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## Asymmetry in beef, lamb and pork farm-retail price transmission in Australia

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### Abstract

The hypothesis of asymmetry in price transmission within the Australian meat market is tested using monthly data for beef, lamb and pork prices at different market levels over the period 1971-1988. The results indicate that asymmetrical price response is a strategy used by beef and lamb retailers and wholesalers to adjust to changing input prices, but not by pork retailers and wholesalers. This difference is perhaps unexpected given the similarity in behaviours relating to price levelling in this market, the high cross-price elasticities of demand between these meats, and the relatively greater degree of concentration in the pork market.

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### 1. Introduction

Previous research has confirmed the presence of short-term price levelling behaviour in the Australian meat market (Naughtin and Quilkey, 1979; Griffith, Green and Duff, 1991). Price levelling refers to the practice of wholesalers (retailers) holding their selling prices relatively stable in the face of rising or falling auction (wholesale) prices. In effect, the resultant impact of fluctuations in raw material prices on the prices charged to consumers is smoothed or made less volatile under price levelling. The evidence of this

type of behaviour by meat wholesalers and retailers has caused increasing concern about the efficiency of the meat market. First, as has been demonstrated by Parish (1967), price levelling destabilises farm level prices while stabilising retail prices. Livestock producers in particular are concerned that changes in prices at the farm level are both greater than they should be and are not fully passed onto the higher levels of the market, and so do not influence consumer purchase decisions. Second, there is the suspicion that wholesalers and retailers are more inclined to pass on price rises than price falls. This is known as asymmetric price transmission.

The ability of the wholesale and retail sectors to undertake these types of pricing strategies depends predominantly on the competitive structure of these sectors. Fewer, larger firms may "...employ pricing strategies which result in

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complete and rapid pass-through of cost increases but slower and less complete transmission of cost savings" (Kinnucan and Forker, 1987, p. 285). In the Australian meat producing, processing and distribution sectors there have been some underlying changes with respect to structure in recent years, especially in the intensive industries. Beef and lamb are the two traditional red meats produced in Australia, mainly from extensive pasture grazing systems, while pork is one of the major meats produced from intensive, indoor production systems. The increasing concentration in the pig processing and marketing sectors has been well documented (Bennett, 1982). Similar consolidation, though not to the same extent, has occurred in the beef and lamb processing and marketing sectors. This variation in concentration in the Australian extensive and intensive meat industries may manifest differing patterns of asymmetrical pricing behaviour. Another possible cause of differences may be variations in the proportion of output exported and in the magnitudes of domestic per capita consumption of each meat.

An understanding of price formation and price transmission, including asymmetric pricing behaviour, is important in explaining the dynamics of price transmission processes and pricing inefficiencies in the marketing of commodities. It is also important in contributing to policy discussions relating to such issues as the rationalisation of processing capacity, the regulation of throughput in the processing sector, and the distribution of the benefits of research among producers, processors and consumers. The value of this information is not constrained to developed agricultural economies such as Australia, but also extends to developing countries where pressure is apparent for better resource allocation and more efficient marketing channels.

Most applications to date in this area have been undertaken in the United States, mainly in the pork market, and this is where the methodology has been developed. Heien (1980) and Schroeder (1988) found evidence of asymmetry in wholesale-retail pork price relationships. Furthermore, Hahn (1990) found that the farm, wholesale and retail prices of pork showed significant

evidence of asymmetric price interactions, with retail prices displaying greater sensitivity to price increasing shocks than to price declining shocks. Alternatively, Boyd and Brorsen (1988, p. 103) found "...that wholesale (packer) prices respond similarly to farm price decreases and increases. Also there is no significant difference between retailers' response to wholesale price increases and their response to wholesale price decreases." Some studies have examined the United States beef market. Hall, Tomek, Ruther and Kyerine (1981) found no evidence of asymmetry in farm-wholesale or wholesale-retail beef price relationships. They concluded (p. 21) that "Wholesalers and retailers do not appear to have treated increases in farm or carcass prices in a manner different than decreases." However, Hahn (1990) found that the farm, wholesale and retail prices of beef showed significant evidence of asymmetric price interactions. Prices displayed greater sensitivity to price increasing shocks than to price declining shocks.

