices, cattle prices, and import prices have an effect on wholesale prices. The equation for the wholesale price exhibits significant serial correlation and heteroscedasticity, indicating that the estimates will be inefficient.

Changes in production of pigmeat are significantly affected by changes in the saleyard price for baconers, with a 1¢/kg increase in producer prices resulting in around a 49 tonne increase in production. Wholesale prices have a positive influence on production with a 1¢/kg increase in wholesale price resulting in around a 24 tonne increase in production. The saleyard price for cattle is borderline significant and suggests that for every \$1.00 increase in cattle prices pigmeat production increases by around 36 tonnes. The introduction of new import protocols after November 1997 has significantly decreased pigmeat production by around 2126 tonnes (per month). Industry sources indicate that quota limits on contract sales to abattoirs have been strictly enforced during 1998 in an effort to restrict supply and this could be an explanation for the negative coefficient on the structural break term. Although import prices and volumes do not appear to have a short-run effect on production changes the significant coefficient for the second ECM term indicates that there is a long-run equilibrium effect of import prices on domestic production. The R^2 for the domestic production equation is 89%, indicating that the model is a good fit of the DGP for domestic production.

3. A VEC model of the Australian retail meat sector

In the section above a model of the Australian pig industry incorporating a marketing margin was developed. The results indicated that the DGP for retail prices was not adequately explained by the model structure and this suggested that there were other factors which better explained changes in pork retail prices.

One of the facets of agricultural industries is the phenomenon of asymmetric price transmission between the producer and retail levels of the marketing chain. The concentration of market power observed at the retail end of the marketing chain means that firms are able to capture increased margins when producer prices are lower and pass on cost increases when producer prices are higher. This phenomenon is by no means restricted to Australia and has been observed in both North America [12], [14] and Europe [6]. Even the recent decline in producer prices for pigs in Australia (See Figure 2.1) has followed quite closely the decline in producer prices and corresponding market share in the US and Canadian markets (See Table 3.1).

Hyde and Perloff [17] estimate market power for the Australian retail meat sector and suggest that in the presence of market power in some markets but not in others the estimation of market power is biased when conducted in a single equation framework (one market at a time) compared with the estimation in a simultaneous market framework. Hyde and Perloff estimate market power between retail and wholesale prices using a model based on the Almost Ideal Demand System (AIDS) combined with optimal pricing conditions for each industry. They find that over the period 1970-1988 market power was insignificant and unchanging over time.

In contrast, Griffith and Piggott [11] found that significant asymmetric price trans-

Table 3.1: US Price Spreads cents/retail lb.

		Nov-97	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98
Beef	Farm to wholesale	20.7	25.4	34.5	28.6	25.5	26.6
	Wholesale to retail	117.8	124.5	118.8	121.0	118.6	121.9
	Farmers share (%)	50.0	46.0	45.0	45.0	48.0	47.0
Pork	Farm to wholesale	38.0	37.3	41.0	45.3	49.1	56.5
	Wholesale to retail	123.4	136.1	134.5	138.0	139.1	142.3
	Farmers share (%)	30.0	25.0	24.0	21.0	18.0	12.0

Source: USDA [29]

mission occurred in the beef and lamb markets but not the pork market over the period 1971-1988. Their model was a markup pricing model estimated for each meat product separately and thus did not incorporate substitution effects between meats.

In this section we formulate a vector error correction model of the Australian retail meat sector that does not impose an ad-hoc structure on the dataset and allows dynamic interactions to take place. The model is estimated over the period 1990:1 to 1997:2, the period after the introduction of pigmeat imports, and models the interactions between retail and producer prices. The model dataset comprises of retail and producer prices for pigmeat, beef and lamb, and retail prices for chicken (producer prices for chicken meat were unavailable) (See Table 3.2 and Figure 3.1).

