Final report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

Analysis of market cycles and price transmission in the red meat sector

Part 2: Price Transmission

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Abstract

AMPC commissioned SG Heilbron Economic and Policy Consulting to complete a detailed analysis of market cycles and price transmission in the red meat sector. This report presents the findings with regard to price transmission in the beef and sheep meat value chains (Part 2). The project methodology included design confirmation, literature review, contextual analysis, data gathering, time series and econometric analysis.

The analysis found that over a period of a year, prices are efficiently transmitted along the beef and sheep meat supply chains from producer to retailer. There is no indication of increased price differentials between the farm and retail stages of the chain that are not explained by cost increases, suggesting price changes at one end of the chain are being fully reflected at the other. This finding is consistent with previous studies suggesting there is no significant market power in either input or output markets for beef or sheep meat. This implies that consumers are not suffering from changes in prices along the chain, which is the primary focus of interest for competition and consumer laws. Moreover, the fact that price transmission is efficient indicates that price transparency is sufficient to enable efficient operation of the market.

Executive summary

The research was commissioned by the Australian Meat Processor Corporation (AMPC) and was conducted by Dr Selwyn Heilbron of SG Heilbron Economic and Policy Consulting, and Professors Garry Griffith and Bill Malcolm of the University of Melbourne, exploring market dynamics in the Australian red meat sector.

The research involved three parts and is presented in separate reports with linked findings.

- Part 1: Analysis of market cycles in the red meat sector
- Part 2: Analysis of price transmission in the red meat sector (this report)
- Part 3: Processor-specific and regional analysis

Both the analysis of market cycles and price transmission involved a separate review of the literature and analysis of long-term (annual) data and short-term (quarterly) data.

Long-term price transmission

Analysis was completed regarding price transmission processes in the red meat industry particularly as it relates to competition policy. Thus, whether there are departures from medium-term equilibrium conditions, not short-term departures such as evident in the common (mostly retail) practices of price levelling (price smoothing over different market levels, ie between farm and retail), price averaging (price smoothing over different products, ie beef and lamb) and price asymmetry (price rises being of a different size or at a different time than price falls). In this part of the project, the focus was only on the former. This focus determines the theoretical framework applied (economic equilibrium theory), the types of data analysed (annual data rather than more frequent periods) and the types of econometric processes used (being able to measure departures from equilibrium).

The process followed was to examine the way prices moved along the aggregate supply chain from producer to retailer. The question asked was whether there was any market power in the aggregate supply chain (i.e. a sustained increase in the price differentials, that being the difference between the prices of livestock and meat) in the domestic market that could not be explained by changes in supply chain costs or other disruptions in the market. In each case, the analysis asks whether there was market power in the market for inputs i.e. having to pay for livestock from producers, and in the market for outputs i.e. selling meat to consumers.

The analysis involved a formal literature review of past research results, and then a formal statistical analysis. The literature review indicated that there is a well-established body of theory and empirical measures that have been used to assess market power in the Australian meat industries. The New Empirical Industrial Organisation (NEIO) framework was recommended as the best modelling tool. NEIO is a formal statistical procedure based on strong theoretical grounds that is well suited to testing using aggregate industry data, unlike outmoded concepts such as the Structure-Conduct-Performance model which has little theoretical basis, or more complicated models which require firm-level data to implement. In the literature to date, no evidence of market power has been found in either the beef or lamb domestic markets in either sales to consumers or purchases of livestock from producers.

In the analysis reported below, the NEIO framework was used on a data set of domestic meat industry variables obtained from publicly available sources (the ABARES Australian Commodity Statistics data base, supplemented with official ABS series). The data are defined later Appendix 1.1. All price and cost variables were adjusted to real values to remove the effects of inflation over time. In relation to the 'market power' variables, the key results indicate that in the domestic market the null hypothesis of no market power cannot be rejected at the 95% level of probability in either beef or lamb input or output markets. These findings confirm the earlier results of Hyde and Perloff (1996), Griffith (2000), Chung and Griffith (2009) and Hilli and Griffith (2022). In other words, there is no indication of increased price differentials between the farm and retail stages of the chain that are not explained by cost increases, suggesting price changes at one end of the chain are being fully reflected at the other.

In relation to other explanatory variables, the costs of providing marketing services are strongly significant positive influences on the domestic price differentials for beef and lamb, and there are significant measurable effects in the various price differential equations from past policy or industry decisions – the 1975-78 curtailment of Australian beef imports by Japan; and the negative effect on price differentials due to the consolidation of industry processing capacity in the red meat industries around 2011 which reduced costs and or prices between farm and retail prices.

The general picture of real marketing price differentials for beef and lamb indicates a reasonably flat and consistent trend for each meat, and in some cases, the real marketing price differentials had declined. The consistency of real marketing price differentials over time, despite the significant structural changes to these industries, re-affirms earlier studies (Griffith, 2000; Hilli and Griffith, 2022) suggesting an absence of market power.

In essence, over a period of a year, prices are efficiently transmitted along the beef and lamb supply chains, and a change in prices at the one end of the chain is reflected in a change at the other, and the price differential between them remains relatively constant once changes in costs are accounted for. This means also that consumers are not suffering from changes in prices along the chain, which is the primary focus of interest for competition and consumer laws. Moreover, the fact that price transmission is efficient indicates that price transparency is sufficient to enable efficient operation of the market.

Short-term price transmission

The short-term price transmission component of the project included data gathering from public sources; analysis using econometric price transmission methodology; analysis of implications and recommendations.

The literature review established that there is a well-established body of theory and empirical measures that have been used to assess short term price transmission in the Australian meat industries. There has been consistent evidence of price levelling, price averaging and price asymmetry, but all of this evidence finds that these practices are short-term phenomena – over one or a few months at most – and that retail prices tend to revert to trends in farm prices over the longer term. According to the most recent study (Woodlock, 1995, 68) “While price levelling has been confirmed, it has also been found that this behavior is confined to short periods of time and that the margin, and therefore wholesale and retail prices in general, do respond to changes in the farm gate price of meat.”

The most recent set of empirical results are now more than 30 years old. Quarterly data for the period 2000 to 2024 were collected to re-evaluate these conclusions.

Coefficients of variation calculated from the domestic value chain part of the data show that both the beef and lamb farm price variables are 2-3 times more volatile than the respective retail prices or the price differentials. This is indicative of consistent actions by value chain participants to keep prices to consumers relatively stable. Also of note is that the price series are considerably more variable than the throughput series, indicative that there are other factors influencing variations in prices than just variations in supply. These differences in relative volatility are also evident from graphs of the respective series.

Granger causality tests were done to assess the direction of information flows in these markets. All of the Granger test results confirm that the direction of causation in both domestic beef and lamb value chains is bilateral, that is, that changes in prices at the farm level “cause” changes in retail prices, and simultaneously, changes in prices at the retail level “cause” changes in prices at the farm level. However, the stronger statistical associations are that in all cases farm price causes retail price. None of the tests suggest that retail prices unilaterally “cause” farm prices. This means that the traditional way of thinking about price transmission (farm to retail) can be applied in this study.

The calculated real price differentials for beef and lamb are both very stable with little trend evident. In the estimated beef price differential models, none of the cost, throughput or trend variables are significant but a lagged dependent variable is positive and significant, suggesting a conscious policy to keep the beef price differential stable. Further, on top of this general preference for stability, there is clear evidence of price levelling in both meats, where changes in the current price differential are negatively and significantly related to changes in the current farm price. Thus, the retail price is more stable than the farm price. However, this is only a short-term response, as in the next quarter part of that contraction in the price differential is given up and the price differential moves in the same direction as the farm price. This matches previous research, however there is no evidence of price averaging across beef and lamb price differentials in this data set which is different from previous research.

To illustrate this, in the beef price differential models the price variables are all measured in c/kg, so the coefficients on those variables in these equations can be interpreted as per unit changes. Thus, if the farm price of beef increases by say 10c/kg in the current quarter and everything else is unchanged, the price differential is reduced by about 7c/kg (the coefficient -0.693) and only 3c/kg of the original price rise is passed on as an increase in the retail price in the current quarter.

In the next quarter however, the price differential is increased by about 4c/kg (the coefficient 0.366), so roughly half of the first-round levelling is recouped. By the end of the second quarter, around three quarters of the original farm price increase is passed on to retail prices. Further small increases will occur over a longer time period due to the effect of the positive and significant lagged dependent variable in the beef price differential equation. But as the long term analysis in the first stage of the price transmission analysis indicates, the increased farm price is fully passed on over a period of a year.

In the lamb price differential model, if the farm price increases by say 10 c/kg in the current quarter and everything else is unchanged, the price differential is reduced by more than 8c/kg (the coefficient -0.836) and less than 2c/kg of the original price rise is passed on as an increase in the retail price in the current quarter. In the next quarter however, the price differential is increased by about 3c/kg (the coefficient 0.284), so roughly a third of the first-round levelling is recouped. By the end of the second quarter, around half of the original farm price increase is passed on to retail prices. In the lamb market, the lagged dependent variable is positive but not significant, so there are no ongoing adjustments in the size of the lamb price differential equation. For lamb, the price levelling impact is large but short lived, whereas for beef the levelling is of smaller magnitude but the adjustments are spread over a longer time frame. In the model used, it is assumed that moves up in the farm price have the same effect in terms of price transmission as moves down, for both beef and lamb.