This issue of asymmetric price transmission has not been examined for the processing and marketing sectors of the Australia meat market except for a brief exploration by Freebairn (1984) and some recent work by Lye and Sibley (1991). In a markup model explaining retail food prices by farm prices, wages and the price of a substitute product, Freebairn added a dummy variable to indicate periods when farm prices were rising. He found a non-significant coefficient on this variable for all foods studied including beef, lamb and pork. Thus the hypothesis of asymmetrical responses to price rises and price falls was not supported. Lye and Sibley (1991), using customer market analysis (emphasising consumer expectations about prices) and this data set, found that retail meat prices in New South Wales were inflexible, and more so in the downward direction than the upward direction. Asymmetrical adjustment of prices was concluded.

The aim in this paper is to test the hypothesis of short-term retail and wholesale price asymmetry in the Australian beef, lamb and pork markets using a different methodology to those employed previously by Freebairn (1984) and Lye and Sibley (1991).

## 2. Methodology

*Background issues.* The markup pricing model popularised by Heien (1980) forms the basis for most subsequent research in this area. This model is:

$$PR = a_0 + a_1 PF + a_2 C \quad (1)$$

where  $PR$  is retail price of the commodity under analysis,  $PF$  is farm price of the commodity on a retail equivalent basis,  $C$  represents processing and marketing costs; and the data are typically measured at monthly intervals.

The use of this pricing rule rests on several critical assumptions. First, the market for the commodity is assumed to be competitive. It is clear that concentration levels in meat processing and distribution in Australia have increased in recent years. For example in New South Wales the four largest pig slaughtering organisations accounted for 54% of total export licensed slaughter in 1978 and 60% in 1984. The 20 or so Australian pigmeat processing firms in the largest employment size group constitute only 15% of firms yet account for over 65% of turnover, value added and employment (Griffith and Gill, 1987). Some 40% of meat is sold through supermarkets and two large chains dominate this market (Australian Meat and Livestock Corporation, 1993). However, there are still large numbers of processors, wholesalers and retailers in the Australian red meat industry, and the overall levels of concentration, although rising, remain relatively low (Australian Bureau of Statistics, 1990). Thus this assumption seems plausible.

Second, the processing function is assumed to be a Leontief-type fixed proportions transformation, with no possibility of other marketing inputs being substituted for the farm commodity when relative prices change. This is recognised as a strong assumption but there is a lack of empirical evidence on this. However, given that the data are monthly, one would anticipate only limited substitutability if any over this time period, hence the assumption may be of little consequence in practice. It would be difficult to make such an assumption with annual data however.

Third, constant returns to scale are assumed. This is equivalent to assuming constant marginal costs of processing, or that variations in the volume of the farm commodity undergoing processing have no influence in explaining price transmission behaviour. This is perhaps the most contentious of the assumptions in the context of the Australian meat industry, as previous work using these or similar data has generally shown a significant negative relationship between the farm-retail margin and the quantity of livestock being processed (Griffith, 1974; Griffith, Green and Duff, 1991). Thus increasing returns to scale are indicated, and a throughput variable should be added to the basic markup model.

Fourth, there is an underlying assumption that the retail price changes in response to a change in price at the farm or wholesale level. Thus farm price "causes" retail price in the Granger sense (Granger, 1969). Although causality tests are not conducted here, Freebairn (1984) has shown that for beef and pork in the Sydney market the farm price does indeed "cause" the retail price. Further, using a cross-spectral analysis Griffith (1975) concluded tentatively that pork auction prices did lead retail prices, so although there may be problems interpreting Granger causality tests, the cross-spectral results provide some corroborating evidence. Hence this assumption seems reasonable for beef and pork. However, for lamb, Freebairn found that retail price "causes" farm price<sup>1</sup>. This may be of some concern in interpreting the results for lamb.