Table 3.2: Retail Meat Sector Dataset and unit root tests

	Phillips-Perron	ADF
Saleyard price for baconers (¢/kg) (SPQ)	I(1)	I(1)
Saleyard price for beef cattle (¢/kg) (SBFQ)	I(1)	I(1)
Saleyard price for lamb (¢/kg) (SPQL)	I(1)	I(1)
Retail price for pork (¢/kg) (RPQ)	I(1)	I(1)
Retail price for beef (¢/kg) (RBFQ)	I(1)	I(1)
Retail price for lamb (¢/kg) (RPQL)	I(1)	I(1)
Retail price for chicken (¢/kg) (RPQC)	I(1)	I(1)

Source: ABARE [1]

As a first step the order of lags needs to be determined for the model. An unrestricted VAR(2) - the maximum available due to the restricted dataset - was estimated regressing RPQ, SPQ, RBFQ, SBFQ, RPQC, RPQL and SPQL as the endogenous variables and a constant, time trend and 1^{st} to 3^{rd} seasonal dummies as exogenous variables. The AIC and SBC were calculated for each lag length (See Figure 3.2). The SBC selects a model with one lag whereas the AIC does not appear to reach a maximum over the lags selected. Since the SBC is a consistent model selection criterion and the AIC generally over parameterises the model lag length a VAR(1) is the more appropriate model. In consideration of the importance of not underestimating the lag length a VAR(2) was chosen instead.

The Johansen maximum-likelihood test for cointegration is carried out on a VAR(2) with unrestricted intercepts and trends and RPQ, SPQ, RBFQ, SBFQ, RPQC, RPQL and SPQL as the endogenous variables and 1^{st} to 3^{rd} seasonal dummies as exogenous variables for the period 1990:1 to 1997:2. The results are conflicting, with the Maximal Eigenvalue statistic indicating that 2 cointegrating vectors exist and the Trace