The long term analysis of price transmission in the project confirmed the absence of long-term market power and emphasised the stability of real marketing price differentials over time. This analysis of short term price transmission has confirmed that retail prices are more stable than farm prices due to price levelling. Changes in farm prices are partially passed on to retail prices over time, indicating a preference for stability. In the case of beef, for example, by the end of the second quarter, around three quarters of the original farm price increase is passed on to retail prices. Further small increases will occur over a longer time period. But as the long term analysis in the first stage of the price transmission analysis indicated, the increased farm price is fully passed on over a period of a year. These findings are consistent with the conclusion reached by other analysis. Meat and Livestock Australia (2023) in observing price transmission noted that the reduction in average retail price of red meat lags prices paid to producers by approximately eight months. Similar conclusions on price levelling have been observed by the Australian Meat Industry Council (2024)

It is worthwhile noting that price levelling indicates a preference for price stability, and mitigates the impacts of farm price volatility on consumer behaviour and preferences for meat from prices rising and falling significantly on a short term basis. To illustrate this, this research finds that both the beef and lamb farm price variables are 2-3 times more volatile than the respective retail prices or the price differentials.

In terms of the export value chain for beef, the correlation analysis showed that Australian farm prices are moderately correlated with both United States import and wholesale prices (around 0.5), but are negatively correlated with United States farm prices. This latter result matches the results of the beef cycles comparison where Australian and United States farm prices for cattle were found to move in opposite directions in recent years.

This was confirmed in the graphical analysis which showed that there is no longer a close relationship between Australian and United States cattle prices as found in earlier work. There are some time periods when both sets of prices are trending in the same direction, but equally there are other periods when the prices are moving in the opposite direction. In the graphs, there seems to be a close relationship between Australian farm prices and United States beef import prices over the whole 25 years of data available, and also with United States wholesale prices for the most recent seven years of so. This matches the moderate positive correlations.

Finally, in the causality analysis done on the export value chain variables, all of the tests done reject any significant degree of causation between Australian farm prices for cattle and United States farm, wholesale or import prices. Statistically, the prices of cattle and beef in the United States and Australia are determined independently of each other.

Relationship between cycles and price transmission

A few points should be made in relation to the relationship between cycles and their impact on competition. There have been long-standing concerns in relation to competition policy about the efficiency of the market in terms of price transmission along the red meat supply chain. As is noted in Part 1 of this project, these concerns are related to the purported cyclical nature of the industry.

When herd liquidation is underway and cattle prices are weak, the industry tends to look at retail prices to see if they have also fallen in tandem. If not, there may be concerns that the market is not competitive, and that retailers are not passing on price falls to consumers to stimulate demand for meat.

What should be noted about this is firstly, the smoothing of prices along the chain from producers to retailers (known as price levelling) is a well-known feature of price transmission in the meat industry globally. Typically, this means that the supply chain (particularly retailers) absorbs producer price fluctuations resulting in less variation in retail prices, but the practice can occur at any transaction level in the chain. This levelling has been analysed in detail for example by Griffith et al. (1991).

However, what is important in terms of market efficiency in an economic context is whether such levelling occurs just in the short-term (which implies a competitive market still prevails) or also in the medium-term (which implies it does not). The economic analysis done on this matter confirms that downstream prices are responsive to farm prices in the longer term. Secondly, the economic considerations just described for defining what constitutes non-competitive markets are reflected in the provisions applying to competition policy. From a competition policy perspective, to reiterate, what indicates an ability of a seller (or purchaser) to alter unilaterally prices from competitive market levels and hence act in a manner is contrary to competitive norms is whether a material difference in price over and above competitive levels can be maintained over a sustained period. This has been indicated by the ACCC as being at least 12 months.

Hence whilst lags in transmission of prices may have short term impacts on profits of various participants along the chain, what matters is whether prices at the retail stage, where consumers decide on purchases of the final product, reflect prices at the farm stage and the supply chain costs involved in transforming the live animal to the retail pack, over the longer term. This has been analysed in Part 2 of this project.

Finally, a competition issue that may be confused with price transmission but is different to it is that of price transparency. Price transparency refers to the openness of the process by which price discovery takes place (market reporting of saleyard and OTH prices, reporting of grid offers, etc). However, if prices are demonstrated to have been transmitted efficiently, subject to the possible meat marketing phenomena of price levelling and averaging behavior by retailers, then it logically suggests they would be expected to have been sufficiently transparent at least, to enable the market to operate efficiently.

Conclusion and Recommendations

Key findings indicate that over a period of a year, prices are efficiently transmitted along the beef and sheep meat supply chains from producer to retailer. There is no indication of increased price differentials between the farm and retail stages of the chain that are not explained by cost increases, suggesting price changes at one end of the chain are being fully reflected at the other. This finding is consistent with previous studies suggesting there is no significant market power in either input or output markets for beef or lamb. This implies that consumers are not suffering from changes in prices along the chain, which is the primary focus of interest for competition and consumer laws. Moreover, the fact that price transmission is efficient indicates that price transparency is sufficient to enable efficient operation of the market.

The findings within this report lead to the following recommendations:

- The findings indicating the absence of market power should be brought to the attention of meat and livestock industry stakeholders.
- The findings should in particular be brought to the attention of the authorities undertaking reviews of competition in relevant inquiries, including that relating to the grocery sector of which the meat processing industry is a part.
- The collaboration should explore the risk management options currently available to supply chain participants, and the potential for future development of risk management approaches and instruments, in order to better address the inherent volatility and uncertainty associated with the short-term ups and downs and hence to ensure mutually beneficial outcomes for chain participants in terms of productivity, profitability and long term industry growth.

The above recommendations are in addition to the following recommendations from Part 1 of the project (analysis of market cycles).

- The findings indicating the existence of much shorter-term market ups and downs in the Australian beef industry rather than longer term cycles in the US industry, and the absence of cyclical behaviour in lamb, should be brought to the attention of meat and livestock industry stakeholders.
- The meat and livestock industries should consider undertaking a collaborative research and engagement initiative to examine the implications of this finding for the industry's supply chain.

1 Introduction

Research was commissioned by the Australian Meat Processor Corporation (AMPC) and was conducted by Dr Selwyn Heilbron of SG Heilbron Economic and Policy Consulting, and Professors Garry Griffith and Bill Malcolm of the University of Melbourne, as part of a two-stage project. The first part was to investigate the cattle and sheep cycles in Australia and the second part was to analyse the transmission of prices along the cattle and sheep supply chains.

This project came about because of the need to explain to stakeholders about the basis of price transmission in the industry. The reasoning was that the information would help to improve the understanding by stakeholders, including livestock producers, industry organisations, consumers and regulators, of the nature and functioning of the red meat processing industry and the key factors influencing its competitive environment.

There was seen to be a need for objective, economic analysis of price transmission, to address subjective views on the nature of the industry and its market which can fail to reflect the industry's competitive market conditions.

The project has undertaken the detailed econometric analysis required and placed it in the broader context of the industry and its stakeholders, enabling objective, rigorously generated research information to be used in a wide variety of forums including in engagement with producers, consumers and regulators as required by the industry and its participants.

Significant value was expected to be generated for the industry:

- Enabling the industry to better engage with its stakeholders, whether they be producers, consumers, other industry organisations or regulators, by having at its disposal objective independent economic information on the industry's competitive market operation.
- Having this information for engagement with stakeholders to help improve producer, consumer and regulatory confidence, improve the industry's social license to operate, and facilitate increased economic sustainability.
- Having access to uniquely up to date information and analysis which provide an advantage in engaging with stakeholders.
- Like previous analyses conducted by the consultants, having very long 'shelf-lives' to be utilised by the industry for its benefit for many years to come.

2 Project objectives

- Undertake advanced analysis of the cattle cycle and the sheep cycle in Australia (Part 1)
- Undertake advanced analysis of the transmission of prices along the supply chain to indicate market efficiency (Part 2)
- Use the results to educate stakeholders about the cattle and sheep cycles and other factors that have a significant impact on beef and sheepmeat market conditions. Thereby improve the understanding of, support for and efficient functioning of the red meat processing industry.

3 Methodology

The methodology for Part 2 of the project (price transmission processes) was as follows:

- Project Part 2 design confirmation with input from Steering Committee
- Literature review of price transmission in Australia and relevant international industries
- Contextual analysis of industry evolution and relevant economic and policy issues
- Development of data list and sources with input from Steering Committee
- Data gathering from public and private sources as appropriate
- Analysis using econometric price transmission methods
- Analysis of implications and recommendations
- Production of draft report
- Feedback from AMPC/Steering Committee
- Production of final report.