Two other methodological issues also require consideration. First, when data periodicity is monthly as in this study, the question of lags in

<sup>1</sup> Freebairn rejected the null hypothesis that future values of beef (pork) retail prices as a group had no influence on current beef (pork) farm prices. Conversely, he could not reject the null hypothesis that future values of farm prices as a group had no influence on current retail prices. Thus current values of farm prices were associated with future values of retail prices, but not vice versa. For beef and pork, farm prices "cause" retail prices. However, for lamb, current values of retail prices were associated with future values of farm prices, but not vice versa. For lamb, retail price "causes" farm price.

responses become important. There are a number of reasons why changes in retail price typically tend to lag changes in farm price (Heien, 1980; Hall, Tomek, Ruther and Kyerine, 1981; Ward, 1982) such as the time required to actually perform the processing, storage, transport and distribution functions; differences in price collection and reporting methods; the cost of retailers changing prices; and differences in information availability, transmission and use at different levels of the market. Therefore, in setting up a model to test the asymmetry pricing hypothesis, some form of lag structure should be incorporated on the independent variables. Also, as is well known, problems of autocorrelation are highly likely with monthly data.

Second, there is the issue of whether the dependent and independent variables should be transformed in some way to more accurately mea-

sure the differential impacts of rising and falling price phases. The conventional method (Ward, 1982; Kinnucan and Forker, 1987; Schroeder, 1988) is that two farm price variables, PFR (rising) and PFF (falling) – or two wholesale price variables – should be constructed following Houck (1977, p. 571) as shown in Table 1. The dependent variable and any other independent variables should be expressed as deviations from their respective initial values. This technique is based on earlier work by Wolffram (1971) and Houck (1977) dealing with asymmetrical supply response and by Heien (1980) who extended the method to price transmission. Houck (1977) provides a detailed justification for using these types of transformations. The key point is that the method decomposes or partitions changes in the dependent variable, from a previous position in time (the initial values) into changes due to rising input prices, falling input prices, and other factors. In applying the model, Heien (1980) calculated the rising and falling farm price variables but did not use any lag structure. Subsequent studies have calculated the PFR and PFF variables and imposed distributed lags (e.g. Ward, 1982).

Table 1  
Example of calculation of PFR and PFF for pork farm price,  
Sydney market, January 1971–March 1972

Month	Actual farm price (PF)	Price increases (PF')	Price decreases (PF'')	PFR	PFF
1971-1	69.6	–	–	–	–
-2	67.5	0.0	-2.1	0.0	-2.1
-3	68.7	1.2	0.0	1.2	-2.1
-4	68.7	0.0	0.0	1.2	-2.1
-5	66.6	0.0	-2.1	1.2	-4.2
-6	70.0	3.4	0.0	4.6	-4.2
-7	71.9	1.9	0.0	6.5	-4.2
-8	73.8	1.9	0.0	8.4	-4.2
-9	76.3	2.5	0.0	10.9	-4.2
-10	76.8	0.5	0.0	11.4	-4.2
-11	70.8	0.0	-6.0	11.4	-10.2
-12	70.8	0.0	0.0	11.4	-10.2
1972-1	66.4	0.0	-4.4	11.4	-14.6
-2	65.2	0.0	-1.2	11.4	-15.8
-3	62.0	0.0	-3.2	11.4	-19.0

where following Kinnucan and Forker (1987) the variables are defined as:

$$PF' = PF - PF(-1) \quad \text{if } PF > PF(-1) \\ = 0 \quad \text{otherwise}$$

$$PF'' = PF - PF(-1) \quad \text{if } PF < PF(-1) \\ = 0 \quad \text{otherwise}$$

where PFR is the cumulative sum of PF', and PFF the cumulative sum of PF''.

*Estimating model and hypothesis.* The model used for estimation in this study, based on Kinnucan and Forker (1987) and the discussion above, is as follows:

$$PR_t = a + bT_t + \sum_i c_i \cdot PFR_{t-i} \\ + \sum_j d_j \cdot PFF_{t-j} + eC_t + fQ_t + E_t \quad (2)$$

where for each meat, PFR and PFF are constructed variables denoting the rising and falling phases of PF as shown in Table 1, Q is the production of meat, T is a trend term, and E is a random error; the other variables are as previously defined; and  $a, \dots, f$  are coefficients to be estimated.