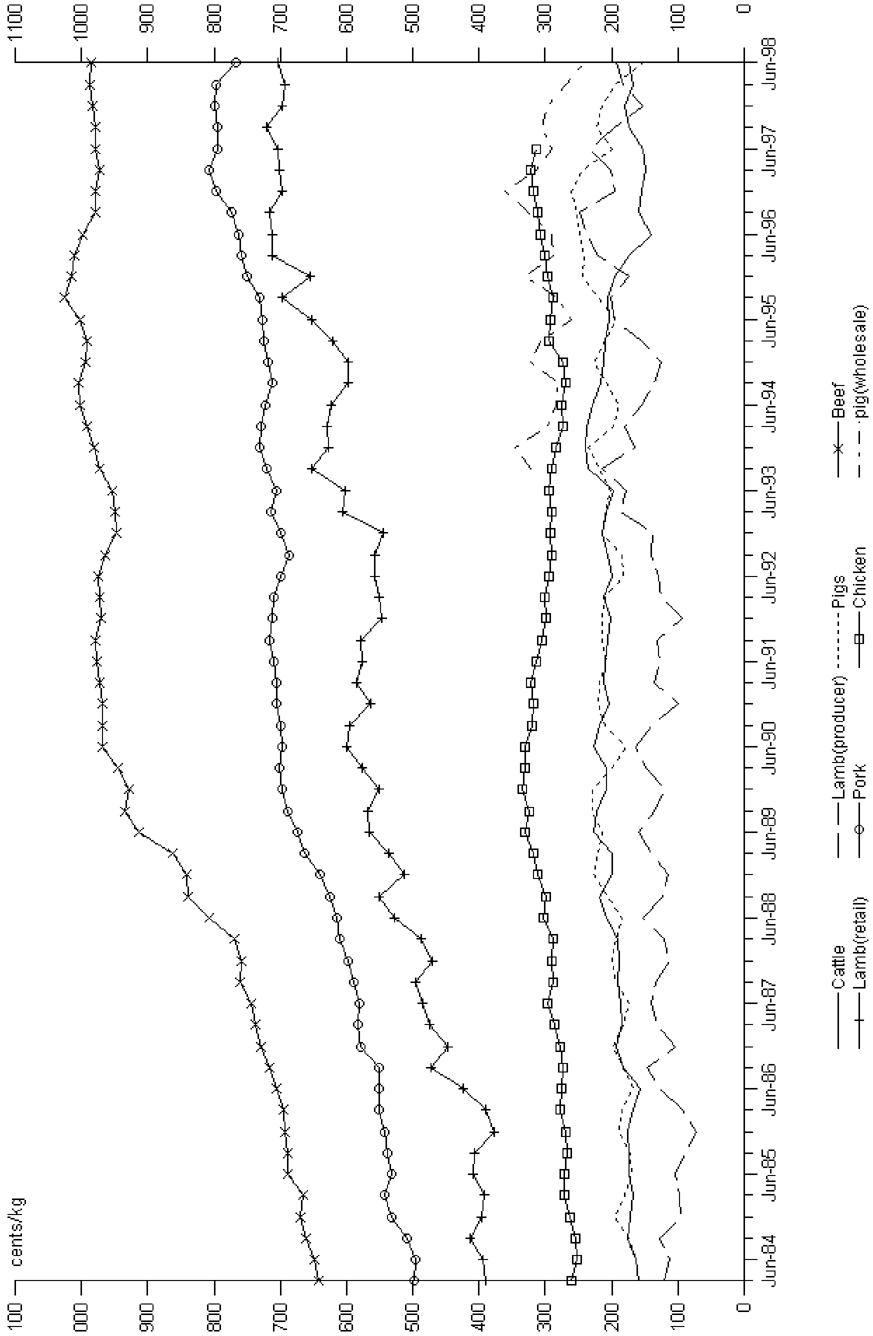

Figure 3.1: Australian meat sector producer and retail prices

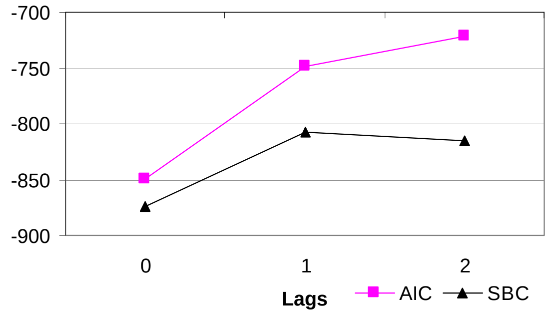

Figure 3.2: Lag length selection for retail meat market

Table 3.3: Johansen ML test for Cointegration

H_0	H_1	Max-Eigenvalue	$LR_{Crit,0.05}$	Trace	$LR_{Crit,0.05}$
$r = 0$	$r = 1$	110.0728	48.5700	251.4793	140.0200
$r \leq 1$	$r = 2$	51.6993	42.6700	141.4065	109.1800
$r \leq 2$	$r = 3$	29.6155	37.0700	89.7072	82.2300
$r \leq 3$	$r = 4$	27.8961	31.0000	60.0917	58.9300
$r \leq 4$	$r = 5$	16.8237	24.3500	32.1956	39.3300
$r \leq 5$	$r = 6$	12.5827	18.3300	15.3719	23.8300
$r \leq 6$	$r = 7$	2.7893	11.5400	2.7893	11.5400

statistic indicating that 4 cointegrating vectors exist (See Table 3.3). The SBC statistic (not reported) indicate that there is some flattening out of the statistic between 3 and 4 vectors selected but no maximum is reached. On balance it was decided that a compromise on 3 cointegrating vectors is probably the best. The error correction mechanism is derived from imposing Johansen's just identifying restrictions on the cointegrating relationships [24][2] (See Table 3.4).

The VEC model is presented in Tables 3.5 to 3.8[3]. The results indicate that the retail price of pork is influenced in the short run only by cattle prices, and that other retail and producer prices do not appear to have a short-run influence. All three of the cointegrating vectors have a significant influence on retail pork prices, indicating that in the long run changes in other meat substitutes significantly affect retail pork prices.

[2] It was decided not to impose over-identifying restrictions on the cointegrating vectors due to the difficulty in determining what the valid restrictions would be in a 7 dimensional system with three cointegrating vectors. For instance, 9 restrictions are necessary just to impose an exactly identified long-run structure. Johansen's just identifying restrictions are imposed in preference as simulations have shown that the presence of non-significant coefficients in the cointegrating vector do not affect the robustness of the ECM coefficient in any particular equation. The only difficulty is in attempting to interpret the long-run coefficients given the possible presence of non-significant coefficients. This is a non-sequitur in any case as the economic interpretation of over-identified multiple long-run relations is difficult at the best of times in much smaller dimensional systems.

