Interactions of Source State and Market Price Trends for Cattle of Korean, Japanese and USA Market Specifications

Abstract

This study analyses the trends in the real prices of steers destined for the Japanese and Korean market, and cows destined for the USA market when sold in Queensland (QLD) or New South Wales (NSW). The aim of this paper is to explore how these prices have influenced each other when faced with the same overall economic and climatic conditions. A Vector Autoregressive model is first estimated to find linkages across six price series defined by source and destination. A Seemingly Unrelated Regressions Model for the real price series is then estimated including lagged prices of linked markets and indicators of macroeconomic and climatic conditions. From our empirical analysis, we find strong evidence of mean-reverting real prices, indicating they can be predicted by their historical mean. Further, the historical mean prices paid in QLD are higher than those paid in NSW for the Korean and US market cattle specifications. The price of cattle of Japanese market specification sold in NSW is solely determined by world conditions and historical values, and it influences directly or indirectly all other markets. The price trends for cattle of US market specifications do not seem to predict movements in the Japanese or Korean markets. This is expected as the Japanese market is a premium market while the US market accepts cattle from a wider range of specifications. This study does not find a systematic relationship between these prices and movements, the Southern Oscillation Index, the Asian financial crises, or the Australian Business Cycle.

Keywords: Beef Export Prices, Seemingly Unrelated Regressions, Causality

JEL Classification: Q13, Q11

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1.   INTRODUCTION

Since the mid-1980s, the total exports of beef from Australia have grown steadily from about 584 kt to 749 kt in 1995 (Ashton et al. 1996) and 902 kt in 2000 (Riley et al. 2001). The Australian beef industry has three major export markets; Japan, The United States (US) and Korea accounting for 83% of the total export tonnage. These three markets individually account for varying tonnages of beef. In terms of tonnage and value, the Japanese is the dominant Australian export market (Riley et al. 2000). Japan is the most valuable market ($AUD1370 million; Riley et al. 2001) whereas the combined value of the three markets is about $AUD2377 million. Sixty-five percent of national beef production was exported in 1998/9 in addition to 845,800 live cattle exported to SE Asia and the Middle East for fattening and/or slaughter. Australia is a major beef exporter with its beef exports comprising 22% of the total world beef exports (Riley et al. 2000).

Due to market cycles, such as the US cattle cycle (Rosen et al. 1994) which affects the Australian market, and climatic phenomena (drought) (Martin et al. 1998; Riley et al. 2000), the Australian cattle population ranges between 24 and 27.6 million (ABS web Ref). Queensland (QLD) has the largest cattle population (ca. 10 million) and New South Wales (NSW) has about 6 million. These two states account for 65% of the Australian herd.

Australian beef production is still largely pasture based, although the numbers of cattle in feedlots has steadily increased over time (Riley et al. 2000). Due to the liveweight gains obtained from pasture, Australian beef production systems are well suited to producing cattle for the Japanese and Korean markets with feedlots being used to produce younger cattle of premium liveweight specifications. Cattle that meet Korean, Japanese and United States market specifications are sourced from a variety of locations and production systems (Bortolussi et al. 2004a,b,c). The export and domestic beef market specifications used in Australia are based on liveweight and age. The capacity to supply various beef markets is determined by a range of factors (Bortolussi et al. 2004a) but this capacity is heavily dependent on the liveweight gains generated by the production system (Bortolussi et al. 2004c) which influences the age at which cattle reach the markets' liveweight specifications.

The Japanese market specifications are supplied by grass or grain fed cattle (usually steers) of <42 months of age and >540kg liveweight (Bortolussi et al. 2004c). Cattle (usually steers, but sometimes heifers) of Korean market specifications may also be supplied by grass or grain based production systems but they are usually <27 months of age and <620kg liveweight. Culled females from breeding herds generally supply the US market (Allerton, 1999) but bulls as well as steers and heifers that fail to meet other market specifications are also accepted. Such cattle are generally used to make hamburger mince. The domestic market, although not discussed in this paper, specifies a younger (<22 months) and lighter (<450kg) class of cattle (usually heifers and steers), which require liveweight gains obtained only from relatively specialised operations. As a result of the specification overlap there may be competition for cattle between the various markets, despite lags in the production system.

A large proportion of beef producers aspire to supply cattle to the Japanese market since it is a premium market. However, the Australian beef industry is very price responsive and can behave opportunistically when price relativities between markets change (Bortolussi et al. 2004a).

Given the large QLD cattle population relative to NSW, the relationships between the three markets' price trends in both states is of interest. This is due to both states' ability to supply cattle to all three markets and the varying production environments and systems. In addition to this, the effects on the price trends of the three market specifications by prevailing economic conditions (which may affect demand), the dynamics of trade and climatic conditions, both of which can affect supply, were also of interest.

This study specifically explores the trends in the real prices of three export cattle categories sold in QLD and NSW. Our main aim is to explore how these markets have related to each other historically when faced with the same overall economic and climatic conditions. The price indicator categories used are: a) Japanese specification (JP) steers (class 32-40), b) Korean specification (KR) steers (class 28-30) and c) USA specification (US) cows (class 22-26). Weekly prices (or whenever transactions occur) for the respective fat scores within each of the three categories were available between January 1977 and September 1999. These prices (c/kg dressed weight) were weighted average prices of all animals reported by the National Livestock Reporting Service (NLRS) in the particular category specified for

the week. For the remainder of the paper we will refer to these price series by a destination-source code; JPNSW denotes Japanese market specification auctioned in NSW; KRQLD denotes Korean market specification auctioned in QLD, and so forth.

This paper provides statistical evidence of price linkages across three important beef export markets at state level. Section 2 presents a descriptive analysis of the prices over the sample period as well as other macroeconomic and climatic indicators. Section 3 presents the econometric analysis. A six-equations model was developed to establish the historical relationship among these indicator prices as well as their relationship to overall economic and climatic conditions. Section 4 presents the results and discussion and Section 5, conclusions.

2. TRENDS IN REAL PRICES AND OVERALL ECONOMIC CONDITIONS

Two major issues of interest to the industry are explored in this study. Firstly, is whether beef export prices are shown stable over time, and secondly, how are the prices in three important export markets (Japanese, Korean and US) linked? Nominal prices can distort the real historical trends, thus we needed to express the prices in real terms, that is, in constant dollars. Some of the suitable price indices for the task, such us the Export Price Index[1], were available on a quarterly basis. The RBA's Index of Commodity Prices (ICP) is reported monthly. There are rural and non-rural components of the index, as well as the combined version. The rural component of the ICP (RBA G05, 2001/02=100, series=GRCPRCAD), we consider, is highly suitable for the current study and was used to express the price series in real terms. The weekly NLRS prices were first aggregated to a monthly level[2] for the analysis. The index was available from July 1982, reducing the sample length to 1982:7 to 1999:9.

Figures 1 to 3 show the real price series for the Japanese, Korean and US markets by state, respectively. These figures appear to indicate that there is a consistently different price

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[1] ABS Catalogue # 6457.0 International Trade Price Indexes, Table 7. EXPORT PRICE INDEX.
[2] Whenever prices for more than one fat score above the minimum specified were reported for a given week, an average price is used. It was considered likely that with some processing such cattle would be suitable for the specified market. If no transactions had been reported for a given month the reserved price was used (i.e. the last known transaction price).

between NSW and QLD for all market specifications. Prices paid in NSW seem to be lower than those paid in QLD particularly for the Korean and US markets. We statistically test this perception in Section 3.

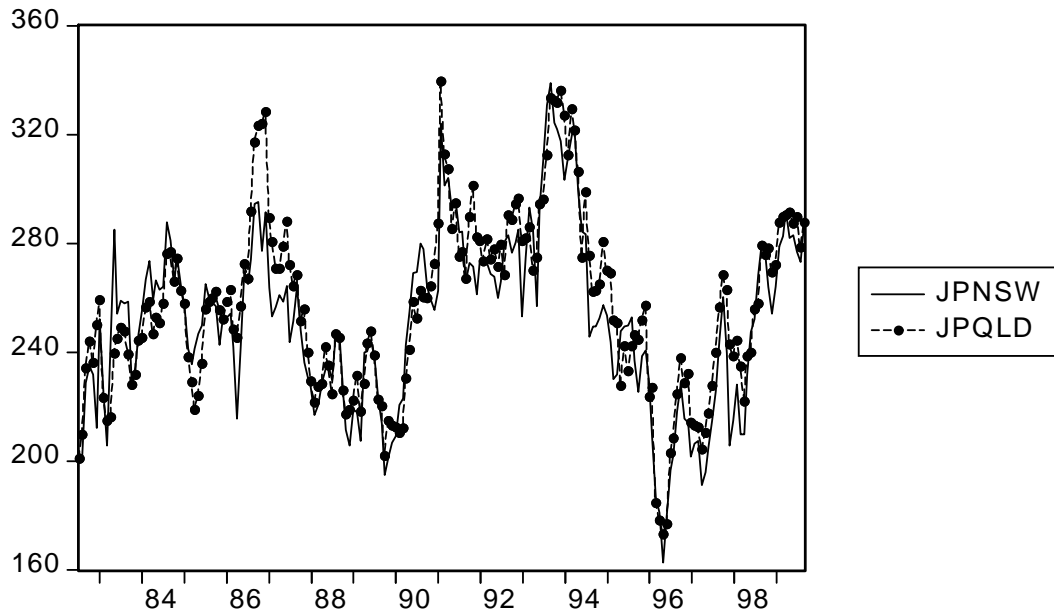Figure 1. Prices of Japanese market specification steers (class 32-40) in cents/Kg of 2001, 1982:7 – 1999:9.