4 Project outcomes

Key findings of Part 2 were:

- In relation to the 'market power' variables, the key results indicate that in the domestic market the null hypothesis of no market power cannot be rejected at the 95% level of probability in either beef or lamb input or output markets. These findings confirm the earlier results of Hyde and Perloff (1996), Griffith (2000), Chung and Griffith (2009) and Hilli and Griffith (2022). In other words, there is no indication of increased price differentials between the farm and retail stages of the chain that are not explained by cost increases, suggesting price changes at one end of the chain are being fully reflected at the other.
- In relation to other explanatory variables, the costs of providing marketing services are strongly significant positive influences on the domestic price differentials for beef and lamb, and there are significant measurable effects in the various price differential equations from past policy or industry decisions – the 1975-78 curtailment of Australian beef imports by Japan; and the negative effect on price differentials due to the consolidation of industry processing capacity in the red meat industries around 2011.
- The general picture of real marketing price differentials for beef and lamb indicates a reasonably flat and consistent trend for each meat, and in some cases, the real marketing price differentials had declined. The consistency of real marketing price differentials over time, despite the significant structural changes to these industries, re-affirms earlier studies (Griffith, 2000; Hilli and Griffith, 2022) suggesting an absence of market power.
- In essence, over a period of a year, prices are efficiently transmitted along the beef and lamb supply chains, and a change in prices at the one end of the chain is reflected in a change at the other, and the price differential between them remains relatively constant once changes in costs are accounted for. This means also that consumers are not suffering from changes in prices along the chain, which is the primary focus of interest for competition and consumer laws. Moreover, the fact that price transmission is efficient indicates that price transparency is sufficient to enable efficient operation of the market.

5 Literature review and industry context

5.1 Literature review

There have been a number of thorough reviews of theoretical models, empirical evidence, government enquiries and competition policy implications of price transmission processes in the food industry in Australia and in many other countries. One of the reviews particularly relevant to the current project was by Piggott et al. (2000). By way of background, they stated:

“Whether or not market power exists in the food chain has been an issue of concern to farmers and policymakers for most of this [the 20th] century. Indeed, the incentive for the establishment of marketing boards for primary products was partly the fear that farmers were at the mercy of powerful players in the food marketing chain who had the ability to earn abnormally high profits at the expense of farmers.”

The authors referred to the gradual removal of agricultural marketing boards in the Australian economy arising from the Hawke-Keating deregulation agenda, the continuing growth of the large domestic supermarket chains, and the expanding influence of overseas food manufacturing companies in the domestic market through the opening up of food and agricultural product trade. This generated a renewed interest in competition policy oversight through the Australian Competition and Consumer Commission (ACCC).

This brings us to the definition of market power, or more broadly, non-competitive behaviour. The definition of market power is never clear in economic theory. One early definition that was used by the ACCC (1999) is "…the ability of a firm to behave persistently in a manner different from the behaviour that a competitive market would enforce on a corporation facing otherwise similar cost and demand conditions."

This would include the ability to raise selling prices and depress input prices, to deter entry, to re-distribute profits to oneself from other players, and, importantly, to be able to sustain these benefits over time. This last point is the most important. If a market player takes advantage of a temporary situation of power, it will have less effect on the economic welfare of other buyers and/or sellers than would a permanent advantage.

More recent definitions are a little more precise. The latest ACCC Merger Guidelines (2008) for example state:

“In general, the exercise of market power by the hypothetical monopolist is characterised by the imposition of a small but significant and non-transitory increase in price (SSNIP) above the price level that would prevail without the merger, assuming the terms of sale of all other products are held constant”.

To paraphrase: what indicates an ability of a seller (or purchaser) to unilaterally alter prices from competitive market levels and hence act in a manner that is contrary to competitive norms is whether a material difference in price over and above competitive levels can be maintained over a sustained period of time.

The key terms in these quotes (sustained, persistent, non-transitory) reinforce the point that the concern of competition policy is in departures from medium-term equilibrium conditions, not in short-term departures such as evident in the common (mostly retail) practices of price levelling, price averaging and price asymmetry.

The long-term analysis within this project is focused was on the former. That focus determined the theoretical framework applied (economic equilibrium theory), the types of data analysed (annual data) and the types of econometric processes used (measures of departures from equilibrium).

The short-term analysis within this project is focus is on the latter. Different theoretical frameworks are applied, different types of data are analysed (quarterly or monthly data) and different types of econometric processes are used (adjustments in margins over short periods of time).

The primary focus is on the transmission of price changes between different market levels, such as between farm and wholesale, wholesale and retail, etc. But the principles apply to the transmission of price changes between any set of different market conditions, such as between different regions, different types of livestock, different grades, etc.

Insights from theory

Long-term price transmission

Piggott et al. (2000) undertook a comprehensive review of the various theoretical approaches to conceptualising market power. They concluded:

"All the above suggests that market power is a complicated and difficult concept to tie down. How is social policy to make fine judgements about markets when it appears that economists have such vague views about identifying market power in practice?"

Each of the theoretical perspectives reviewed by Piggot et al. (2000) had their own particular indicators and remedies.

In particular:

"Neoclassical [economic] theory suggests examining price-cost margins1, the existence of conjectural variations that suggest firms react to each other's actions, and inter-industry rates of profit. This theory is a theory of market behaviour, rather than of firm behaviour. It is appropriate where it is sensible to expect equilibrium observations and statistically tractable data sets…Where either of these conditions is not to be expected, alternatives should be taken. Either large numbers, or a monopoly (or a tightly disciplined cartel) is the requirement."

These are the textbook microeconomic theories, as applied to agricultural markets by Muth (1965) and Gardner (1975) among many others.

[1] There are a number of different terms used to describe price differences between different market levels. The 'marketing margin' is that which is commonly used in academic economics documentation – the difference between the price of a kg of product sold at retail and the price of a kg of product sold at the farm gate. However, it has connotations of profit margins in general usage. Another term is 'price spreads', as calculated and reported by for example USDA, where byproducts are accounted for and the kg of product is transformed so that both prices are in carcase weight equivalent, or alternatively, both are in retail carcase equivalent. In this study the data available to do these transformations is not available. Here, the term 'price differential' is used to measure the price difference between farm and retail prices.

Some of the alternative approaches reviewed in the Piggot et al. study were the structure-conduct-performance paradigm, contestability theory, new institutional economics, and evolutionary economics approaches such as the resource advantage theory.

The most recent treatments of the theoretical underpinnings of this type of research follow that same path – the textbook economic models (see for example, Kaiser and Suzuki, 2017) explaining the profit-maximising behaviour of industries with seller market power (oligopoly and monopoly) and of industries with buyer market power (oligopsony and monopsony). The appropriate theoretical framework has not changed with the passage of time.

Given that, in this project, it is sensible to expect equilibrium observations and there are statistically tractable data sets, a standard microeconomics theoretical perspective (the New Empirical Industrial Organisation (NEIO) approach) is maintained. This is the same approach used in previous studies of these industries in Australia.

Short-term price transmission

The major concept in studies of short-term price transmission is whether 'price levelling' occurs or not. The concept of price levelling has a history of around 60 years. It was developed to explain behaviour by food retailers when setting prices charged to customers: "price levelling is said to occur when the retailer takes a smaller margin when farm prices are high, and a higher margin when farm prices are low." Retail prices are kept more stable, are levelled, than the prices of the agricultural input. Parish (1967) explained the broad rationale as a desire to keep prices to customers relatively stable so they would continue to visit their shop and purchase approximately the same quantities as usual, and to minimise the costs of changing prices and informing customers of these price changes.

An underlying assumption here is that the direction of causality is farm price to retail price - any variability that influences input prices comes from the supply side of the market, and that variability is then passed up the value chain. This is certainly the case for the current discussion about supermarket pricing behaviour – why did retail beef prices not fall to the same extent when farm prices for cattle fell?

Parish (p.194) mentions in passing that if the cause of price fluctuations are shifts in demand, with retail price levelling, the same price impacts are expected but that "quantities marketed are less stable than they would be in the absence of levelling'. But every other published paper that was reviewed that mentions "price levelling" (with just one exception) does so in the context of a domestic consumer market, where any variability that influences input prices comes from the supply side of the market.

This situation can be represented in a typical multi-level supply/demand diagram, as explained by Griffith et al. (2023). An initial assumption might be that the farm supply curve shifts to the left, perhaps as a result of an adverse weather event. The equilibrium quantity is reduced, the equilibrium farm price increases the equilibrium retail price increases. With a typical upward-sloping supply curve for market services, the primary and derived demand curves, and the primary and derived supply curves, diverge as quantity increases. Thus, the change in retail price is smaller than the change in farm price. Retail prices are more stable than farm prices in equilibrium.

But price levelling is a deliberate, short-term behaviour. The question is what does the behaviour change that results in even more stable retail prices? In his analysis, Parish (p.193) explicitly states that retail demand is assumed not to shift, but derived demand does. Thus, it must be the supply of retail marketing services, that the retailer has some control over, that has to adjust. He also mentions (p. 197) a retailer choosing to supply different bundles of attributes to customers, depending on the relative cost of the services versus the meat.