Likelihood Ratio tests of restricting individual coefficients to zero indicate that all the variables play a significant role in determing the long-run equilibrium.

[3] The equations for the retail price of lamb and the retail price for chicken show significant heteroscedasticity. Tests indicate that this heteroscedasticity does not follow an ARCH process.

Table 3.4: Cointegrating vectors

CI vector	RPQ	SPQ	$RBFQ$	$SBFQ$
β_1	0.026244	0.014946	0.018598	0.037645
β_2	−0.028018	0.028513	−0.0059684	0.015043
β_3	0.0064299	−0.010250	−0.0081921	−0.0040178
$\tilde{\beta}_1$	−1.0000	−0.56951	−0.70866	−1.4344
$\tilde{\beta}_2$	−1.0000	1.0176	−0.21302	0.53689
$\tilde{\beta}_3$	−1.0000	1.5941	1.2741	0.62487

CI vector	$RPQC$	$RPQL$	$SPQL$
β_1	0.045542	−0.039738	0.026339
β_2	0.033448	−0.0088480	0.0031710
β_3	−0.0044303	−0.0049093	0.3893×10^{-3}
$\tilde{\beta}_1$	−1.7354	1.5142	−1.0036
$\tilde{\beta}_2$	1.1938	−0.31579	0.11317
$\tilde{\beta}_3$	0.68902	0.76352	−0.060539

CI matrix $= [\beta_1, \beta_2, \beta_3]$, Normalised CI matrix $= \left[\tilde{\beta}_1, \tilde{\beta}_2, \tilde{\beta}_3\right]$

The saleyard price for baconers does not seem to be influenced by any of the other prices, neither at the retail or producer levels of the marketing chain and neither in the short nor long run. Combined with the results from Section 2 this indicates that other factors, such as production and imports, have a greater influence on producer price DGP than prices further down the marketing chain.

The retail price of beef appears to be significantly influenced by the saleyard price for baconers and its own lagged values in the short run as well as the second cointegrating vector in the long run. This indicates that changes in the other meat substitutes play an important role in the long-run equilibrium of beef prices.

The saleyard price of cattle appears to be significantly influenced in the short run by changes in both the retail and producer price for pigmeat and lamb. Cattle prices are also influenced by short run changes in both the retail beef price and changes in the cattle price. Only retail chicken prices do not appear to have an impact on cattle prices in the short run. All three cointegrating vectors play an important role in the long-run equilibrium price of cattle.

The retail price of lamb appears to be influenced by short run changes in the price of beef and the producer price of lamb as well as changes in the retail price of lamb appear to impact significantly on the retail price of lamb. The second and third cointegrating vectors appear to have an influence on the long-run equilibrium retail price for lamb. In contrast, the producer price for lamb does not appear to be influenced by any short run changes in the prices of other meat products, with only the third cointegrating vector appearing to have an influence on long run changes in producer prices for lamb.

The retail price of chicken does not appear to be a good substitute for the other types of met with no significant effect of short run changes in other meats impacting on chicken prices. In the long-run the first cointegrating vector appears to play a significant role in determining changes in the retail price of chicken.

The results appear to be consistent with the results of the model estimated in the previous section. What seems obvious though is that the data generating process