Figure 2. Prices of Korean market specification steers (class 28-30) in cents/Kg of 2001, 1982:7 – 1999:9.
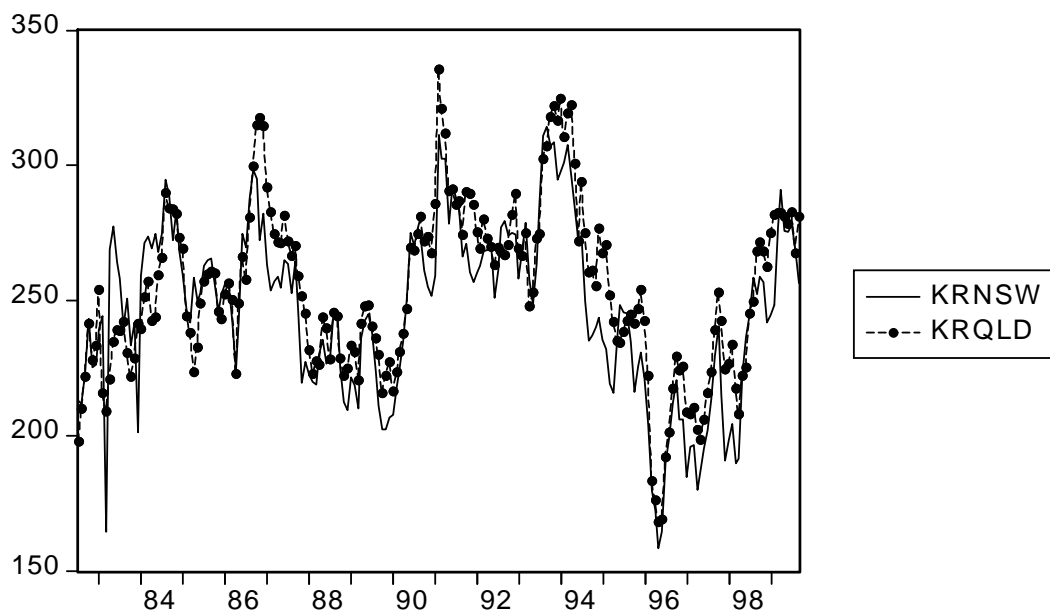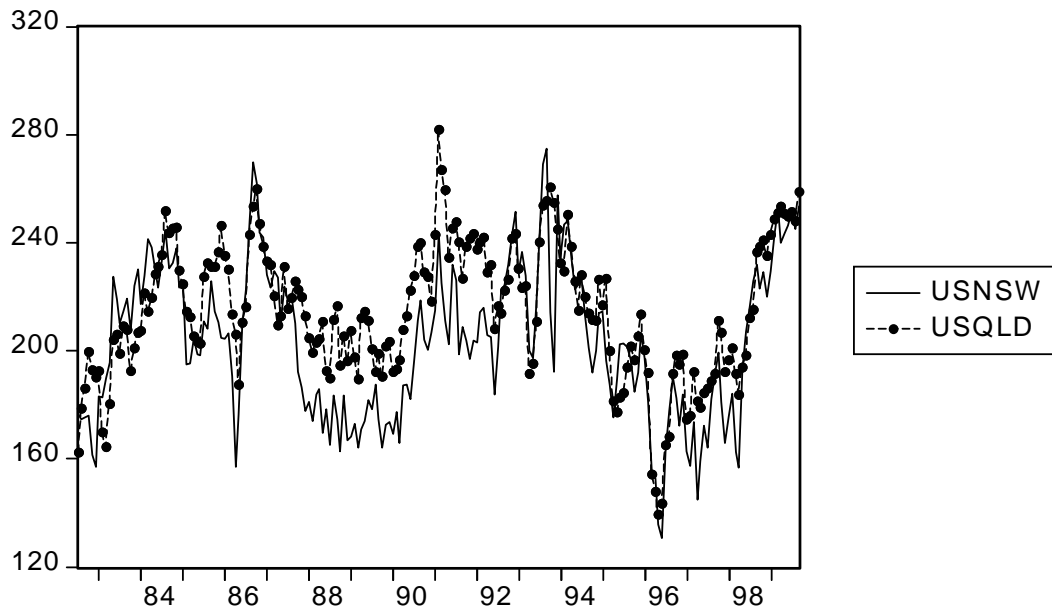
Figure 3. Prices of US market specification Cows (class 22-26) in cents/Kg of 2001, 1982:7 – 1999:9.

There are also periods where prices were lower across all markets and both states. These periods are likely to coincide with overall macroeconomic conditions (such as marked changes in exchange rates, world and Australian economic conditions, and climatic events) that affected all of them equally. To gain an understanding of some of the price trends in relation to overall economic fluctuations, Figures 4 to 6 show the price series as well as other macroeconomic indicators such as the Trade Weighted Index (TWI) the US/$AUD exchange rate in cents, and the climatic indicator Southern Oscillation Index (SOI). On the figures we have also marked the periods of recessions in the Australian economy identified in the literature for the sample period under consideration. Traditionally, two consecutive quarters of negative GDP growth define a recession (2QT). A "peak" and a "trough" define the traditional cycle. A peak is the last quarter before the two consecutive quarters of negative growth, while a trough is the last quarter of negative growth before the recovery period. Thus, a trough is the last quarter of negative growth followed by two consecutive quarters of positive growth. More sophisticated methods for dating the business cycle exist (relevant discussions on this topic can be found in Cavenagh (2001), Layton (1997), Bodman and Crosby (2002) and Harding and Pagan (2002)). On the figures (refer to Figures 4 to 6), the dated business cycles (from peak to trough) for the Australian economy as dated by the Melbourne Institute (MI), the Economic Cycle Research Institute (ECRI) and the 2QT methodology are marked. During the sample period there are two cycles. The

first is dated roughly, depending on the method used, between the third quarter of 1981 (peak) to the second quarter of 1982 (beginning of our sample) where the trough is reported. The second cycle varies markedly depending on the method used. ECRI's dating is from April 1990 (peak) to December 1991(trough). The plots would seem to indicate a counter-cyclical behaviour of real prices as they are recovering during the downturn of the economic cycle. There is however a marked decrease in real prices in the second part of the 1990s which does not coincide with a dated cycle of the Australian economy. A few important events warrant consideration; (i) the liquidation of stock by the US between January of 1996 and July 1998, mainly selling into Korea, affecting demand for Australian beef and thus prices, and (ii) the Asian financial crisis, which affected both Japan and Korea (mid 1997 to December 1998) and Indonesia. Indonesia in particular imported large numbers of live cattle from northern Australia (Martin et al. 1998) thus putting a floor in cattle prices (especially QLD) until a sharp fall in demand for live cattle.

Finally, the overall climatic conditions must be taken into account. The years 1991-1995 were a period of below average rainfall and prolonged drought in QLD. By October 1994, approximately 88% of QLD beef properties were in drought declared areas (Ashton et al. 1995). Fewer NSW beef properties were in drought. During the sample period 1982/83, 1987/1988, 1991-95, and 1997/98 were "El Niño" years, and therefore drought years. The SOI (plotted in Figure 4 to 6 with scale on the right hand side) was well into negative values (below –10) during these years, showing a correlation between the two. For the years 1991 to 1995, when the SOI was highly negative, real prices seem above historical values. Better seasonal conditions resulting in increased pasture and grain availability in parts of the latter half of the 1990s would have influenced the availability of finished cattle and thus affected prices.

The next section quantitatively explores how these markets related to each other over time when faced with the same overall economic and climatic conditions.