Therefore, to achieve retail price levelling, retailers impose a more inelastic supply of retail marketing services which has the effect (because of the assumed direction of causality) of making the short-term derived demand curve more inelastic. This curve rotates through the initial equilibrium point. This gives us the familiar result that when farm prices rise (due to the assumed leftwards shift in supply), with retail price levelling the farm-retail marketing margin contracts and retail prices are more stable than they otherwise would be. Conversely, farm prices are more unstable than they otherwise would be.

If supply were to increase in the short run, with retail price levelling behaviour in place, the farm-retail marketing margin would expand and again retail prices would be more stable than they otherwise would be in equilibrium.

In this domestic market situation, the causal flow of information is that changes in the farm price cause changes in the retail price, and in empirical estimation we expect the size of the farm-retail marketing margin to be negatively related to the farm price in the short term. We also include longer-term trends in farm prices, a measure of marketing cost and a measure of throughput.

There is also a substantial body of literature that focuses on the implications for agricultural producers of instability in prices received and farm incomes due to world market disruptions, and mechanisms to reduce this instability. This is the levelling of farm prices. Some of these mechanisms are legislated government stabilisation policies, but many are implemented by value chain participants. Many different types of industries in many different countries have experienced this situation. There have been a lot of empirical studies but none have used the concept of price levelling to explain this type of private sector stabilisation behaviour.

This situation can also be shown in a multi-level supply/demand diagram. Here the assumption is that causation goes from market to farm, so variability comes from the demand side. An initial assumption might be that the export demand curve shifts to the left, perhaps as a result of a recession in an importing region. The equilibrium quantity is reduced, the equilibrium export price decreases and the equilibrium farm price decreases. Again, with an assumed upward-sloping supply curve for market services, the primary and derived demand curves and the primary and derived supply curves diverge as quantity increases. Thus, in this case, the change in export price is larger than the change in farm price. Farm prices are more stable than export prices in equilibrium.

But again, to consciously and deliberately achieve short-term price levelling, processors/exporters must be able to impose a more inelastic supply of marketing services, rotated through the initial equilibrium point. This has the effect (because of the direction of causality) of making the short-term derived supply curve more inelastic. This gives us a new farm price levelling result that when export prices fall (due to the assumed shift in export demand), the farm-export marketing margin contracts, farm prices are more stable than they otherwise would be and export prices are more unstable than they otherwise would be.

If demand were to increase in the short run, with farm price levelling in place, the farm-export marketing margin would expand and again farm prices would be more stable than they otherwise would be in equilibrium.

In this export market situation, the causal flow is that changes in the export price cause changes in the farm price, and in empirical estimation we expect the size of the farm-export marketing margin to be positively related to the export price in the short term. As in the retail price levelling case, we also have to account for longer-term trends in export prices, marketing cost and throughput.

Insights from empirical studies

In line with the NEIO theoretical approach, most empirical studies focus on explaining the determinants of marketing price differentials or price spreads, as being related to the costs of providing the necessary market services, the potential for non-competitive conduct in the purchase of the agricultural raw material and the potential for non-competitive conduct on the sale of the final output. Major reviews of this literature were undertaken by Wohlgenant and Haidaicher (1989) and Wohlgenant (1999).

International studies

Bresnahan (1989) compared the estimated price-cost price differentials from various US and Canadian studies covered in his review. The estimated price cost price differentials ranged from about 5% to about 90%. These studies covered manufacturing, retail and service industries. He drew two main conclusions from that review:

- There is a great deal of market power, in the sense of price-cost price differentials, in some concentrated industries. But he was cautious about being more definite in this conclusion.
- One significant cause of high price-cost price differentials is anti-competitive conduct (behaviour). Some of the studies found conduct well towards the collusive end of the spectrum, but there were substantial differences between firms in some industries, such as between dominant and fringe firms.

There have been many US studies using these methods with a direct focus on agriculture/food

markets. With respect to food processing, the meat packing sector has been the focus of a substantial amount of research activity. Many studies found market power in the purchase of finished cattle and/or in the sale of packed beef (for example, Koontz et al. 1993). However, Muth and Wohlgenant (1999a) found no evidence of market power in this industry in either input or output markets. Muth and Wohlgenant (1999b) continued this line of inquiry with a more flexible modelling approach similar to Bresnahan (1989). When the market power terms were held fixed, imperfect competition was found in at least one market. However, when the market power terms were allowed to vary with changing industry conditions, no evidence of market power was found.

In a series of influential papers, Paul (1999a,b) stressed the need for a rigorous treatment of the cost structure of the industry when attempting to measure market power effects. Paul concluded (p.629) "Increasing concentration in the US meat packing industry seems justifiably to have emerged from cost economies, which appear in turn to be primarily transmitted to suppliers and demanders of cattle and meat products rather than generating excessive profits for the plants or firms." With specific regard to food retailing, Holloway (1991) found no major departures from competition in the whole farm-retail marketing chain for eight major US food groups, Ailawadi et al. (1995) found no concrete evidence confirming an increase in market power exercised or accumulated by grocery retailers, and Messinger and Narasimhan (1995) found that neither accounting nor stock market data clearly indicated a shift in channel profitability from manufacturers to retailers.

In a rigorous treatment, Park and Weliwite (1999) used aggregate retail industry data obtained from official and trade sources to examine whether there has been any evidence of market power in US food retailing. They found price-taking behaviour in US food retailing prior to 1983, but some evidence of market power since then following an increase in merger activity. Other influential US studies

during this period were by Cotteril (1986, 1997), Hall et al. (1979), Lopez (1984) and Schroeter (1988).

Then followed a big gap in the academic literature until around 2015. US fed cattle prices collapsed in 2015 but the meat packers were accused of raising wholesale and retail prices of beef to increase price differentials. A number of antitrust lawsuits were filed against the largest beef packers. This environment spawned a renewed interest in the economics of market power, with the recent literature reviewed by Bolotova (2022, 2024). An example is Blair and Angerhofer (2021) who explained the market power of US beef packers under different collusion scenarios. Russo and Goodhue (2018) recently examined US supermarket food pricing decisions.

Most of the international studies reviewed related to longer-term equilibrium price transmission, but a few used short-term data. A more recent study using US data was Ward (1982).

Australian studies

Long term analysis

Hyde and Perloff (1997) found that the Australian domestic retail meat market was competitive for beef, lamb and pork and that market power had not increased over time. Zhao et al. (1997) modified the model developed by Holloway (1991) to account for trade and applied it to the Australian beef market. When the domestic and export markets were separated, there was no evidence found of non-competitive behaviour in the domestic beef market.

Using a simple empirical model and a highly aggregated data set, Griffith (2000) estimated the market power of different Australian food chains. He found that the null hypothesis about the competitive behaviour of the various food products could not be rejected for the meat product group. This work was subsequently updated by Chung and Griffith (2009) and most recently by Hilli and Griffith (2022). Both these studies used the same NEIO model with a successively more updated data set and found no evidence of non-competitive behaviour.

Evidence from another livestock industry is also of interest, that of the dairy industry. A particular area of concern in Australia during the late 1990s was the retail fluid milk markets, and the extent to which retail prices might change because of concentration in food retailing following the deregulation of milk marketing boards in the various states. For carton milk, looking at the retail to the farmgate price differential, O'Donnell (1999) found that the estimate for the term containing the conjectural elasticity on output was significantly different from zero, implying that in deregulated markets carton milk retailers do possess market power in the sale of market milk to consumers. Similarly, evidence was found of carton milk processors possessing market power in the purchase of market milk from farmers. These results were confirmed in the processor-to-farmgate price differential, where carton milk processors were found to have market power in both output and input markets.

O'Donnell et al. (2005) used a similar model to examine and measure market power in grains and oilseeds purchases by processors and millers.

Short term analysis

There is extensive empirical evidence of price levelling behaviour in a number of fresh meat markets. Parish (p.187) quoted evidence presented to government enquiries and empirical evidence from published research during the 1960s that price levelling existed in retail meat markets in Australia (and in at least two other countries (the United Kingdom and the United States). These conclusions were supported by the results of Marceau (1967), Griffith (1974) and Naughtin and Quilkey (1979).

A number of investigations in the 1990s confirmed this behaviour in Australian meat markets (Griffith, Green, & Duff, 1991; Piper, 1992; Wooklock, 1995). All of the empirical evidence finds that price levelling is a short-term phenomena – over one or a few months at most – and that retail prices tend to revert to trends in farm prices over the longer term. However it is noteworthy that there have been no published studies on this issue for almost 30 years.

The concept of price averaging – taking a smaller margin on one meat type but offsetting that by taking a larger margin on a substitute meat type - was also found to be prevalent in the Australian retail meat market (Griffith, 1974; Griffith, Green and Duff, 1991).