Table 3.5: VEC representation for pigmeat

	ΔRPQ		ΔSPQ	
	$\hat{\beta}_i$	S_{β_i}	$\hat{\beta}_i$	S_{β_i}
α_0	625.2755	244.7839[.022]	151.7069	584.0805[.799]
ΔRPQ_t	0.0078977	0.27515[.977]	−0.40220	0.65654[.549]
ΔSPQ_t	−0.048596	0.11826[.687]	0.26847	0.28217[.356]
$\Delta RBFQ_t$	0.054029	0.19615[.787]	−0.053566	0.46804[.910]
$\Delta SBFQ_t$	0.39434	0.16146[.027]	0.42273	0.38527[.290]
$\Delta RPQC_{tt}$	−0.26719	0.26092[.322]	0.44309	0.62258[.488]
$\Delta RPQL$	−0.18654	0.15997[.262]	−0.052609	0.38171[.892]
$\Delta SPQL_t$	0.10602	0.12068[.394]	0.28408	0.28795[.340]
T	1.4426	0.99361[.167]	−3.1876	2.3709[.199]
Q_t^1	−3.4882	4.8205[.480]	−3.4483	11.5022[.768]
Q_t^2	−4.6115	5.9049[.447]	−24.6687	14.0897[.100]
Q_t^3	3.0034	4.8786[.547]	4.6884	11.6408[.693]
ECM_{t-1}^1	−13.2513	5.4456[.028]	−9.5374	12.9937[.474]
ECM_{t-1}^2	18.6195	5.4456[.004]	−15.0499	12.9937[.265]
ECM_{t-1}^3	−11.9888	5.4456[.044]	−11.5139	12.9937[.390]
R^2	0.83088		0.77569	

underlying producer and retail prices of meat in the Australian meat industry is not solely reliant on substitution effects between meats, at both the producer and the retail level. In order to capture the data generating process information on production as well as consumer demand needs to be incorporated. The incorporation of such additional information in a VEC framework is extremely data intensive, and data with a higher frequency must be used in order to obtain sufficient degrees of freedom.

The generalised impulse response functions [25] for the cointegrating vectors and the persistence profile for the model are presented in Figures 3.3 and 3.4. The ECM terms in the VEC model describe the speed of adjustment of the system to an exogenous shock in prices. The results indicate that the short-run deviations from the long-run equilibrium take a long time to dissipate - around 15 quarters for most of the prices. The ECMs tend to counterbalance each other and the system wide speed of adjustment is faster, taking around 8 to 10 quarters to dissipate (See Figure 3.4(d)).

4. Conclusions

The apparent divergence between producer and retail prices in the presence of a marketing chain is a common facet in agricultural industries. There is evidence to suggest that changes in producer prices are not passed on fully to changes in retail price, especially in the situation where producer prices are in decline. In the presence of market power reductions in producer prices are not reflected in reductions in retail prices but increases in producer prices are immediately reflected in increases in retail prices. This paper has examined asymmetric price transmission in a VEC framework. Two models are presented. The first model attempts to capture the price transmission between producer, wholesale and retail prices in the Australian pig industry and the second model examines the substitution effects between red meat at both the producer

Table 3.6: VEC representation for beef

	$\Delta RBFQ_t$		$\Delta SBFQ_t$	
	$\hat{\beta}_i$	S_{β_i}	$\hat{\beta}_i$	S_{β_i}
α_0	346.9469	424.9883[.427]	2148.0	378.2748[.000]
ΔRPQ_t	0.049913	0.47771[.918]	1.0920	0.42520[.021]
ΔSPQ_t	−0.38723	0.20531[.079]	−0.42908	0.18275[.033]
$\Delta RBFQ_t$	0.71409	0.34056[.053]	1.0815	0.30312[.003]
$\Delta SBFQ_t$	−0.0013985	0.28033[.996]	0.57335	0.24952[.036]
$\Delta RPQC_t$	−0.31077	0.45300[.503]	−0.35515	0.40321[.392]
$\Delta RPQL_t$	−0.17332	0.27774[.542]	−0.98963	0.24721[.001]
$\Delta SPQL_t$	0.088830	0.20952[.678]	0.43304	0.18649[.035]
T	3.0420	1.7251[.098]	0.52991	1.5355[.735]
Q_t^1	2.8632	8.3692[.737]	−2.9319	7.4493[.699]
Q_t^2	1.0550	10.2519[.919]	5.3559	9.1251[.566]
Q_t^3	0.87227	8.4701[.919]	4.2732	7.5390[.579]
ECM_{t-1}^1	−1.4211	9.4545[.883]	−39.4779	8.4153[.000]
ECM_{t-1}^2	21.2162	9.4545[.040]	26.6264	8.4153[.006]
ECM_{t-1}^3	7.8961	9.4545[.417]	19.6253	8.4153[.034]
R^2	0.61429		0.78662	