Figure 4. December 2001 prices (cents/kg) of Japanese market specification steers, Macroeconomic and Climatic Indicators.
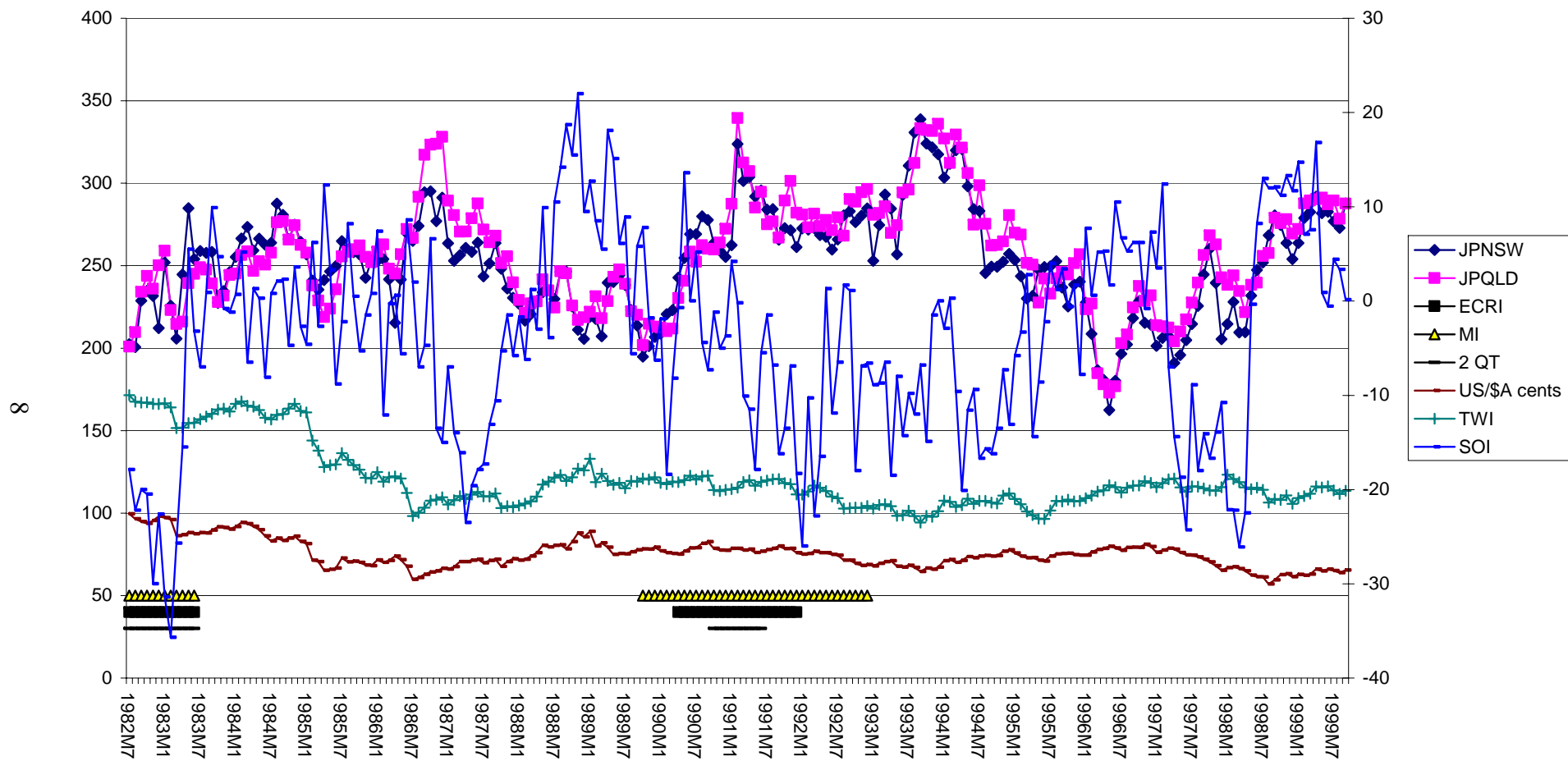
Figure 5.   December 2001 prices (cents/kg) of Korean market specification steers, Macroeconomic and Climatic Indicators.
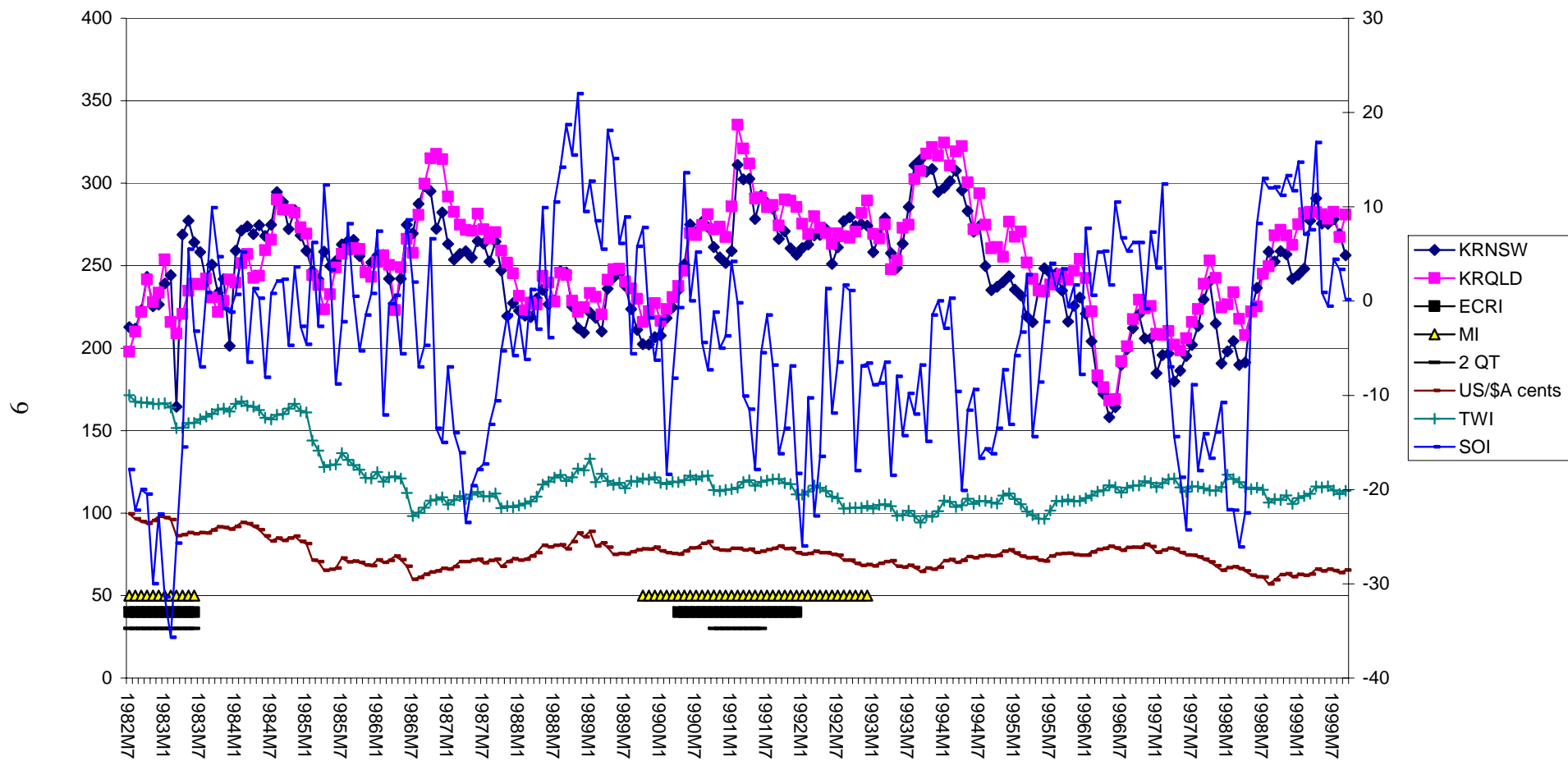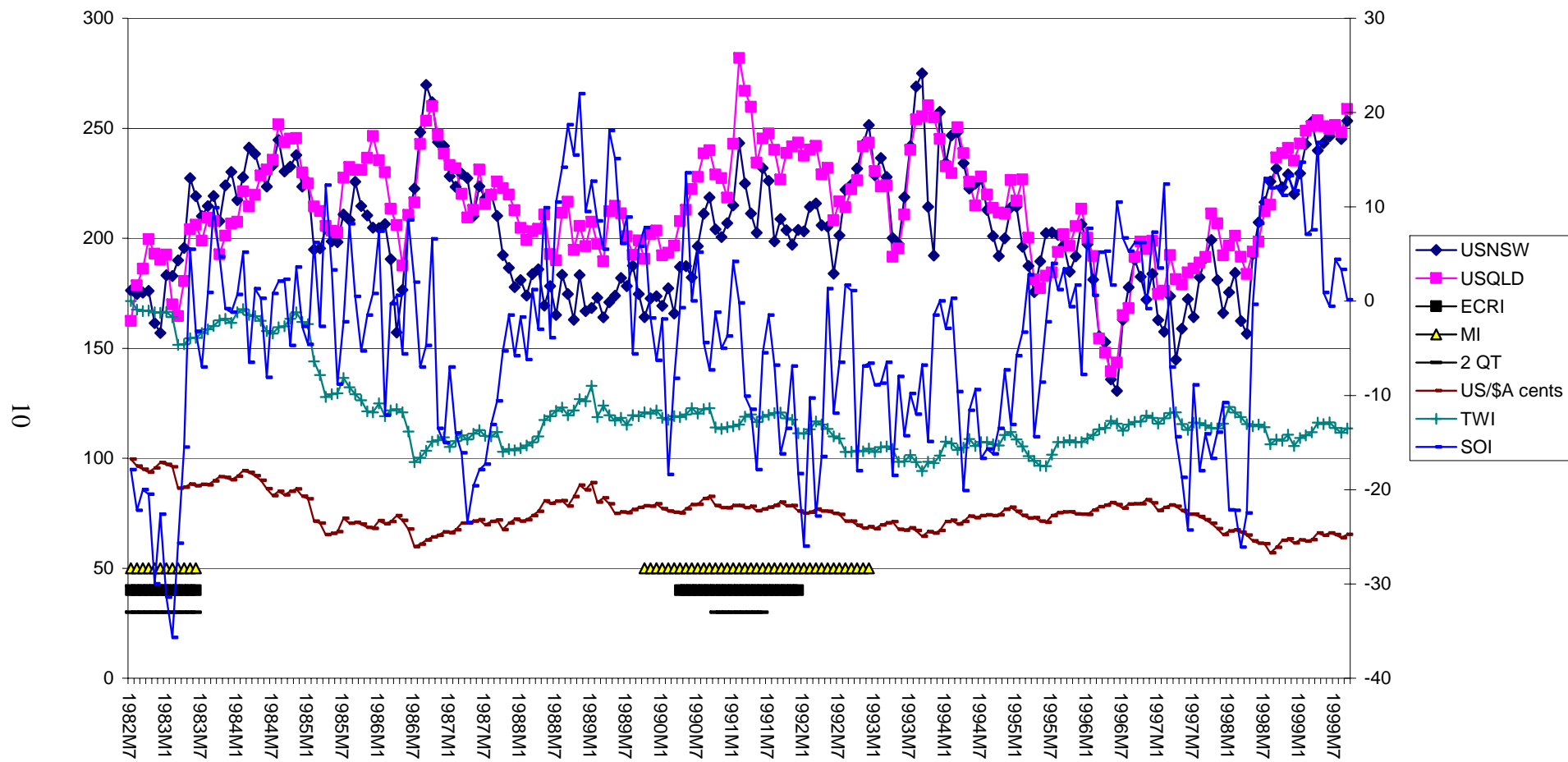
Figure 6.   December 2001 prices (cents/kg) of US market specification cows, Macroeconomic and Climatic Indicators.