There is also evidence of price levelling behaviour in fresh fruit and vegetable markets (Griffith, Jamandre and Piggott, 1992). Again, the empirical evidence finds that price levelling is a short-term phenomena.

The hypothesis of asymmetry in price transmission within the Australian meat market was tested by Griffith & Piggott (1994)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. The authors found this difference to be 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.

Examples from time series studies

Another recent theme of research into price transmission processes has been to examine the time series properties of the major price series in a particular food chain to infer industry behaviour from market outcomes. This relies on the availability of short frequency data such as monthly or quarterly observations (rather than the annual data are used in this study) but modern time series econometric methods are able to separate out short-term and long-term influences.

Most of this research has been undertaken in the US. For example, Reed and Clark (1998) used cointegration methods on data from seven US food industries. Their paper was primarily methodological, and they reminded readers that analysts are more likely to reject competitive market behaviour if they do not correctly account for the characteristics of the data series they are using. They also make the same point as emphasised above (p.1142) that "... deciding whether markets are competitive rests not on whether an industry establishes a gap between price and marginal cost but on whether the gap is maintained over time and as capital moves in and out of the sector."

Goodwin and Holt (1999) also used cointegration methods to examine the long-run equilibrium relationships between US farm, wholesale and retail beef prices, with a particular emphasis on the causal direction of price changes and on whether responses were symmetric to price rises and price falls. They found unidirectional price transmission, from farm to wholesale to retail, which does not imply the existence of market power at higher levels of the chain. They also found that the responsiveness to price shocks had increased in recent years, and they suggested that this result may imply that markets have become relatively more efficient in transmitting information through vertical marketing channels.

Palaskas (1995) used cointegration methods to examine the dynamic transmission of five agricultural producer prices through the food marketing system in seven countries of the European Union. Statistical tests rejected the hypothesis of short run ‘perfect’ price transmission across all pairs of prices in all countries. Further, in the long run, perfect price transmission was not rejected in only two

of five price pairings across six of the countries. The UK was the exception. For all products in the UK and for three of the products in the other six countries, non-competitive behaviour was concluded.

Dawson and Tiffen (1997) also use cointegration models to look at beef, lamb and pork farm and retail prices in the UK and Wales. They could not find a cointegrating relationship for either beef or pork and while they did find one for lamb, the relationship implied causality from retail to producer prices. This suggests that for the UK lamb industry, prices are set at the retail level and thus there is some evidence of market power in retailing, while for the beef and pork industries there is some evidence against a competitive market.

A problem with both these analyses (and for many studies of European and North American food markets) is the confounding impacts of agricultural policy measures which are in place to influence and supplement farm prices. These impacts are not properly handled in either of these studies. In Australia, Chang and Griffith (1998) found that the farm, wholesale and retail prices for beef were cointegrated and thus moved together over time, all responding to exogenous shifts in demand and supply curves. This suggests no evidence of non-competitive conduct. However, the wholesale price was found to be weakly exogenous, suggesting some disequilibrium behaviour.

Insights from government and industry reviews

The Piggott et al. (2000) review covered the report of the Joint Select Committee on the Retailing Sector (Australian Parliament, 1999) in considerable detail. The Committee was asked primarily to inquire into and report on the degree of industry concentration within the retailing sector in Australia, with particular reference to the impact of that industry concentration on the ability of small independent retailers to compete fairly in the retail sector.

A significant number of industry submissions alleged instances of predatory pricing, where it was said that the major chains were prepared to lose money indefinitely in certain stores to wipe out the competition. While the major chains denied these claims, the Committee thought that the evidence was consistent and widespread, with the common complaint being that the difficulties lie in establishing predatory conduct under the current provisions of the Trade Practices Act. The Committee made 10 recommendations.

The evidence used by the Committee to reach its conclusions and make its recommendations was a combination of factual data on market shares and price changes and largely anecdotal evidence about firm conduct derived from submissions and hearings. There is some mention in the reported submissions and in the discussion of developments in other OECD countries. However, the Committee did not expound any particular theoretical framework used in its deliberations and it seems that no formal empirical studies were undertaken as part of the inquiry.

Chung and Griffith (2009) recognised the significant interest of government bodies and the ACCC in the Australian meat industries (ACCC, 2002, 2007, 2008). Since then, such reviews have continued.

In 2017, the ACCC conducted a Cattle and Beef Market Study (ACCC, 2016b, 2017), and the Senate concluded an Inquiry on the Effect of Market Consolidation on the Red Meat Processing Sector (Senate, 2017). At the same time, Meat and Livestock Australia (MLA), published the results of their investigation into Sheep-Meat Market Structures and Systems (Herrmann, Dalgleish and Agar, 2017).

In particular, the ACCC report noted the risks of market power through further consolidation in regional markets, with multiple submissions highlighting the ownership changes which have occurred. The ACCC noted that their discretion is already required in the assessment of merger and acquisition activity, and that broadly, the recent ownership changes had not caused anti-competitive conduct

within the respective markets. However, they did note that through the process of their market study it had become clear that cattle purchases typically occur within a 400km radius of the abattoir responsible for processing them, so they would continue to heavily scrutinise merger or acquisition activity in these regions, as a specific risk to market power scenarios. Despite not giving an overall conclusion on the presence or absence of market power within the Australian meat processing sector, the report noted that "Most producers of prime cattle in Australia have access to various buyers within the regional market in which they sell their cattle. These buyers are generally processors but may also include supermarkets and live exporters." (ACCC, 2017, p.8).

The ACCC (2017) advised a list of 15 recommendations to increase competitiveness and transparency in the industry. The ACCC has also launched several legal cases against major retailers. In the period from 2011 to 2014, two separate unconscionable conduct cases were launched (ACCC, 2014, 2015) against major meat retailers for their conduct towards suppliers. The ACCC has also undertaken major inquiries into the horticulture and dairy markets (ACCC, 2016a, 2018).

In the current year, following months of media and political agitation about the 'cost-of-living' crisis, on 25 January 2024, the Australian Government announced that it will direct the ACCC to conduct an inquiry into Australia's supermarket sector. The ACCC's Inquiry will examine competitive dynamics in the retail supply of groceries and in associated supply chains. The ACCC will have particular regard for how prices are set at different levels of the supply chain, and the associated margins.

An issues paper was released (ACCC, 2024), containing the following terms of reference:

- the structure of the markets for the supply of groceries by suppliers, wholesalers and retailers, including:
    - the level and nature of competition at each of these levels of the markets; and
    - relationships between the parties at different levels of each of the markets (for example, relationships between wholesalers and retailers); and
    - the competitiveness of small and independent retailers, including those in regional and remote areas; and
    - the impact of technological change on each of the markets, including the impact of the growth of online shopping; and
    - the approach of suppliers, wholesalers and retailers to setting prices for groceries, including the use of data analytics in setting prices; and
    - factors affecting the price of inputs along the supply chain for groceries, including:
    - any impediments to the efficient availability of inputs along the supply chain; and
    - any impediments to the efficient pricing of inputs along the supply chain; and
    - any difference between the prices paid, and prices charged, by suppliers, wholesalers and retailers for groceries; and non-price aspects of competition in the markets for groceries, including the impact of:
    - loyalty programs; and
    - discounts offered by retailers for future purchases of groceries or other goods or services.

The ACCC released the Interim Report of the inquiry in September 2024 (ACCC 2024). In respect of relevance to the red meat processing industry, the report stated that in the Final Report, the ACCC will draw on a series of case studies of selected grocery supply chains, including across meat and livestock, fresh produce and packaged food and non-food items, selecting supply chains with varying market dynamics to compare the issues and outcomes. In preparing for the Final Report, the ACCC will examine to the extent possible prices and margins across these supply chains and the difference

between the prices paid, and prices charged, by suppliers, wholesalers, and retailers for these grocery products.

The interim report notes that meat suppliers appear to have stronger export market opportunities compared to fresh producers, which could result in these suppliers being comparatively less reliant on supermarkets to distribute their goods. According to the Australian Meat Industry Council, domestic consumption of beef was 27 per cent of the total produced in Australia, and 22 per cent for sheep meat. However, supermarkets still account for an estimated 85 per cent of domestic meat consumption and 80 per cent of domestic volume.

One statement by the ACCC relating to the meat industry is worth noting: it argues that, unlike other product categories, Coles and Woolworths predominately procure livestock directly from farmers through forward contracts. The Australian Meat Industry Council submits that the 2 major supermarkets then engage an intermediary to have animals custom-processed for retail sale. The ACCC suggests that this model limits any product differentiation at the retail level. However, there is no inherent economic logic or cited evidence to support the link being made between the procurement of livestock directly from farmers and the lack of product differentiation. Supermarkets purchasing livestock and selling meat may result in products being differentiated no more or less than through other procurement methods.

More broadly, the interim report comes to a significant conclusion, namely that Australia's supermarket industry at the retail level is an oligopoly. That is, most supply in the market is from a small number of market participants. The ACCC claims that in an oligopoly, we expect market participants to maximise their profits based on expectations of how other market participants are likely to react. If dominant market participants believe that a reduction in prices will provoke an equal reduction by other dominant market participants, resulting in a lower profit margin without a change in market shares, this will tend to reduce the incentive to compete vigorously on price.