Table 3.7: VEC representation for lamb

	$\Delta RPQL_t$		$\Delta SPQL_t$	
	$\hat{\beta}_i$	S_{β_i}	$\hat{\beta}_i$	S_{β_i}
α_0	857.4882	709.3140[.245]	745.3604	757.2117[.341]
ΔRPQ_t	−0.16516	0.79731[.839]	−0.63144	0.85115[.470]
ΔSPQ_t	−0.049083	0.34267[.888]	0.14907	0.36581[.689]
$\Delta RBFQ_t$	1.1836	0.56840[.055]	0.50505	0.60678[.418]
$\Delta SBFQ_t$	−0.45430	0.46787[.347]	−0.56676	0.49947[.274]
$\Delta RPQC_t$	−0.18934	0.75607[.806]	0.21830	0.80712[.790]
$\Delta RPQL_t$	−0.88812	0.46355[.075]	−0.27191	0.49485[.591]
$\Delta SPQL_t$	0.99628	0.34969[.012]	0.26633	0.37330[.487]
T	6.1964	2.8792[.048]	3.9129	3.0736[.222]
Q_t^1	41.2442	13.9684[.010]	52.5573	14.9116[.003]
Q_t^2	7.6497	17.1107[.661]	34.1544	18.2661[.081]
Q_t^3	23.1918	14.1367[.122]	26.4131	15.0913[.101]
ECM_{t-1}^1	−4.3310	15.7797[.787]	−5.5924	16.8453[.744]
ECM_{t-1}^2	37.4593	15.7797[.031]	24.5346	16.8453[.166]
ECM_{t-1}^3	32.3242	15.7797[.058]	28.9402	16.8453[.106]
R^2	0.81355		0.81930	

Table 3.8: VEC representation for chicken

	$\Delta RPQC_t$	
	$\hat{\beta}_i$	S_{β_i}
α_0	563.3374	209.1381[.017]
ΔRPQ_t	0.21259	0.23508[.380]
ΔSPQ_t	0.026461	0.10104[.797]
$\Delta RBFQ_t$	0.098792	0.16759[.564]
$\Delta SBFQ_t$	0.14908	0.13795[.297]
$\Delta RPQC_t$	0.071723	0.22292[.752]
$\Delta RPQL_t$	−0.19046	0.13667[.184]
$\Delta SPQL_t$	0.17444	0.10310[.111]
T	−1.5072	0.84892[.096]
Q_t^1	10.2202	4.1185[.025]
Q_t^2	2.7691	5.0450[.591]
Q_t^3	−5.3516	4.1681[.219]
ECM_{t-1}^1	−14.5713	4.6526[.007]
ECM_{t-1}^2	−2.3739	4.6526[.617]
ECM_{t-1}^3	−3.0747	4.6526[.519]
R^2	0.75903	