3.   ECONOMETRIC ANALYSIS OF PRICE TRENDS

This section presents the econometric analyses of overall price trends as well as developing a seemingly unrelated regressions model (SURM). A Vector Autoregressive Model (VAR) is initially set up to pre-test for non-causality across the six series and the results incorporated in the specification of the SURM. Underlying trends in the series can be stochastic and/or deterministic. A time series with a stochastic trend is non mean-reverting, such as a random walk. Well-known tests for stochastic trends are the Augmented Dickey Fuller-ADF (Dickey and Fuller, 1979) and the KPSS (Kwiatkowski, Phillips, Schmidt, and Shin, 1992). Table 1 presents the results of these two tests for all six price series (JPNSW, JPQLD, KRNSW, KRQLD, USNSW, and USQLD where the data were in log transformed[3]), as well as the other indicators plotted in Figures 4, 5 and 6 (i.e. TWI, Exchange Rate (US/$A) and the SOI). The logarithm of all six real price series showed no evidence of a stochastic trend thus suggesting that these price series are mean reverting. The economic implication of this finding is that a historical mean can be meaningfully computed for each series. The historical mean prices in 2001/02 were: JPNSW (251 c/kg), JPQLD (256 c/kg), KRNSW (245 c/kg), KRQLD (253 c/kg), USNSW (202 cents/kg), and USQLD (214 cents/kg). The mean prices are not statistically different between NSW and QLD for the Japanese market, but are statistically different for the Korean market (at 5% level) and US market (at 1% level)[4].

To establish the relationships and linkages between these prices over the sample period, we specify an econometric model that treats all prices as endogenous. In order to allow for endogeneity of all prices as well as account for possible contemporaneous correlation due to macroeconomic conditions, we estimated a pseudo-Vector Autoregressive Model (PVAR)[5]. To specify the PVAR, we initially estimated a

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[3] All analysis in this section were carried on the logarithmic transformation of the prices.
[4] Three t-tests for the null hypothesis of no difference between the mean prices of QLD and NSW for the Japanese, Korean and US markets.
[5] In a pseudo VAR the explanatory variables are not common across equations, thus it becomes a Seemingly Unrelated Regressions system. In a SUR system, the parameters and standard errors are estimated accounting for contemporaneous correlations through a contemporaneously correlated variance-covariance matrix (see Greene, 2003 Ch.14).

Table 1.   Unit Root Tests on Individual Series

Series	ADF (Ho: Unit Root)	KPSS (Ho: No Unit Root)	Conclusion
JPNSW [a]	-3.507***	0.114	No Unit Root
JPQLD [a]	-3.160**	0.119	No Unit Root
KRNSW [a]	-4.002***	0.237	No Unit Root
KRQLD [a]	-3.472***	0.138	No Unit Root
USNSW [a]	-3.777***	0.090	No Unit Root
USQLD [a]	-3.548***	0.119	No Unit Root
TWI	-2.682*	0.966***	Unit Root
Ln(TWI)	-2.543*	0.951***	Unit Root
ΔLTWI	-13.677***	0.242	No Unit Root
US/$A	-2.856*	0.620**	Unit Root
Ln(US/$A)	-2.662*	0.589**	Unit Root
ΔLUS/$A	-13.630***	0.108	No Unit Root
SOI	-4.407***	0.081	No Unit Root

[a] Data are in natural logarithm and prices of 2001.

[b] *** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level

traditional Vector Autoregressive Model (VAR) (including only the log prices) to test for block causality across the six series. The Granger non-causality results from this initial model enabled us to omit highly non-significant linkages[6] from individual equations[7]. Figure 7 shows the results of block Granger non-causality tests based on the six-equations VAR(4). The lag length order of the VAR was chosen by AIC, SBC and a Wald Lag Exclusion test. AIC suggested four lags, SBC suggested two lags and the Wald Lag Exclusion test, four lags. It was decided to use four lags in the analysis; particularly after inspection of the residuals indicated that some autocorrelation was apparent in some equations using three lags. Levels of significance at 5% and 10% are shown in the graph. As this model is only preliminary we analyse the results based on the PVAR results.

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[6] We used a 15% level of significance, as the aim was to use this preliminary analysis to exclude those price series that were highly insignificant in a particular equation, not just marginally significant
[7] Detailed treatment of VAR models, including lag order selection, and Granger Non-Causality, can be found in Lütkepohl, 1993(Chapters 2, 3 and 4).

Figure 7.   Granger Non-Causality Tests Results based on a Six Equations - VAR Model (4)
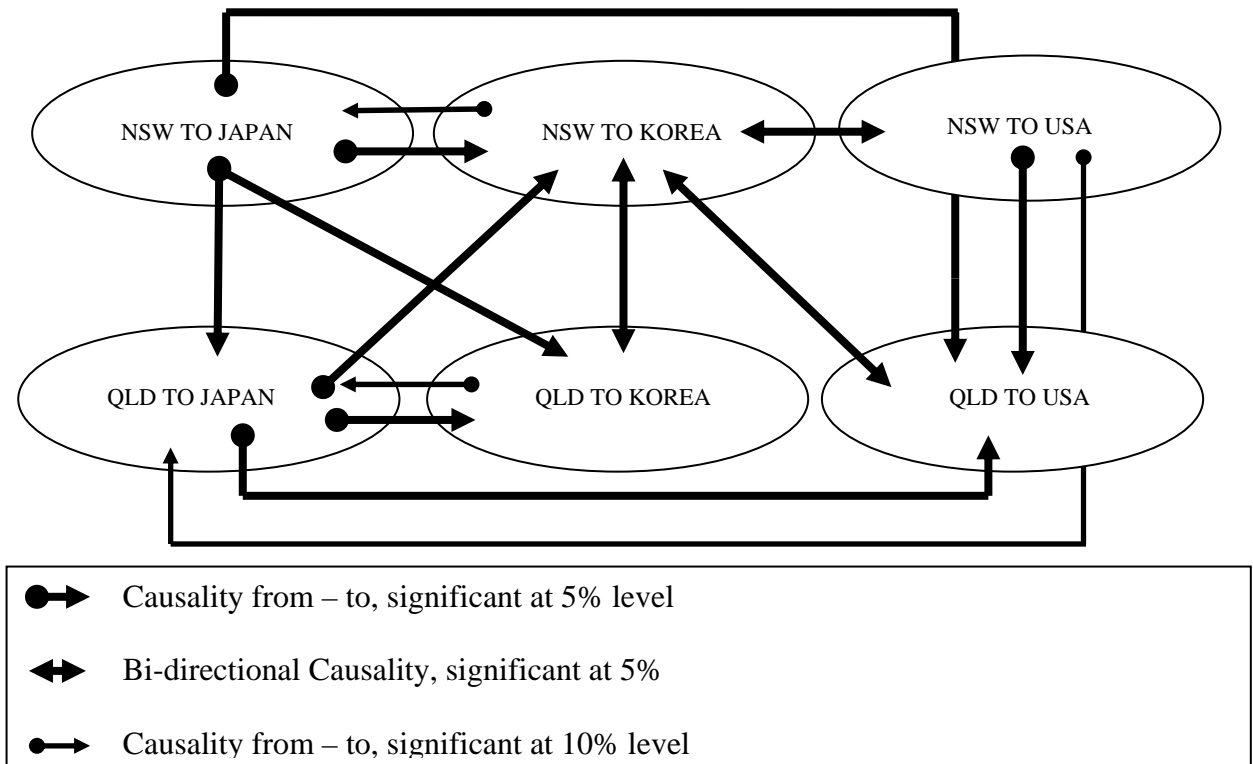
A PVAR system of six equations was specified excluding from individual equations the price series that were found not to Granger-cause the specific dependent variable in the initially estimated VAR (see Figure 7) as well as a set of exogenous explanatory variables:

$$LJPNSW_t = C_1 + \sum_{i=1}^{4}\beta_{11,i}LJPNSW_{t-i} + \sum_{i=1}^{4}\beta_{13,i}LKRNSW_{t-i} + \gamma_1 MSOI_t + \sum_{i=1}^{2}\phi_{1,i}\Delta TWI_{t-i}$$
$$+ \alpha_1 RECDUM_t + \theta_1 ASIAF_t + \lambda_1 USCOM_t + e_{1t}$$

$$LJPQLD_t = C_2 + \sum_{i=1}^{4}\beta_{22,i}LJPQLD_{t-i} + \sum_{i=1}^{4}\beta_{21,i}LJPNSW_{t-i} + \sum_{i=1}^{4}\beta_{24,i}LKRQLD_{t-i}$$
$$+ \sum_{i=1}^{4}\beta_{25,i}LUSNSW_{t-i}$$
$$+ \gamma_2 MSOI_t + \sum_{i=1}^{2}\phi_{2,i}\Delta TWI_{t-i} + \alpha_2 RECDUM_t + \theta_2 ASIAF_t + \lambda_2 USCOM_t + e_{2t}$$

$$LKRNSW_t = C_3 + \sum_{i=1}^{4} \beta_{33,i} LKRNSW_{t-i} + \sum_{i=1}^{4} \beta_{32,i} LJPQLD_{t-i} + \sum_{i=1}^{4} \beta_{31,i} LJPNSW_{t-i} + \sum_{i=1}^{4} \beta_{34,i} LKRQLD_{t-i}$$

$$+ \sum_{i=1}^{4} \beta_{35,i} LUSNSW_{t-i} + \sum_{i=1}^{4} \beta_{36,i} LUSQLD_{t-i}$$

$$+ \gamma_3 MSOI_t + \sum_{i=1}^{2} \phi_{3,i} \Delta TWI_{t-i} + \alpha_3 RECDUM_t + \theta_3 ASIAF_t + \lambda_3 USCOM_t + e_{3t}$$

$$LKRQLD_t = C_4 + \sum_{i=1}^{4} \beta_{43,i} LKRNSW_{t-i} + \sum_{i=1}^{4} \beta_{42,i} LJPQLD_{t-i} + \sum_{i=1}^{4} \beta_{41,i} LJPNSW_{t-i} + \sum_{i=1}^{4} \beta_{44,i} LKRQLD_{t-i}$$

$$+ \gamma_4 MSOI_t + \sum_{i=1}^{2} \phi_{4,i} \Delta TWI_{t-i} + \alpha_4 RECDUM_t + \theta_4 ASIAF_t + \lambda_4 USCOM_t + e_{4t}$$

$$LUSNSW_t = C_5 + \sum_{i=1}^{4} \beta_{53,i} LKRNSW_{t-i} + \sum_{i=1}^{4} \beta_{55,i} LUSNSW_{t-i}$$

$$+ \gamma_5 MSOI_t + \sum_{i=1}^{2} \phi_{5,i} \Delta TWI_{t-i} + \alpha_5 RECDUM_t + \theta_5 ASIAF_t + \lambda_5 USCOM_t + e_{5t}$$

$$LUSQLD_t = C_6 + \sum_{i=1}^{4} \beta_{63,i} LKRNSW_{t-i} + \sum_{i=1}^{4} \beta_{62,i} LJPQLD_{t-i} + \sum_{i=1}^{4} \beta_{61,i} LJPNSW_{t-i} +$$

$$+ \sum_{i=1}^{4} \beta_{65,i} LUSNSW_{t-i} + \sum_{i=1}^{4} \beta_{66,i} LUSQLD_{t-i}$$

$$+ \gamma_6 MSOI_t + \sum_{i=1}^{2} \phi_{6,i} \Delta TWI_{t-i} + \alpha_6 RECDUM_t + \theta_6 ASIAF_t + \lambda_6 USCOM_t + e_{6t}$$

where,

LJPNSW, LJPNQLD, LKRNSW, LKRQLD, LUSNSW, LUSQLD are the real log prices series.

ΔLTWI: first differences in the log of TWI,

MSOI: the average value of the SOI of the previous six months,

RECDUM: a dummy variable taking the value of one for the ECRI dated of recessions of the Australian economy, and zero otherwise,

ASIAFC: a dummy variable taking the value of one from July 1997 to December 1998 to capture the financial crises mainly affecting Korea, and zero otherwise; and

USCOM: a dummy variable with the value of one between January 1996 and July 1998 signalling the liquidation of US stock into the Korean market, and zero otherwise.

$\beta_{kj,i}$ is the parameter in equation k for price j and lag i.

$\alpha_k \phi_k \gamma_k \lambda_k \theta_k$ are the parameters of the exogenous variables in equation k.

Increases (lagged) in the TWI are expected to have a negative impact on real prices as a relatively higher Australian dollar is likely to lower the quantity demanded of Australian beef. Lower values (i.e. higher negative values) of MSOI would signal prolonged droughts (see Section 2 for discussion). We expect a negative relationship between MSOI and Korean and Japanese prices due to supply restrictions. The relationship between MSOI and USA cow prices would be expected to be positive due to increased disposal of females under such climatic conditions.

As mentioned previously, dated economic recessions appear to coincide with higher than average prices, thus the parameter of RECDUM is expected to be positive. The Asian financial crises dummy is expected to have a negative sign, as it is the USCOM dummy.

The system of six equations was estimated using an iterated Seemingly Unrelated Regressions estimator (SURE). A conservative approach was taken to further test for block non-causality on the estimated PVAR using Wald statistics. No price series was deleted from any of the equations unless their significance was lower than 10%. In some cases the number of lags was shortened from 4 to 2 using Wald tests and 10% significance level. Individual t-ratios were used to exclude the exogenous indicators at the 10% significance level. Figure 8 shows the significant relationships between the six price series based on the final PVAR model, while Table 2 shows the final estimated equations in the PVAR model[8]. We discuss the findings in the next section.

It is well established that there is an efficiency gain in estimating a system of equations by SURE instead of least squares on individual equations, if the contemporaneous correlations across equations are statistically significant (See Greene, 2003, Section 14.2 for detailed discussion). A likelihood ratio test (LR) can be computed for the null hypothesis of a diagonal variance-covariance matrix in the

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[8] This conservative approach is taken since the econometric consequences of omitting important variables are much higher than those of including irrelevant variables. All intermediate output and data are available from the authors.