The first summation variable is always positive, while the second is always negative. Almon distributed lag procedures are imposed on the calculated rising and falling variables, PFR and PFF, so  $i$  and  $j$  are the lengths of the Almon lags on PFR and PFF, respectively. The retail price, cost and quantity variables are expressed as deviations from their respective initial values. Neither the

cost nor quantity variables are specified in distributed lag forms. Cost changes gradually over time and as Heien (1980) has noted, retailers tend to use the smoothed value of cost as a basis for pricing (see also Griffith, Green and Duff, 1991). Presumably, these retailers would also even out the price impacts of throughput fluctuations. The  $c_i$  coefficients represent the net effect of rising farm prices on retail prices while the  $d_j$  coefficients represent the net effect of falling farm prices on retail prices. The appropriate test of whether there is a significant difference in the sum of the coefficients of the rising phase of farm prices versus the falling phase in farm prices can be formally represented as:

$$H_0: \sum_i c_i = \sum_j d_j \quad (3)$$

$$H_1: H_0 \text{ not true} \quad (4)$$

A *t*-test was used to test this null hypothesis. Equivalent models to that specified in Eq. (2) are also specified for the farm-wholesale and the wholesale-retail components of the price transmission process. So in all there are nine equations to be estimated. In addition, in all models, a dummy variable *DD* is added to reflect a change in price calculation procedures in 1980, and monthly dummy variables *D1, ..., D11* are added to measure any seasonal patterns not already accounted for.

Alternative modelling frameworks to Eq. (2) that have been used in the asymmetry and price transmission literature are the Vector Autoregressive (VAR) Models of Babula, Bessler and Schulter (1990) and the Generalised Switching Model (GSM) of Hahn (1990). VAR is a "data-oriented technique [which] provides evidence on the dynamic properties of relationships" (Babula et al., 1990, p. 13). However, no explanation of the reasons for this behaviour is provided. More structural, economic models, such as those reported here, are required for this purpose. Hahn (1990, p. 21) considers his GSM to be "the rough equivalent of a set of unrestricted reduced form equations for a general set of endogenous switching regressions relating the farm, wholesale, and retail prices of a meat." The models reported here are structural models rather than reduced

form models, and are therefore more suited to explanation of the factors causing price transmission differences across meats. Neither of these alternative models are applied in this study, but a comparison of results and policy implications from each would be of interest.

### 3. Data

Monthly data for the period January 1971 to December 1988 were used ( $n = 216$ ) for the following variables:

$PF_k$  Monthly estimated dressed auction carcass price, in cents/kg, of composite beef, lamb and pork carcasses sold at Homebush sale-yards in Sydney and adjusted for byproducts and shrinkage.

$PW_k$  Monthly wholesale price, in cents/kg, of composite beef, lamb and pork carcasses sold in the Homebush meat halls in Sydney and adjusted for shrinkage.

$PR_k$  Monthly composite retail price, in cents/kg, of beef, lamb and pork at selected retail outlets in Sydney.

$CW_k$  Indices of monthly wholesale marketing costs for beef, lamb and pork. Slaughtering fees comprise over 50% of wholesale operating costs, so slaughtering fees charged at Homebush abattoir in Sydney were used as a proxy for all wholesale costs. The base period was January 1971 = 100.00.

$CR$  An index of monthly retail marketing costs. Since wages contribute over 50% of retail operating expenses, the weekly wage rate for a New South Wales General Butcher Shopman under the Federal Meat Industry Award was used as a proxy for all retailing costs. The base was January 1971 = 100.00.

$Q_k$  Throughput of each meat. Due to the closure of the Homebush abattoir in mid 1988, it was not possible to obtain throughput at the Homebush meat halls. As a proxy New South Wales production of beef, lamb and pigmeat was used.