The following should be noted about this conclusion:

- It is based purely on the market share of the major supermarket chains, not on objective economic analysis and supporting data on the basis of competition or determination of prices.
- Even assuming the conclusion about oligopoly is correct, and that this will reduce the incentive for price-based competition, this does not explain the real-world market consequences of oligopolies. Oligopolies stand somewhere between pure competition and monopoly, but exactly where they stand is very significant in terms of their effects on competition and consumers. Oligopolies can reduce consumer choice, but the extent to which this takes place is dependent on their ability and willingness to collude and behave like a cartel. They can also manipulate consumer decision making but evidence that will withstand scrutiny, potentially in a court of law, is required before the conclusion on manipulation can be reached.
- Oligopolies can also adopt highly competitive strategies that generate economic outcomes approaching pure competition with high innovation, new product development and non-price competition. They may also generate price stability enabling consumers to plan and stabilize expenditure.

Summary of the background literature

There is a well-established body of theory and empirical measures that have been used to assess market power in the Australian meat industries. To date, no evidence of market power has been found in either the beef or lamb domestic markets. There is consistent evidence of price levelling, price averaging and price asymmetry, but all of this evidence finds that these practices are short-term phenomena – over one or a few months at most – and that retail prices tend to revert to trends in farm prices over the longer term. According to the most recent study (Woodlock, 1995, 68), "While price levelling has been confirmed, it has also been found that this behaviour is confined to short periods of time and that the margin, and therefore wholesale and retail prices in general, do respond to changes in the farm gate price of meat."

One point to make coming out of this literature review concerns the influence of trade. Australia is a small country that exports a significant share of farm output and imports a smaller but still significant share of food requirements. World market prices do matter in the Australian food chain. However, most of the theoretical models reviewed here have been initially constructed in the context of the US and European markets where trade, and the link between domestic and world prices, is not nearly as important. Further, the confounding effects of policy programs in these regions is not always adequately addressed. Any empirical models developed to test market power in the Australian domestic market have to properly recognise the trade status of the industry being studied (see Zhao et al., 1998).

The influence of trade can be negative when the domestic market is non-competitive. Ahmadi-Esfahani (2009) assessed the influence of trade and market structure on price transmission, noting that market structure itself can be a source of imperfect price transmission. Some studies have assessed the influence of trade agreements on competitive markets, however, it is worth noting that when there is speculation for a domestic imbalance of power, the potential influence of trade could be further limiting for the domestic industry, particularly when the domestic industry is unable to compete with international imports. Ahn and Nayga (2016) recognised the market power of exporting nations as an influence on price transmission in an importing nation.

5.2 Evolution of the industry and price transmission

The Part 1 analysis of cattle and beef cycles in the Australian industry revealed a somewhat different picture of the Australian industry than has hitherto been believed to be the case. Conventional wisdom of long standing has suggested the existence of medium-term, predictable cycles in beef cattle industries that are driven by biological-market processes.

This logic follows that cattle (and potentially sheep) breeding herds expand at the biological pace of reproduction over a number of years as producers respond to favourable market conditions (known as herd rebuilding). But then this build-up eventually leads to increased supply on the market and producers reduce breeding numbers in response to price signals (herd liquidation). This eventually leads in turn to low supply and upward pressure on prices, and the rebuilding cycle recommences.

The periods of rebuilding are accompanied by higher prices for cattle and reduced beef production, whereas the reverse is the case when herds are being liquidated. These cycles lasting, 8-10 years from beginning to end, have long been observed in the US cattle market. It was believed that similar cycles also existed in Australia and that the cycles in each country were closely connected.

The research undertaken in Part 1, including analysis of data going back decades, reconfirmed the existence of the 8-10 year cycle in the US beef industry with regard to inventories and prices. But in none of the Australian beef industry series modelled is there any evidence of significant regular patterns of the same order of magnitude as the long-term US cycles. There is also no significant relationship between cattle prices in the US and in Australia. There is similarly no evidence of sheep cycles in Australia.

The only significant regular patterns revealed in the Australian beef industry data are in the numbers of cattle slaughtered, and in cattle prices, and these are for a 2-year lag between changes in these series. Thus, a price rise in the current year is associated with a price fall 2 years ago, so peak to peak or trough to trough would be 4 years. These are indicative of much shorter-term beef industry variability in Australia than the traditional view of cycles in prices and quantities being of medium-term length. However, while this is a significant pattern, it is difficult to say whether it is a major or a minor driver of the slaughterings and price series. This shorter-term lag between changes in prices and quantities is more likely to be caused by the transmission of volatility in world market conditions on the demand side, and by volatile environmental conditions on the supply side than by the expectations and decisions of beef cattle producers on which the persistence of a cattle cycle is predicated. However, once producers make decisions on numbers and output, biological factors also come into play. There is similarly no evidence of sheep cycles in Australia.

The US industry is essentially a controlled-environment production system. The US cattle industry is grainfed, whereas the Australian industry also uses pasture for raising and finishing cattle; the US industry is more vertically-coordinated and integrated than here; and the US industry is far less dependent on exports to global markets. Australian production is inherently more subject to uncertainty, especially in relation to climatic conditions and global market impacts.

At the same time as the industry is revealed to be a far more dynamic and volatile one, there have been a number of developments in the industry that are directly relevant to the issue of price transmission.

Price transmission is significant to the industry in a number of respects. Firstly, the industry has been criticised for an alleged lack of competition because it is claimed that changes in prices to producers are not reflected in prices along the value chain. This is discussed further below as a key economic and policy issue facing the industry.

Secondly, complaints about price transmission are sometimes conflated with concerns that the basis on which prices paid to producers are determined is opaque i.e. there is a lack of transparency that allegedly facilitates anti-competitive conduct by making it difficult for producers to know what alternative offer prices are for their products and hence to secure the best possible price for their livestock.

In relation to transparency, a number of points are worth considering:

- The way in which prices are determined impacts the degree of transparency. In the supply of cattle to processors, for example, there are a number of alternative ways of selling. Cattle can be sold via open-outcry auctions, which provide a publicly visible means of price determination between the buyer and seller that is relatively highly transparent. But another means of sale is over-the-hooks, where producers sell animals directly to processors. These are either undertaken on a bilateral negotiation basis or by means of a grid of prices and qualities for different classes of cattle published by the processor. The ultimate sale price is commonly kept private by the parties to the transaction. Similarly, cattle may be sold from a

feedlot to a processor either on a bilateral negotiation basis or by internal transfer pricing where the processor owns the feedlot. The choice between different sales methods is made on a commercial basis and the proportion of total cattle sales accounted for by each method has evolved over time according to the economic costs and benefits for the parties involved. Quite clearly, prices do not have to be transparent to anyone other than the parties engaged in the transaction for them to be economically efficient. Not every producer needs to know the prices paid to every other producer in order for markets to operate efficiently.

- Another aspect of transparency is the claim by producers that the prices paid by processors are not 'fair'. This commonly is taken to mean they do not reflect the full value of the animal concerned. These allegations tend to focus on the lack of definition or clarity thereof in the prices paid for different qualities or characteristics of animals. However, in a similar manner to the discussion above on price transparency, increasing the specificity of quality definitions entails both benefits and costs. Expanding definitional specificity may entail costs that may be less than the benefits.

5.3 Relevant economic and policy issues

Some key economic and policy issues that arise from price transmission in the red meat industry are:

- The relationship between cattle and sheep cycles and price transmission and
- The impact of price transmission on competition and competition policy.

Cycles and price transmission

If there was a longer-term predictable cycle, the stage of the cycle could have a significant impact on market conditions facing producers. When the herd is rebuilding, all other things being equal, slaughter numbers will tend to decline, and prices of livestock will tend to be firm. However, supply trends may be altered because of factors such as changes in weather conditions. And of course, as with any market, what happens on the supply side is only half of the story. Changes in market demand can accentuate or moderate the impact of changes in supply.

But all things being equal, a reduction in supply will lead to upward pressure on prices in a rebuilding phase and vice versa in a liquidation phase. Whilst producers can undertake actions on production and pricing aimed at maximising the profit arising from market conditions facing them, the stage of the cycle would create an underlying economic environment that would influence their returns. However clearly the absence of long-term cycles undermines any conclusions as to long-term outcomes derived from an assumption as to their existence.

The market conditions facing processors as purchasers of animals could then also be impacted by the stage of the animal cycle in which they are operating. All things being equal, during a rebuilding stage, processors will have to pay higher prices to compete for relatively scarce supplies of animals for processing, and in a liquidation stage, the obverse applies.

Similarly, to the case applying to producers, whilst processors can undertake actions on processing output and pricing aimed at maximising the profit arising from market conditions facing them, the existence of a cycle would create an underlying economic environment that will influence their returns. The existence of short-term market ups and downs as opposed to long-term cycles would tend to confound the expectations of producers and processors and place a premium on risk management.