Figure 8. Price Trends Relationships Based On the Final Model, Six Equations – PVAR.
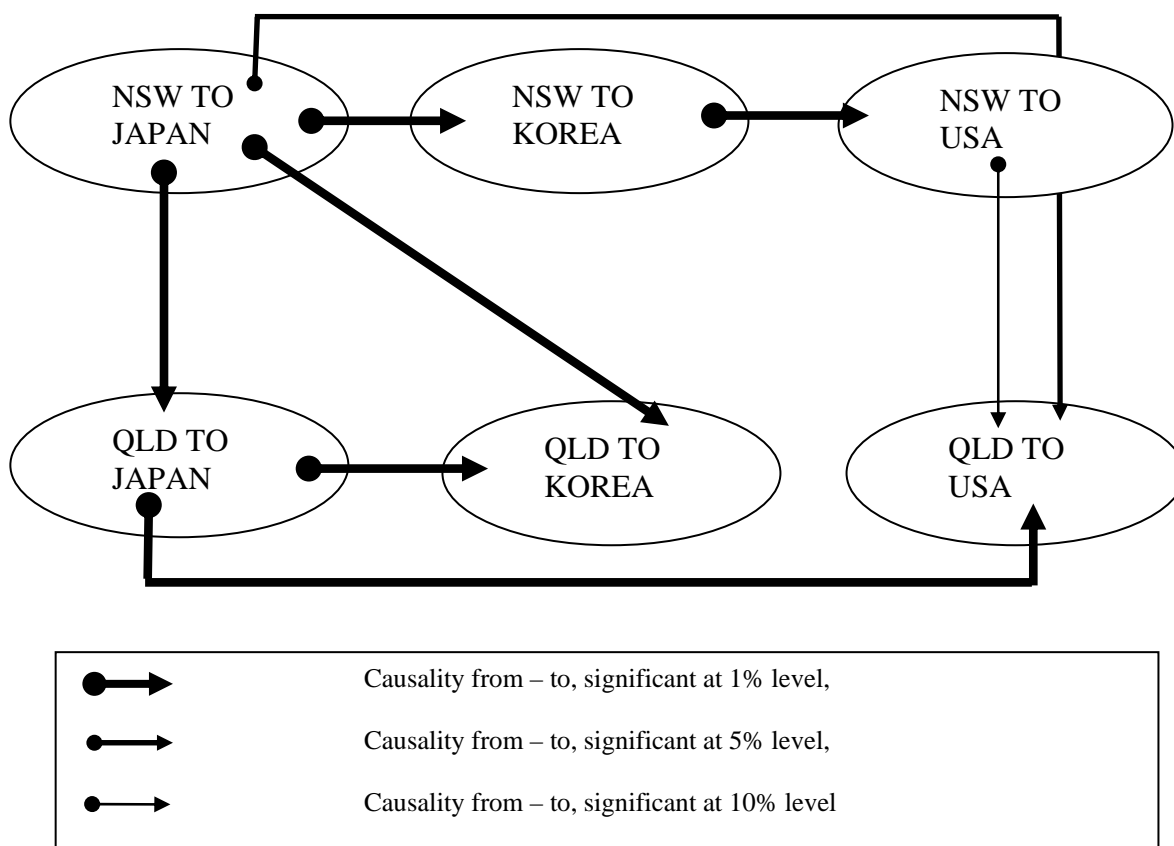
system. The statistic has a chi-squared distribution with M(M-1)/2 degrees of freedom and M the number of equations in the system, six in this case. Rejection of this test supports the estimation by SURE. The computed LR is 1028.89[9], and the critical value is 24.995 at the 5% level. Thus, as expected, the PVAR is a preferred specification over estimating each equation individually by least squares, indicating that common unmeasurable or omitted factors are affecting these prices at any given time period, resulting in contemporaneous correlation. Possible factors might be economic conditions affecting beef importers, weather conditions not captured by the SOI, other world economic conditions, etc.

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[9] $LR = 2 \times [2328.2\text{-}(296.2184+326.3772+278.4675+337.3004+255.6521+319.7385)]$

Table 2.   Final Model, PVAR, Estimated in log Prices

\Equation Regressor	JPNSW	JPQLD	KRNSW	KRQLD	USNSW	USQLD
Intercept	0.854*** (0.197)	0.492*** (0.157)	1.001*** (0.233)	0.545*** (0.161)	0.5255** (0.211)	0.586*** (0.173)
JPNSW(-1)	0.904*** (0.063)	0.310*** (0.070)	0.887*** (0.096)	0.263*** (0.068)		0.218*** (0.081)
JPNSW(-2)	-0.056 (0.063)	-0.070 (0.071)	-0.344*** (0.103)	-0.073 (0.069)		-0.051 (0.081)
JPNSW(-3)			-0.095 (0.0863)			
JPNSW(-4)			-0.212*** (0.079)			
JPQLD(-1)		0.611*** (0.070)		0.278*** (0.077)		-0.092 (0.088)
JPQLD(-2)		0.173** (0.080)		-0.095 (0.084)		0.202** (0.102)
JPQLD(-3)		-0.097 (0.068)		-0.209*** (0.078)		-0.177* (0.096)
JPQLD(-4)		-0.015 (0.048)		-0.054 (0.686)		-0.110 (0.757)
KRNSW(-1)			0.059 (0.072)		0.284*** (0.068)	
KRNSW(-2)			0.251*** (0.072)		-0.087 (0.069)	
KRNSW(-3)			0.096 (0.072)			
KRNSW(-4)			0.175** (0.070)			
KRQLD(-1)				0.431*** (0.067)		
KRQLD(-2)				0.160** (0.069)		
KRQLD(-3)				0.213*** (0.067)		
KRQLD(-4)				-0.012 (0.061)		
USNSW(-1)					0.692*** (0.065)	0.087* (0.045)
USNSW(-2)					-0.119 (0.077)	-0.016 (0.053)
USNSW(-3)					0.151** (0.072)	0.073 (0.050)
USNSW(-4)					-0.027 (0.054)	-0.081** (0.041)
USQLD(-1)						0.722*** (0.066)
USQLD(-2)						-0.047 (0.083)
USQLD(-3)						-0.012 (0.084)
USQLD(-4)						0.177*** (0.067)
DLTWI(-1)	-0.045 (0.079)		-0.021 (0.101)			-0.027 (0.075)
DLTWI(-2)	-0.178** (0.079)		-0.233** (0.109)			-0.209*** (0.074)
USCOM	-0.020** (0.09)		-0.043*** ((0.013)	-0.012** (0.006)		
$R^{2\ a}$	0.807	0.855	0.794	0.864	0.761	0.820

[a] R^2 is computed as the correlation between actual and fitted values for each equation.
 Standard Errors in Brackets. *10%, **5%, ***1% Significance Level, respectively.

In order to assess the fit of the PVAR model, one-step ahead forecasts were calculated for 1999:5 to 1999:9[10]. They are plotted in Figures 9 to 14 together with the actual values and the historical mean. They show that the model produces quite reasonable forecasts (in all cases an improvement over the historical mean) and as previous graphs would indicate, during 1999 real prices were considerably above the historical mean. Table 3 shows the prediction mean squared error (PMSE) of the historical mean and model's forecasts. On average, over the forecasted period, the PMSE of the historical mean is seventeen fold larger than that of the model's forecasts.

Finally, it is important to recognise that individual coefficients and associated standard errors are difficult to estimate accurately in these types of models, as regressors that are lagged values of each other are highly collinear. However, multicollinearity affects neither the causal relationships between variables, nor the overall prediction ability of the model. We take this into account in summarising our findings.

Figure 9.   Out-Sample Model Performance. Actual (A), One-Step Ahead Forecast (F), and Historical Mean Price (M) for Japanese specification steers sold in, 1999:5 – 1999:9.

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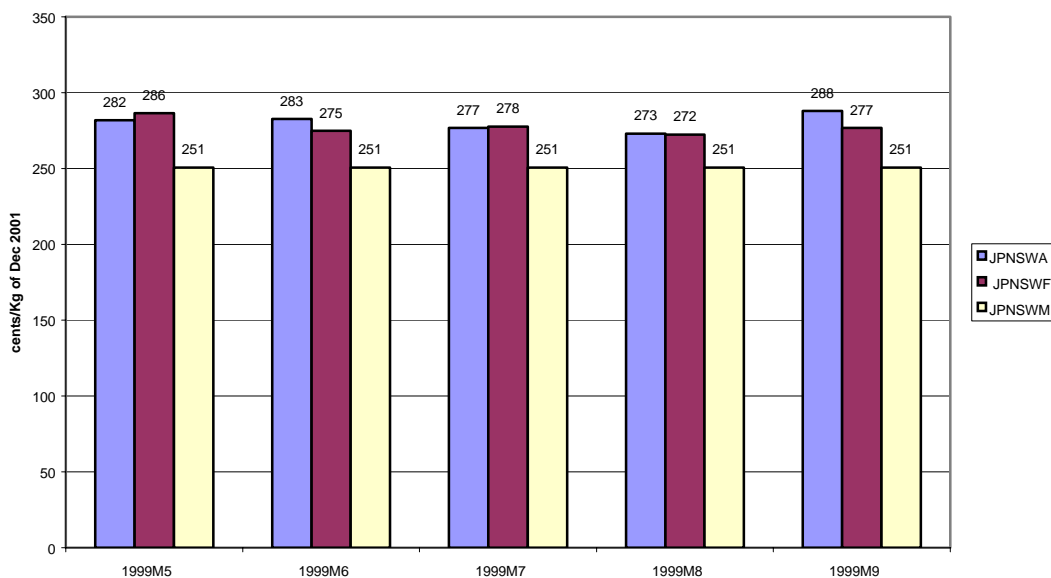
[10] That is, a forecast for each price for 1999:5 was obtained by estimating the model with data from 1982:7 to 1999:4, forecasts for 1999:6 were based on 1982:1-1999:5, and so forth. In all cases the log prices were forecasted and converted back to cents/Kg.