<i>T</i>	a linear time trend, where January 1971 = 1, February 1971 = 2, etc.
<i>DD</i>	a dummy variable to reflect changes in the calculation procedures for <i>PF</i> , where January 1971 to December 1979 = 0, January 1980 to December 1988 = 1.
<i>d1-</i>	
<i>d11</i>	monthly dummy variables.
<i>k</i>	beef, lamb and pork.

All the basic auction, wholesale and retail price data came from the records of the now Economic Services Unit of N.S.W. Agriculture. The procedures for adjusting and weighting these prices and for calculating the wholesale and retail spreads are outlined in detail by Griffith, Strong, Green and Freshwater (1992). Slaughtering fees came from the records of the Homebush Abattoir Corporation and the N.S.W. Meat Industry Authority, throughput came from the Australian Meat and Livestock Corporation, and wage rates came from the Meat and Allied Trades Federation and the N.S.W. Department of Industrial Relations. The price and cost variables were all expressed in nominal terms.

As noted above, *PFR* and *PFF* were calculated from *PF*, and the equivalent rising and falling wholesale price variables *PWR* and *PWF* were calculated from *PW*, for use in the estimating equations. For beef, approximately 51% of the observations on *PF* and 50% of observations on *PW* were falling, while for lamb the relevant percentages were very similar, 49% and 51%. For pork, approximately 44% of the observations on *PF* and 41% of observations on *PW* were falling, so a reliable estimate of the presence or absence of asymmetrical price response should be able to be provided.

#### 4. Estimation technique

The nine equations were estimated using least squares procedures. Limited experimentation indicated that autocorrelation was endemic and all subsequent equations were estimated with a first-order correction.

The question of jointly choosing lag length and order of polynomial for the Almon lags was resolved as follows. First, the lengths of the lags were determined by adding lagged variables until insignificant coefficients were encountered using a *t*-test. Where significant lag lengths greater than two were found, higher order polynomials were tested for using an *F*-test.

#### 5. Results

*Estimated equations.* The results of estimating the nine equations of the form specified in Eq. (2) above, using the data transformations and methods described there, are reported in Tables 2, 3 and 4 for beef, lamb and pork, respectively.

There were some common features of all of these equations: the extremely high level of explained variance; the large size and high significance of the rho coefficient, which indicated that there was very strong positive autocorrelation in the raw residuals; the overall lack of significance of seasonality, significant only in the pork farm-wholesale and in the lamb farm-wholesale price linkages; and the short lag lengths which were significant in the Almon lags, only reaching a lag of three months in the lamb wholesale-retail linkage (Table 3).

Features which differed across equations included the influence of cost factors, which were significant in five of the nine equations, but – contrary to expectations – were mostly negative; the influence of time trends, which were mostly significant for lamb and pork but not for beef; the influence of the dummy variable for the change in calculation procedure, which was significant for beef but not generally for lamb or pork; and the influence of throughput, which had a significant effect on the explanation of price transmission for lamb but not generally for beef or pork.

Only the lag lengths for lamb were greater than two (Table 3). An *F*-test of the null hypothesis of a linear model could not be rejected. All Almon polynomials were therefore linear.

Table 2

Beef regression equations and asymmetry tests, Sydney market, January 1971–December 1988

Item	Wholesale-Retail	Farm-Wholesale	Farm-Retail
$R^2$	0.997	0.993	0.997
DW	2.361	2.082	2.585
Rho	0.946 *	0.524 *	0.885 *
INT.	–19.159	1.768	3.526
T	0.708 **	–0.050	–0.247
DD	13.704 **	27.899 *	19.040 *
D1	–1.549	0.578	–0.774
D2	–3.779	2.817	–1.149
D3	–2.707	1.844	–1.440
D4	0.390	1.899	2.497
D5	4.904	0.792	4.714
D6	1.337	2.417	1.535
D7	–0.084	1.579	–0.927
D8	–3.081	0.912	–3.273
D9	–0.670	–0.698	–2.528
D10	–2.113	0.199	–3.955
D11	–2.740	0.283	–2.912
Q	–1.48E-04	–3.10E-04 *	–1.11E-04
CR	–0.262 **		
CW		4.329 *	–1.595
PR <sub>t</sub>	0.683 *	0.209 *	0.208 *
PR <sub>t-1</sub>		0.623 *	0.430 *
PR <sub>t-2</sub>			0.250 *
PF <sub>t</sub>	–0.113	0.772 *	0.169
PF <sub>t-1</sub>	0.481 *		0.220 **
Cumulative rises	0.683	0.832	0.888
Cumulative falls	0.368	0.772	0.389
t-test value	2.151 *	1.322	3.563 *
Polynomial order	1	1	1