The impact of price transmission on competition and competition policy

There have been long-standing concerns in relation to competition policy about the efficiency of the market in terms of price transmission along the chain.

As was noted in Part 1, these concerns are related to the purported cyclical nature of the industry. Especially when herd liquidation is underway and prices to producers are weak, they tend to look at retail prices to see if they have also fallen in tandem. If not, producers may be concerned that the market is not competitive and that retailers are not passing on price falls to consumers to stimulate demand for meat.

For example, a recent media report (Beef Central, 2023b) states:

> *"Much has been said about the relationship between this year's collapsing livestock prices and relatively stable retail meat prices over the past six months.*
>
> *In a recent commentary, Meat & Livestock Australia noted that while livestock prices for cattle and sheep have declined significantly this year following historic highs in 2022, the reduction in average retail price of red meat lagged prices paid to producers by approximately eight months".*

Further, the article indicates:

> *"Livestock prices are only one component of retail meat prices. Producing retail meat requires investment in energy costs, transport and freight costs, labour costs, packaging and disposal costs, retailer margins, processor margins, PPE, and hygiene, all of which have increased in price over the last year, along with almost everything else.*
>
> *This is important to remember when considering when livestock prices increased as they did to historical highs last year. When saleyard prices were at those highs a year ago, retail prices increased but not at the same rate. What we are seeing now is that same trend, just in the opposite direction. Consumers need a degree of certainty for their shopping basket and retailers smooth the retail pricing impact over the longer term, rather than sharply increase or decrease the price of meat in accordance with livestock prices."*

A few points should be made in relation to this aspect of cycles and their impact on competition.

Firstly, the smoothing of prices along the chain from producers to retailers (known as price levelling) is a well-known feature of price transmission in the meat industry. This levelling has been analysed in detail by for example in Griffith et al. (1991). However, what is important in terms of market efficiency in an economic context is whether such levelling occurs just in the short-term (which implies a competitive market still prevails) or also in the long-term (which implies it does not). The economic analysis done on this matter confirms that downstream prices are responsive to farm prices in the longer term.

Secondly, the economic considerations just described for defining what constitutes non-competitive markets are reflected in the provisions applying to competition policy. From a competition policy perspective, to reiterate, what indicates an ability of a seller (or purchaser) to alter unilaterally prices from competitive market levels and hence act in a manner is contrary to competitive norms is whether

a material difference in price over and above competitive levels can be maintained over a sustained period of time.

Competition concerns about monopolistic conditions arise for example if the party can impose a small but significant, non-transitory increase in price (or SSNIP).

The ACCC Merger Guidelines (2008) for example state:

> *"In general, the exercise of market power by the hypothetical monopolist is characterised by the imposition of a small but significant and non-transitory increase in price (SSNIP) above the price level that would prevail without the merger, assuming the terms of sale of all other products are held constant".*

A small but significant increase has been stated in the merger context to "consist of a price rise for the foreseeable future of at least 5 per cent above the price level that would prevail without the merger".

The duration of 'non-transitory' has been indicated as being at least 12 months (see https://www.tcd.ie/Economics/staff/masseyp/term1lecture4.htm)

Similarly in the context of abuse of market power (ACCC, 2018):

> *"Market power comes from a lack of effective competitive constraint. A firm with market power can act with a degree of freedom from competitors, potential competitors, suppliers, and customers. The most observable manifestation of market power is the ability of a firm to profitably sustain prices above competitive levels."*

Hence whilst lags in the transmission of prices may have short-term impacts on the profits of various participants along the chain, what matters is whether prices at the retail stage where consumers decide on purchases of the final product reflect prices at the farm stage over the longer term. This will be analysed in Part 2 of this project.

Finally, a competition issue that may be confused with price transmission but is different to it is that of price transparency. A recent Issues Paper (NFF, 2023) describes price transparency as follows:

> *"Price transparency refers to the information available to a farmer to accurately compare the price offered with product supply, demand, market conditions, and prices paid to other farmers. In other words, can a farmer know they are being offered a fair price for what the market demands? In the agricultural supply chain, the lack of market price transparency is used against farmers. Increasing market concentration across the Australian economy has allowed businesses with a large market share to use their market power to exploit the lack of price transparency within the supply chain."*

However, if prices are demonstrated to have been transmitted efficiently, subject to the possible meat marketing phenomena of price levelling and averaging behaviour by retailers, then it logically suggests they would be expected to have been sufficiently transparent at least, to enable the market to operate efficiently.

6 Analysis

6.1 Long-term analysis of price transmission

Data for price transmission analysis

The data required and sourced for this part of the project is indicated below (further detail is provided in Table 6 and in Appendix 1.1). The data required were obtained from public sources. The opportunity was provided for the Committee to provide input into the data list.

- Price of slaughter cattle for domestic markets, at farm gate
- Price of sheep and lambs, at farm gate
- Prices of beef at retail, price of lamb at retail
- Total beef consumption in the domestic market, total lamb consumption in the domestic market
- Prices of non-agricultural inputs (processing and retailing costs) – usually labour, energy and interest costs
- Measures of climate events (BOM, CSIRO)
- Measures of policy events (ABARES)

All these data are available as annual averages or totals, from the early 1970s onwards, from publicly available resources such as the ABARES Australian Commodity Statistics, the MLA statistics database and ABS.

Using this data, the competitive nature of the whole farm-retail price differential can be assessed.

Method

Approaches to measuring market power

Parliamentarians, the rural media, the Australian Competition and Consumer Commission (ACCC) and other government bodies have continued to express their interest in competitiveness in the domestic meat industry in the form of numerous reviews and legal proceedings. Using the New Empirical Industrial Organisation framework, this study re-assessed the question of whether there is any market power present in the domestic fresh beef and lamb markets within Australia, using aggregate data covering the period 1976-2021.

As noted in the literature review section above, there are many theoretical approaches available to assess whether market power is present in agricultural markets. That is, whether the relatively small number of large processing and/or retailing firms in modern economies have sufficient influence in the market to shift input purchasing outcomes or output selling outcomes away from the outcomes predicted by a competitive or contestable market, in a sustained or non-transitory manner.

A summary of the literature review would be that the New Empirical Industrial Organization (NEIO) approach is the approach most often used, across many different industry environments, even though

it has some deficiencies. Bonanno et al. (2018) did a thorough review of modern approaches to market power assessment, noting that as the dimensions of agricultural transactions change, including the expansion of vertical relationships and non-traditional procurement schemes, agricultural economists will need to consider new market power assessment methods. In departing from the commonly applied NEIO framework, Bonanno et al. (2018) relied heavily on the research of Mérel and Sexton (2017) which attempted to show that monopsony behaviour can provide some benefits to markets. However, accounting for highly differentiated products within the market, as well as the uniqueness of contracts in place, is inherently complex. McCorriston (2014) agrees, noting that in the context of the European food and marketing system, the NEIO application is unable to capture some multiproduct buyer power exerted through some retail relationships.

This view is similar to the limitations of the NEIO framework recognised in some modern industry economics textbooks (Kaiser and Suzuki, 2017; Perloff, Karp and Golan, 2007). Yet the application of the NEIO framework remains common and successful in the assessment of market power. There are numerous international case studies of successful market power assessments using NEIO (Ahn and Nayga, 2016; Umar Muazu, Abidin Mohamed, Shamsuddin and Abdulatif, 2016; Sexton, 2013).

Also, it is worth noting that whilst the NEIO framework can be successful in identifying the 'presence' of market power, it fails to identify the 'source' of market power, forcing authors to speculate (Digal and Ahmadi–Esfahani, 2002). But, if market power is found using this simple framework, the option remains of re-examining the particular case using more sophisticated methods. An example is the work of O'Donnell et al. (2007) as a more detailed follow-up to the initial (NEIO-based) results of grains and oilseeds input buying market power found by Griffith (2000).

The NEIO framework

For consistency with previous domestic market research (Griffith, 2000; and Chung and Griffith, 2009) and more recently Hilli and Griffith (2022) and Dhakal and Griffith (2023), the present study uses the particular form of the NEIO framework specified and applied by O'Donnell (1999) to assess market power. This formulation is also consistent with that used by Zhao et al. (1997) in the beef export market.

Access to disaggregated data has limited Australian empirical research into fresh meat market power, so studies done have had to take a very aggregated view. To reiterate the history, several studies used data up until about the mid-1990s. Hyde and Perloff (1996) estimated market power in Australian retail fresh meat markets using the NEIO framework, finding that the Australian retail meat market was competitive and that market power had not been increasing over time. Zhao et al. (1997) modified the model developed by Holloway (1991) to account for trade and applied it to the Australian beef market. When the domestic and export markets were separated, there was no evidence found of non-competitive behaviour in the domestic beef market.

Using the O'Donnell (1999) model and a highly aggregated data set, Griffith (2000) estimated the possibility of market power in seven different Australian domestic food chains. He found that the null hypothesis of competitive behaviour of the various food products could not be rejected for any of the meat product groups.