Figure 10.   Out-Sample Model Performance. Actual (A), One-Step Ahead Forecast (F), and Historical Mean Price (M) for Japanese specification steers sold in QLD, 1999:5 – 1999:9.
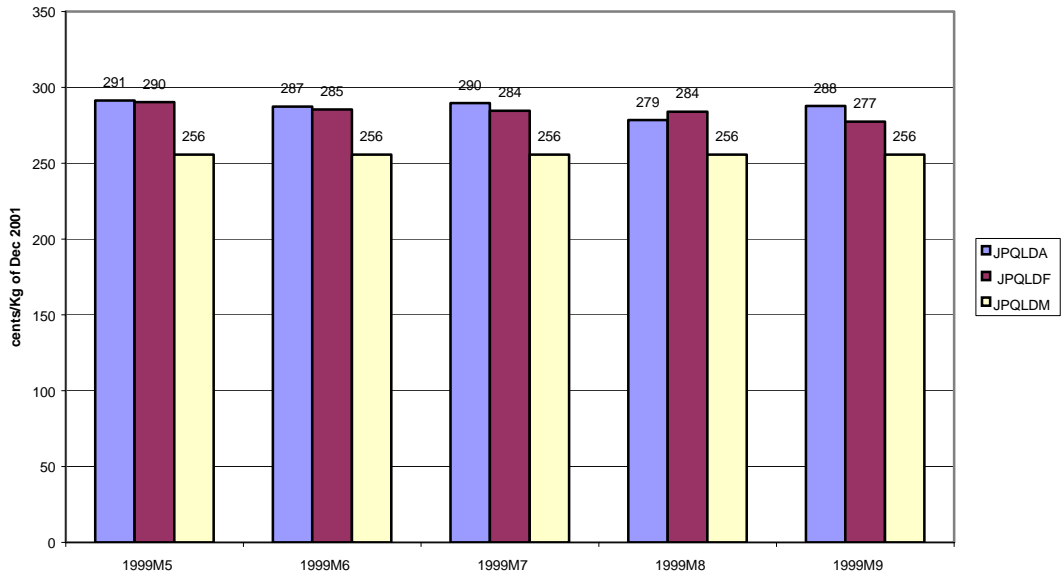

Figure 11.   Out-Sample Model Performance. Actual (A), One-Step Ahead Forecast (F), and Historical Mean Price (M) for Korean specification steers sold in NSW, 1999:5 – 1999:9.
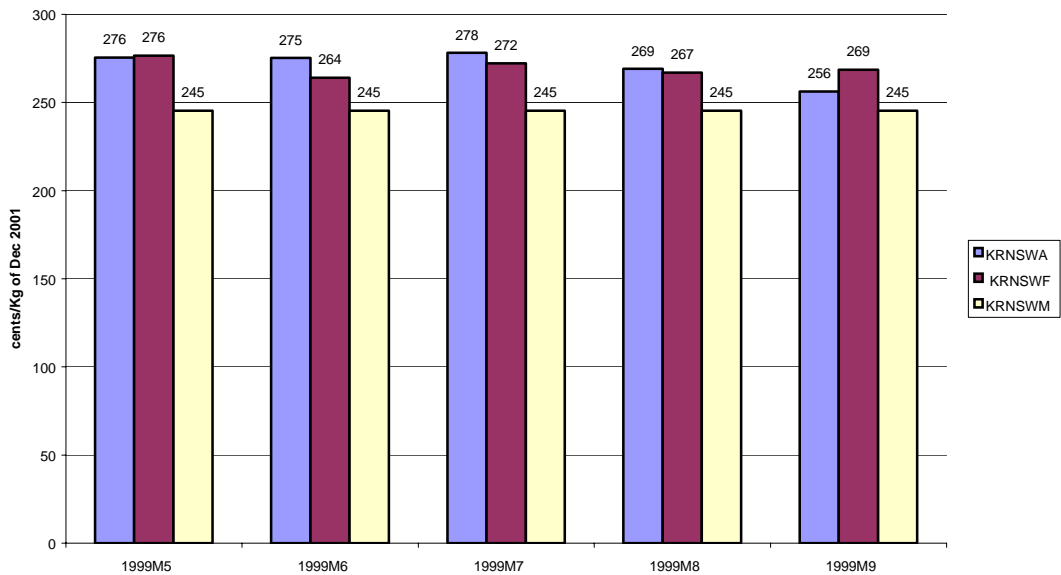
Figure 12.   Out-Sample Model Performance. Actual (A), One-Step Ahead Forecast (F), and Historical Mean Price (M) for Korean specification steers sold in QLD, 1999:5 – 1999:9.
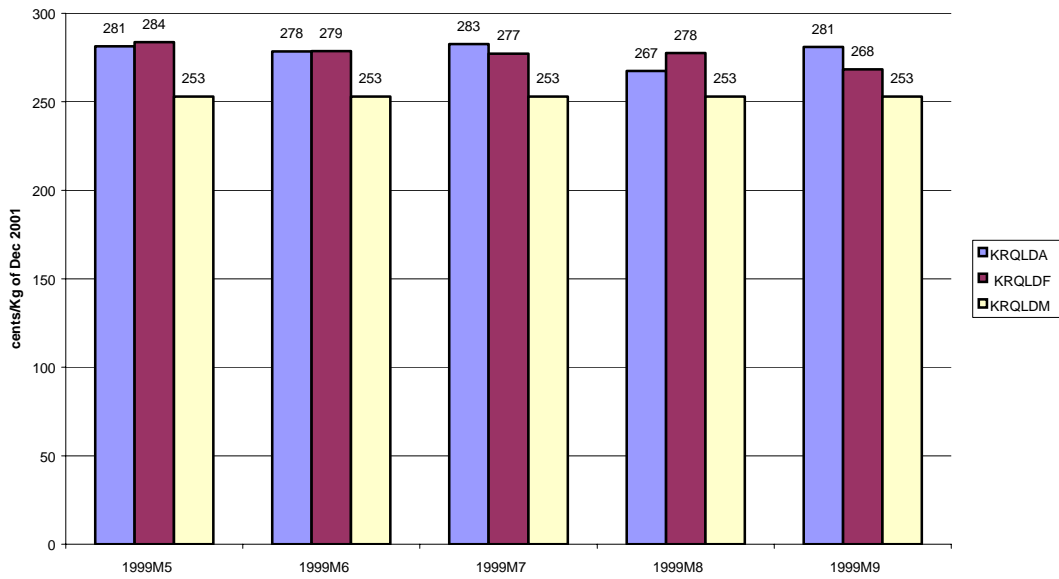