\* Significant at the 5% level.

\*\* Significant at the 10% level.

*Asymmetry hypothesis.* A test of the asymmetry hypothesis was formulated following Mendenhall, Schaeffer and Wackerly (1981):

$$t = \frac{(\sum_i c_i - \sum_j d_j)}{\sqrt{[\text{VAR}(\sum_i c_i - \sum_j d_j)]}}$$

where the variance of the difference between the sums is calculated from the variances of each of the components of both sums and the covariances between each of the components of both sums. This procedure was followed for each of the equations estimated in this study and the results

Table 3

Lamb regression equations and asymmetry tests, Sydney market, January 1971–December 1988

Item	Wholesale-Retail	Farm-Wholesale	Farm-Retail
$R^2$	0.993	0.986	0.992
DW	2.062	1.768	2.178
Rho	0.741 *	0.770 *	0.805 *
INT.	–5.173	–8.085	–8.773
T	–0.263	1.138 *	1.022 *
DD	–7.499	25.673 *	13.401
D1	–1.380	0.531	–3.447
D2	4.936	1.334	2.022
D3	6.141	0.322	0.939
D4	3.925	0.774	1.406
D5	6.392	0.766	3.435
D6	8.490 *	–0.064	5.630
D7	4.914	1.792	0.908
D8	–0.404	6.579 *	–1.453
D9	–0.388	4.694 **	–2.039
D10	2.779	1.147	–0.076
D11	3.436	1.247	3.116
Q	–1.23E-03 **	–1.56E-03 *	–1.33E-03 *
CR	–0.082		
CW		–5.584 *	–4.615 **
PR <sub>t</sub>	0.501 *	0.374 *	0.347 *
PR <sub>t-1</sub>	0.095	0.240 *	0.160 **
PR <sub>t-2</sub>	0.351 *		0.195 *
PR <sub>t-3</sub>	0.212 **		
PF <sub>t</sub>	0.826 *	0.295 *	–0.038
PF <sub>t-1</sub>		0.426 *	0.562 *
Cumulative rises	1.159	0.615	0.703
Cumulative falls	0.826	0.722	0.600
t-test value	3.121 *	–2.463 *	1.366
Polynomial order	1	1	1

\* Significant at the 5% level.

\*\* Significant at the 10% level.

are reported near the bottom of Tables 2, 3 and 4.

The results show that for six of the nine price linkages (all three beef; wholesale-retail and farm-retail lamb; and farm-wholesale pork), the cumulative effect on the dependent variable of *rising* input prices ( $\sum_i c_i$ ) exceeded the cumulative effect of *falling* input prices ( $\sum_j d_j$ ). In three of these six cases (beef wholesale-retail and farm-retail, and lamb wholesale-retail) the test statistics were significantly different from zero, rejecting the null hypothesis. Thus there was asymmetry in

Table 4

Pork regression equations and asymmetry tests, Sydney market, January 1971-December 1988