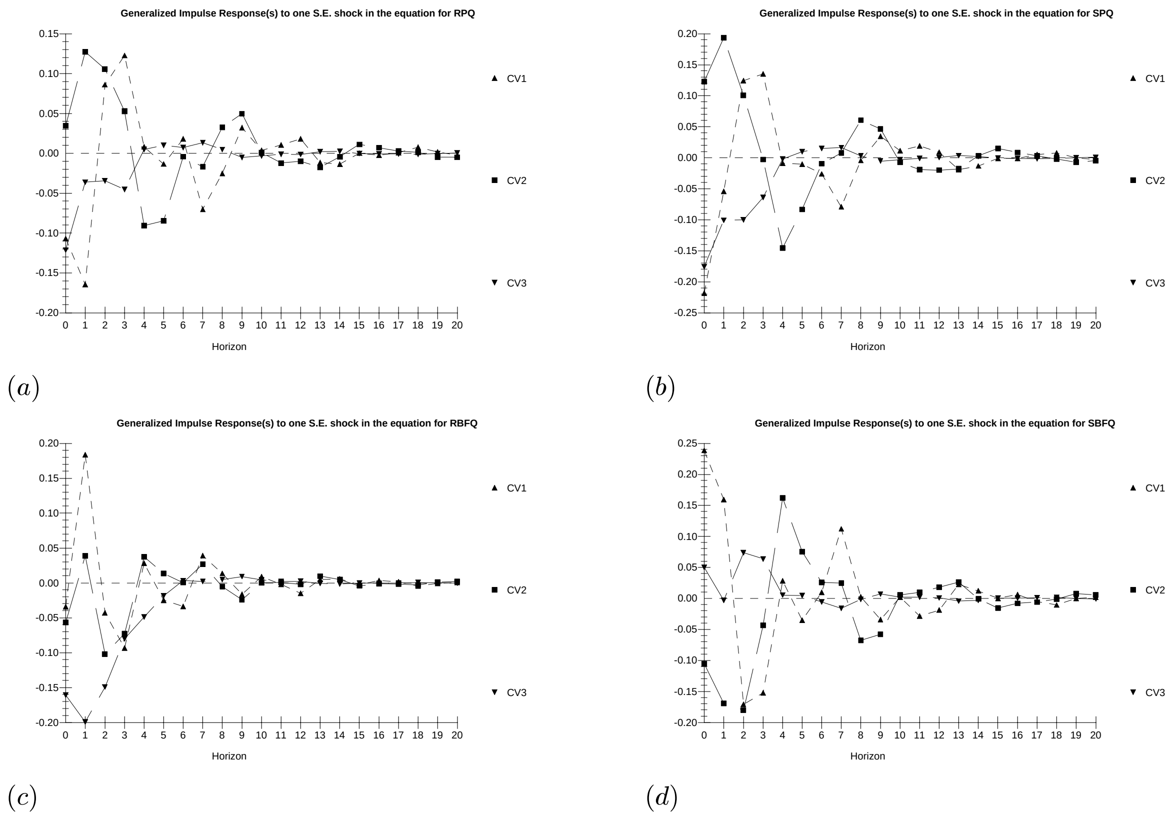

Figure 3.3: Generalised Impulse-Responses for Cointegrating Vectors

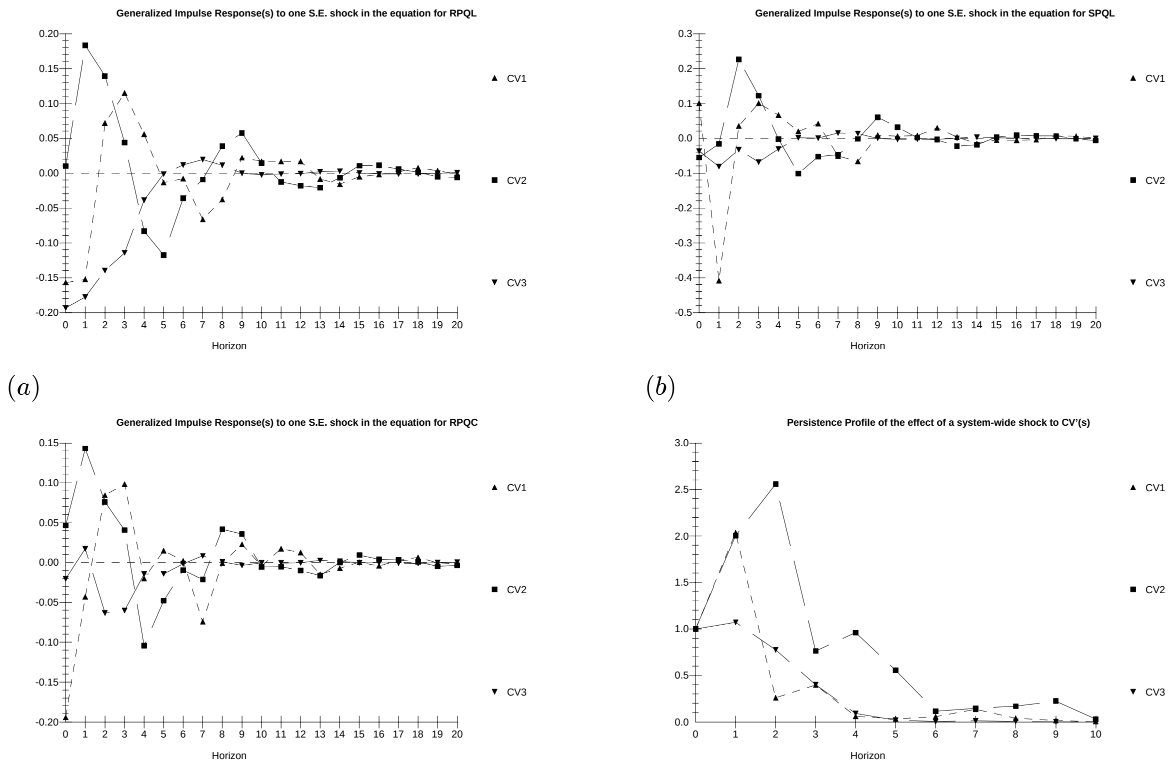

Figure 3.4: Generalised Impulse-Responses for Cointegrating Vectors

and retail level.

The results of the first model of price transmission in the Australian pig industry indicate that producer prices for pigs are significantly affected by short run changes in cattle prices and import volumes of pigmeat from Canada. Long-run effects do not appear to play an important role in producer price formation in this model framework. Retail prices are not significantly affected by the variables in the model, indicating that the DGP for retail prices is influenced by other factors like other meat substitutes. Wholesale prices appear to be affected by short-run changes in the saleyard price for baconers and long-run changes in domestic production, producer prices, cattle prices, and import prices. The domestic production of pigmeat is influenced by changes in the saleyard price for baconers, cattle prices and wholesale prices.

The results of the second model of substitution between red meats in the Australian retail meat sector indicate that the retail price of pork is influenced in the short run only by cattle prices, and that other meat prices do not appear to have a short-run influence. However, in the long run changes in other meat substitutes significantly affect retail pork prices. The saleyard price for baconers does not seem to be influenced by any of the other prices indicating that other factors, such as production and imports, have a greater influence on producer price DGP than prices further down the marketing chain.

The retail price of beef appears to be significantly influenced by the saleyard price for baconers and its own lagged values in the short run and changes in the other meat substitutes play an important role in the long-run equilibrium of beef prices. The saleyard price of cattle appears to be significantly influenced in the short run by changes in both the retail and producer price for pigmeat and lamb. Cattle prices are also influenced by short run changes in both the retail beef price and changes in the cattle price. Only retail chicken prices do not appear to have an impact on cattle prices in the short run. Changes in the other meat substitutes play an important role in the long-run equilibrium of cattle prices