Figure 13.   Out-Sample Model Performance. Actual (A), One-Step Ahead Forecast (F), and Historical Mean Price (M) for US market specification cows sold in QLD, 1999:5 – 1999:9.
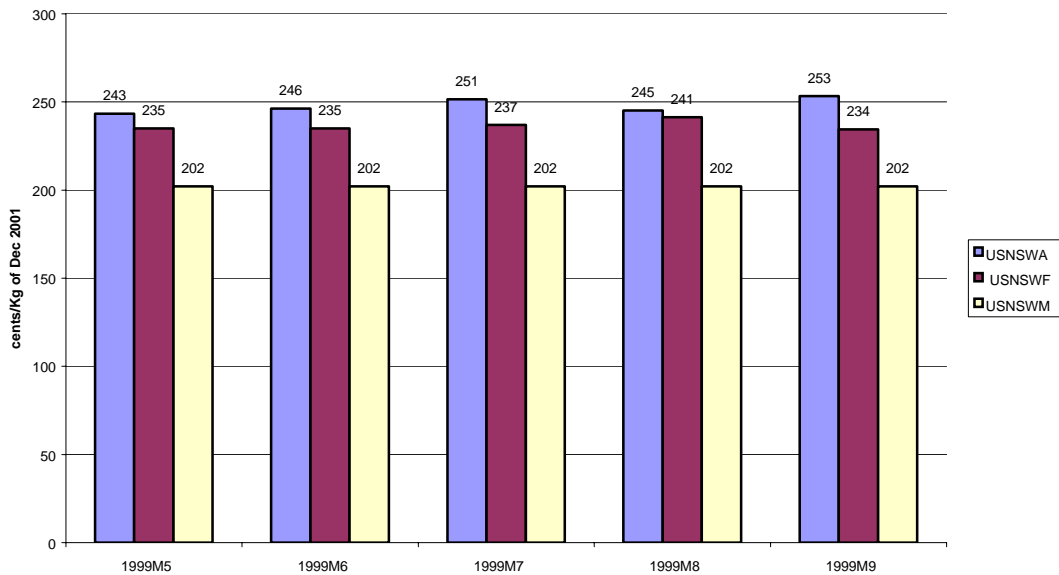
Figure 14.   Out-Sample Model Performance. Actual (A), One-Step Ahead Forecast (F), and Historical Mean Price (M) for US market specification cows sold in NSW, 1999:5 – 1999:9.
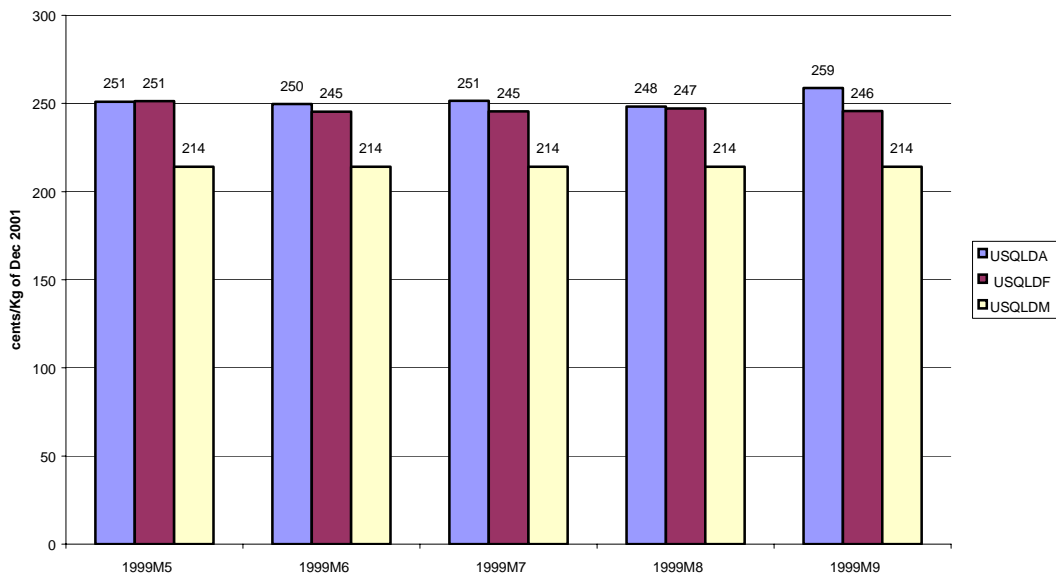

Table 3.   PVAR Out-of-sample Performance. Prediction Mean Squared Error (PMSE) for the One-Step Ahead Forecast and the Historical Mean (1999:5-1999:9)

Prices	PMSE One Step Ahead Forecast	PMSE Historical Mean
JPNSW	41.90	921
JPQLD	33.09	992.16
KRNSW	64.22	715.40
KRQLD	59.92	664.49
USNSW	156.94	2120.50
USQLD	45.30	1431.98
Average	66.90	1140.92

4.   DISCUSSION OF THE RESULTS

In discussing these results it is important to remember that the estimated PVAR model accounts for macroeconomic shocks common to all markets through the contemporaneously correlated covariance matrix. A summary of the results from the estimated PVAR is as follows:

- There is strong evidence of contemporaneous correlation across all six price series. Therefore, the data supports the use of a system estimation procedure.

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- The estimated PVAR model produces considerably more accurate forecasts of individual prices than the individual historical means.

- Based on this sample, there is no empirical evidence that overall trends in real prices have been related to the Australian business cycle.

- Based on this sample, there is no empirical evidence that climatic conditions, as indicated by the average value of the previous six months of the Southern Oscillation Index, have had a systematic effect on real price trends over the sample period. The study is based 18 years of data, thus the length is likely to be too short to allow for a conclusive finding in relation to either economic or climatic cycles.

- Changes in the Trade Weighted Index have had a significant impact in some markets. Increases in the index have resulted in a decrease in real prices to the Japanese and Korean markets from NSW, and the US market from QLD as expected. This result is likely to be a consequence of the dominant influence of the NSW Japanese market over all others, and the fact that the prices in this market are strongly influenced by changes in the TWI.

- The liquidation of US stock between 1996 and mid 1998 had a significant and negative impact on the Korean specification cattle in QLD (1.1% reduction) and NSW (4.2% reduction), and the Japanese specification cattle in NSW (2% reduction).

- The Asian Financial Crisis (July 1997 to December 1998) did not have a significant effect on real price trends. Most of the financial crisis period overlapped with the liquidation of US stock into the Korean market. Thus, the financial crisis effect could not be statistically separated.

Concentrating on the causal relationships across markets, the following evidence has emerged from the analysis:

- Prices for USA market specification cattle in QLD do not seem to influence any other prices, and are themselves strongly[11] influenced by the Japanese (QLD) market, and Japanese (NSW) market, significant at the 5% level, and only weakly by the US (NSW) prices from all three destinations.

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[11] The use of "strongly" refers to statistically significant at the 1% or higher. The use of "weakly" refers to statistically significant at the 10% level.

- Prices for Japanese market specification cattle in QLD strongly affect the other two markets in QLD. They are strongly influenced by the prices for Japanese specification cattle in NSW.

- Prices for Korean specification cattle in QLD, like the US market, do not influence any other prices, but they are strongly influenced by the Japanese market.

- Prices for Japanese market specification cattle in NSW are not influenced by any of the other five prices, but it strongly influences all others. As it can be observed from Table 2, this price is strongly influenced by its recent past and changes in the TWI. This behaviour is usually termed "weakly exogenous" to the system, meaning the other endogenous prices in the system cannot predict its future behaviour.

- QLD prices (for any of the destinations) have no significant influence on the NSW prices.

- The prices for USA specification cattle are not relevant to the determination of prices in the other two markets.

Overall, the findings of this study indicate that the Australian beef industry has managed to maintain a stable level in real prices over the, almost, two decades covered by the study. Mean reverting price behaviour is expected in commodity prices. There has been a series of articles discussing this issue since the early 1990s, for a summary see Smith and Schwartz (2000) and Schwartz (1997).

We find two important results which are consistent with the status of "premium market" enjoyed by the Japanese specification. The first is that prices paid in that market influence all other beef export prices either directly or indirectly. The second is that prices paid for the Japanese specification in NSW are only influenced by its own previous values and changes in the relative competitiveness of Australia, as measured by the trade-weighted index (TWI). Japan is Australia's largest trading partner and the yen has the largest weight in the TWI as a consequence (Becker and Davies, 2002). Thus, the TWI is an extremely useful indicator for the Japanese market.

Substantial appreciation of the Australian dollar results in lost of competitiveness and this has a negative influence in beef export prices of all specifications. We find a lag of two months to be consistently significant across the three markets, which indicates that substantial increases in the TWI lead decreases in real prices by two months.

The price differentials between Queensland and NSW for various markets may explain the cross border movement of cattle and warrants further investigation of price trends in other cattle markets such as the store (unfinished cattle) market.

CONCLUSIONS

This study analysed the trends in the real prices of steers destined for the Japanese and Korean market, and cows destined for the US market when sold in QLD (QLD) and New South Wales (NSW). The aim was to explore how these markets have influenced each other when faced with the same overall economic conditions.

A six-equation pseudo-VAR model was estimated by an iterated seemingly unrelated regressions estimator. Real prices were treated as endogenous. Exogenous variables included in the model were the (log changes in the) weighted trade index, a dummy variable for the dated recessions in the Australian economy, a dummy variable for the ASIAN financial crises, a dummy variable for the liquidation of US stock in the Korean and Japanese markets in the late 90s, and the mean value of the Southern Oscillation Index of the previous six months to an observed transaction.

The paper has found strong statistical evidence of real prices being mean reverting to a long-term historical mean, indicating that the Australian beef industry has managed to maintain a stable level in real prices over the, almost, two decades covered by the study.

The Japanese market is considered a premium market by the industry and our results confirm that this market is highly influential in the determination of prices to the other two specifications (i.e. Korean and US).

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The Trade Weighted Index is a significant leading indicator of declines in beef export prices.

The price differentials between Queensland and NSW for various markets may explain the cross border movement of cattle and warrants further investigation of price trends in other cattle markets such as the store (unfinished cattle) market.

This study has only examined the relationships between two states, NSW and QLD, which carry the majority of the Australian cattle herd. The study has shown some important linkages in the determination of beef export prices. A wider study would be of interest to examine relationships between New South Wales, Victoria and South Australia due to cross border transactions and if there are relationships between the cattle markets in all eastern Australian states. This would provide a more complete picture of pricing relationships since these states when combined with Queensland account for almost 85% of the Australian cattle herd.

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