Item	Wholesale-Retail	Farm-Wholesale	Farm-Retail
$R^2$	0.994	0.985	0.993
DW	2.571	1.877	2.617
Rho	0.913 *	0.869 *	0.907 *
INT.	-30.444 **	0.760	-14.554
T	2.281 *	0.780 **	1.800 *
D <sub>D</sub>	1.065	3.664	3.738
D <sub>1</sub>	1.926	-3.617	2.309
D <sub>2</sub>	0.853	-5.605 *	2.694
D <sub>3</sub>	-2.042	-7.126 *	-2.627
D <sub>4</sub>	0.432	-7.921 *	-0.378
D <sub>5</sub>	1.462	-9.222 *	1.202
D <sub>6</sub>	2.636	-10.045 *	2.495
D <sub>7</sub>	-1.563	-13.258 *	-2.597
D <sub>8</sub>	-2.213	-11.609 *	-2.961
D <sub>9</sub>	0.925	-11.463 *	-0.545
D <sub>10</sub>	0.031	-6.725 *	-1.610
D <sub>11</sub>	2.710	-3.448 **	1.472
Q	-6.62E-04	-3.62E-04	-3.38E-04
CR	-0.565 *		
CW		-0.029	-1.465
PR <sub>t</sub>	0.166	-0.054	-0.184
PR <sub>t-1</sub>		0.313 *	0.373 *
PF <sub>t</sub>	-0.248 *	0.244	0.257 *
PF <sub>t-1</sub>	0.466 *		
Cumulative rises	0.166	0.259	0.189
Cumulative falls	0.217	0.244	0.257
t-test value	-0.335	0.127	-0.405
Polynomial order	1	1	1

\* Significant at the 5% level.

\*\* Significant at the 10% level.

wholesale or retail price transmission between periods of rising and falling farm or wholesale prices, in these three cases, over this data period. Price *rises* were passed on more fully than price *falls* in these cases. In the other three cases where the cumulative rise exceeded the cumulative fall (beef and pork farm-wholesale and lamb farm-retail), the test statistics were not significantly different from zero, failing to reject the null hypothesis. Thus there was no asymmetry in price transmission in these instances.

In the remaining three price linkages (lamb farm-wholesale, and pork farm-retail and wholesale-retail), the cumulative effect on retail price

of *falling* farm or wholesale prices ( $\sum_j d_j$ ) exceeded the cumulative effect of *rising* farm or wholesale prices ( $\sum_i c_i$ ). For the two pork linkages (Table 4), the test statistics were not significantly different from zero, failing to reject the null hypothesis. Thus the results indicate no asymmetry in wholesale or retail price transmission between periods of rising and falling pork farm or wholesale prices, over this data period. However, in the lamb farm-wholesale linkage (Table 3), the test statistic was significantly different from zero, rejecting the null hypothesis. Thus some asymmetry in lamb wholesale price transmission between periods of rising and falling farm prices seems evident over this data period. Price *falls* were passed on more fully than price *rises* in this case.

Further, there was some evidence that the response to price changes at lower levels of the market was slower for beef and lamb price rises than for price falls because in most of the equations there was a longer lagged response on the rising prices than there was on the falling prices. For pork, however, this did not seem to be apparent because in one of the equations there was a lagged response on the falling prices while in the other equations there was a lagged response on the rising prices.

The means of the price rises and price falls for each price level were also examined, using a *t*-test for the difference between two sample means. The results are reported in Table 5. For each of the nine prices, the mean increases were greater than the mean decreases, but only for beef and pork retail prices were these differences significant (at the 5% and 10% levels, respectively). This suggested that for these two cases, retail prices adjusted less fully to falling wholesale prices than to rising wholesale prices. This confirmed the evidence reported in Table 2 for beef, where the coefficient on the price fall variable was less than the coefficient on the price rise variable in the two relevant equations. However, the results contradicted the evidence for pork, where the coefficient on the price rise variable was less than the coefficient on the price fall variable in the two relevant equations.