The retail price of lamb appears to be influenced by short run changes in the price of beef and the producer price of lamb as well as changes in the retail price of lamb appear to impact significantly on the retail price of lamb. In contrast, the producer price for lamb does not appear to be influenced by any short run changes in the prices of other meat products. Both the producer and retail price of lamb are influenced by the long-run equilibrium between meat prices.

The retail price of chicken does not appear to be a good substitute for the other types of met with no significant effect of short run changes in other meats impacting on chicken prices.

The results of the two models appear to be consistent in that retail prices for pork seem to be influenced by changes in other meat prices whereas the producer price of pigmeat is influenced by other factors such as domestic production and imports. What seems obvious though is that the data generating process underlying producer and retail prices of meat in the Australian meat industry is not solely reliant on substitution effects between meats, at both the producer and the retail level. In order to capture the data generating process information on production as well as consumer demand needs to be incorporated.

The result of the error correction models looking at price transmission between producer and retail prices suggest that the speed of adjustment of retail prices to changes in producer prices is very slow, indicating that market power in terms of intertemporal price averaging exists. When close substitutes, such as beef, chicken, and lamb are taken into consideration it seems that retail prices of pork are sensitive to changes in those retail prices, specifically changes in saleyard cattle prices. This implies that pork is competitive with beef at the retail level, indicating horizontal competition exists but not vertical.

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