Finally, there were more price rises than price falls at the retail level, and the actual numbers of

Table 5

Numbers and means of rising, falling and stable beef, lamb and pork price changes, Sydney market, January 1971–December 1988

Price	Rising		Falling		Stable	<i>t</i> -test
	No.	Mean	No.	Mean		
<b>Beef</b>						
Farm	103	3.41	110	–2.91	2	0.70
Wholesale	108	3.07	99	–2.31	8	1.01
Retail	128	3.51	84	–1.72	3	2.20 *
<b>Lamb</b>						
Farm	106	5.18	106	–4.79	3	0.33
Wholesale	109	4.20	99	–3.55	7	0.73
Retail	123	4.81	92	–3.18	0	1.58
<b>Pork</b>						
Farm	117	3.60	94	–2.94	4	0.95
Wholesale	85	2.72	88	–1.65	42	1.27
Retail	124	4.11	90	–2.54	1	1.89 **

\* Significant at the 5% level.

\*\* Significant at the 10% level.

rises and falls were very similar reflecting the high cross-price elasticities of demand between these meats (Piggott and Griffith, 1992). The picture was somewhat different at the farm and wholesale levels where there were similar numbers of price rises and price falls, except for pork at the farm level where the number of rises exceeded the number of falls by a substantial margin. At the wholesale level there were a relatively greater number of "no changes", especially for pork. This fact reinforced findings of short-term price levelling at the wholesale level found in other work (Griffith, Green and Duff, 1991). For pork, the substantial number of "no changes" may explain why neither of the components of the overall pork farm-retail price linkage showed any significant asymmetry behaviour. The wholesale market was disrupting the process of transmitting changes in market conditions between the different levels of the market.

## 6. Summary and Conclusions

In this paper the hypothesis of asymmetrical pricing behaviour in the Australian beef, lamb and pork market has been examined. There were five main results. First, the cumulative effect on retail or wholesale price of the rising wholesale or

farm beef and lamb price variable exceeded the cumulative effect of the falling wholesale or farm price variable in five of the six relevant equations. Three of these equations rejected the null hypothesis suggesting that there was some asymmetry in price transmission between periods of rising and falling wholesale or farm beef and lamb prices. In the sixth equation, the cumulative effect on wholesale lamb price of the falling farm lamb price variable exceeded the cumulative effect of the rising farm price variable, with the test statistic being significant. Again this suggests asymmetry.

Second, the cumulative effect on retail or wholesale price of the rising wholesale or farm pork price variable did not exceed the cumulative effect of the falling wholesale or farm price variable in two of the three relevant equations. In the third equation, the cumulative effect on wholesale pork price of the rising farm pork price variable exceeded the cumulative effect of the falling farm price variable. However, in each case, the test statistics were very small, indicating failure to reject the null hypothesis. The results suggest that there was no asymmetry in price transmission between periods of rising and falling wholesale or farm pork prices.

Third, for each of the three prices of each meat, the mean increases were greater than the mean decreases, although only for beef and pork retail prices were these differences significant. This suggests that the beef and pork retail prices adjust less fully to falling wholesale prices than to rising wholesale prices.

Fourth, for pork there were a much greater number of price rises than price falls at the farm and retail levels. The picture was somewhat different at the wholesale level where there were similar numbers of price rises and price falls and a substantial number of "no changes". This fact reinforces findings of price levelling at the wholesale level found in other work (Griffith, 1974; Naughtin and Quilkey, 1979; Griffith, Green and Duff, 1991).

Finally, for beef and lamb there were a much greater number of price rises than price falls at the retail level. At the farm and wholesale levels there were similar numbers of price rises and

price falls and at the wholesale level there were a greater number of "no changes". Again findings of price levelling at the wholesale level found in other work are validated.

Therefore this study provides new evidence which confirms Freebairn's (1984) conclusion relating to the absence of price asymmetry for pork, but not for beef and lamb. Conversely, for beef and lamb the results of this study accord with those of Lye and Sibly (1991) who found evidence of asymmetrical adjustment of retail prices in the New South Wales meat market.

On balance it appears that in the Australian meat market, asymmetrical price response is an adjustment strategy used by beef and lamb retailers and wholesalers to contend with input price changes, but it is not employed by pork retailers and wholesalers. This difference in behaviour is perhaps unexpected given the similarity in behaviours relating to price levelling and the high cross-price elasticities. Also, given the relatively greater degree of concentration in the pig market, if any meat was to show evidence of asymmetry it would be expected to have been pork.

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