This work was subsequently updated to 2007 by Chung and Griffith (2009) and again recently to 2017 by Hilli and Griffith (2022). Both these studies used the same NEIO model with a successively updated data set and found no evidence of non-competitive behaviour in the beef and lamb markets.

A related study was by Freebairn (2018). He used a long-run static equilibrium model and showed that there is limited opportunity for monopsony behaviour in the large majority of Australian agricultural industries, such as cattle and sheep, largely due to the elasticity of the farm input supply curve.

Applying the NEIO Framework to the Domestic Fresh Meat Market

To reiterate, the NEIO framework (as described in Chung and Griffith, 2009) is an approach based on real price differentials (price differentials adjusted for the effects of general costs in the economy over time). In equation 1 below referring to the domestic meat market, the possible contributors to the price differential can be broken down into the following three key components (O'Donnell, 1999):

- the marketing services cost, referring to the cost of transitioning the product from a raw commodity into a saleable retail product;
- any potential financial benefits from non-competitive behaviour in the output market; and
- any potential financial benefits from non-competitive behaviour in the input market.

The equation for this domestic market model (taken from O'Donnell (1999)) is as follows:

$$m_j = a_j + \Sigma^{K}_{k=1}\, c_{jk} z_k + \beta_j q_j + \Sigma^{M}_{m=1}\, \gamma_{jm} x_m / w_m, \qquad (1)$$

where, for any product j (for this study j could be beef or lamb);

m_j = industry (whole-of-chain) price differential, $p_j - w_j$;

p_j = price of the food output j (the retail price);

w_j = price of the agricultural input j (the farm price);

a_j = constant term;

c_{jk} = coefficient of the price of non-agricultural inputs (marketing services) k that contribute to food output j;

z_k = price of the non-agricultural inputs k (k could be wages, energy, etc) plus any trend and dummy variables if required;

q_j = quantity of the food output j going to the domestic market;

β_j = coefficient of a term that includes the output conjectural elasticity (a measure of market power in output markets);

γ_{jm} = coefficient of a term which includes the input conjectural elasticity (a measure of market power in input markets); and

x_m = quantity of agricultural input m (in this case q=x and j=m).

In this model, all prices and costs are defined in real terms. Thus, this equation, therefore, measures the factors explaining variation in the real (adjusted for inflation) industry (farm-retail) price differential, mj. The key relationship is the link between the costs of providing the required market services and the resulting price differential. The terms βj (the output conjectural coefficient) and γjm (the input conjectural coefficient) represent the possibility of market power in the output and input markets, respectively. These two coefficients measure the extent to which firms change their outputs or inputs

depending on perceived supply or demand in their market. These coefficients must be non-negative if market power is present. Restrictions may be necessary to constrain the signs of these coefficients to be non-negative.

The overall null hypothesis tested is that there is no market power present in the domestic beef or lamb industries in Australia, over the period 1970 to 2021, in either input or output markets. If the hypothesis is not rejected, equation (1) reduces to the familiar price = marginal cost formulation which is the foundation of a competitive market. Failure to reject this hypothesis means that the βj and γjm terms are not significantly positively different from zero. If the hypothesis is rejected, this means there is evidence of market power in the input market, the output market, or both. Rejecting this hypothesis means that the βj and/or the γjm terms must be significantly positively different from zero.

Data for the domestic market study

In testing this hypothesis annual data are almost always used as the underlying models are set up to reflect medium to longer-term equilibrium conditions as specified by theory and as suggested by the terminology used in competition policy documentation (ACCC Merger Guidelines, 2008). For this application to the domestic market, data for each meat product includes the sale yard price reflecting the farmgate return (for each animal category), the retail price for each meat category, and domestic consumption as representative of throughput in the domestic value chain.

The cost of marketing services is the key in explaining real price differentials. Three individual value chain inputs (wages, interest costs and electricity costs) are assumed to comprise aggregate marketing costs. Chung and Griffith (2009) found that treating these cost variables separately resulted in very high correlation coefficients leading to estimation difficulties (for example, in the current data set, the wage and electricity indexes have a correlation coefficient of 0.95). Thus, they developed an aggregate index for these costs, as originally recommended by Zhao, Griffith, and Mullen (1998). For consistency, this study has used the same indexing calculations.

The aggregate index is formed from: (0.75*Wage) + (0.1*Electricity) + (0.15*Interest), with all components having a base of 2001. The CPI is used to account for inflation over the period 1970–2021.

The sources for both sets of data are outlined in Table 1. Variable definitions are given in Appendix 1.1. The data period for the estimation is 1976-2021 after variable lags etc are taken into account.

Table 1 Sources of data required for estimating equation (1) in the domestic market

Meat Data	General Data
Retail Price (1970–2021) (ABARES, 2022)	Interest Rates, converted to an index base 2001=100 (ABARES, 2022)
Saleyard Price [2](1970 – 2021) (ABARES, 2022)	Wage Price Index, base 2001=100 (ABS, 2024b)
Domestic Demand (1974-2021) (ABARES, 2022)	Electricity Cost Index, base 2001=100 (ABS, 2024a)
	CPI (1970 – 2021), base 2010/2011=100 (ABARES, 2022)

In addition, a number of 'dummy variables' were constructed in Hilli and Griffith (2022) to reflect the discussion about changes in the meat industry structure and in the policy environment. These same dummy variables are used here. The dummy variables take the value of zero from 1970 until the designated year, then they take the value of one. For example, Dum95 represents the period after 1995 when the Commonwealth government implemented a new deregulation agenda. Its value is zero from 1970 until 1994, then one from 1995 to 2017. Likewise, Dum07 represents the entry of Aldi into the domestic supermarket sector; and Dum11 represents the major consolidation in the ownership of beef and lamb processing firms.

One further dummy variable was constructed to represent another policy intervention. As shown in Figure 1, in 1974/75 the Japanese Livestock Industry Promotion Corporation stopped imports of Australian beef under the then quota arrangements, and severely restricted access in the following years until late 1978. A considerable quantity of beef exports destined for Japan had to be redirected to the domestic market (and other export markets) with a consequent reduction in prices and disruption to market arrangements (ABARE, 1988). Dum75 takes the value one from 1975 to 1978 inclusive, and zero otherwise.

Dum95, Dum07 and Dum11 apply to both meat types, and Dum75 applies specifically to beef, although of course there may well be spillover impacts onto related markets. These potential spillovers are tested in the econometric analyses.

Also tested as an alternative to the individual dummy variables is a generic trend variable (TIME), which seeks to account for some of the general structural changes that may have occurred throughout the agricultural and retail environments over the period of the data and which are not captured by the specified individual dummy variables. Changes in the quality of meat products, such as the gradual evolution of Meat Standards Australia over the past 25 years, is one such change.

[2] The farm price variable is that published in ABARES Australian Commodity Statistics. It is an average of saleyard prices across all regions and all livestock types and uses, just as the retail price series is the average across all regions, outlets and qualities. Subsequent research could test more disaggregated expressions of the farm price such as saleyard prices specifically purchased by processors and OTHs prices to reflect the increasing volume of sales direct to processors.

Estimation techniques

A number of linear and non-linear single equation models and seemingly unrelated regression (SUR) models were developed to estimate equation (1), using the statistical package TSP Version 4.5 (Hall and Cummins, 2003). The standard single equation regression procedure in TSP is OLSQ, which provides least squares estimates of the coefficients of a linear regression of an individual dependent variable on a set of independent variables. An alternate single equation estimator is LSQ, which estimates the same set of coefficients using a general-purpose maximum likelihood estimation procedure. LSQ is particularly useful if non-linear restrictions on some coefficients are required.

Finally, the SUR procedure is also used where a number of LSQ equations are jointly estimated so as to test whether the disturbance terms across these equations are interrelated. It is often used when a set of similar equations is being estimated and it is likely that decision makers would account for the joint effects of all equations. A set of per capita meat demand equations is often used as an example of a SUR system. Hyde and Perloff (1996) and Chung and Griffith (2009) also pointed out the significance of this in estimating market power models. Given that the majority of fresh beef and lamb is offered to consumers through the major supermarket chains and that these products are also close substitutes in demand, these two meats are considered to be a closely related product group and are included in the SUR system estimations.

7.2.2 Results

Summary statistics

Summary statistics for the calculated real farm-retail price differentials are given in Table 2.

The average real price differential for lamb is around 760c/kg, while the average real differential for beef is considerably higher at around 1260c/kg. The price differentials for beef and lamb are relatively stable as shown by the coefficient of variation, with that for lamb being the least stable.

Table 2 Summary of real domestic farm-retail price differentials from 1976 – 2021, base 2010/11

	Mean	SD	Minimum	Maximum	Coefficient of Variation (CV)
Beef	1263.4	122.4	1000.4	1546.2	0.097
Lamb	763.9	98.6	593.3	940.8	0.129

Trends

The real and nominal aggregate price differentials over the data period for beef and lamb are plotted in Figures 1 and 2 respectively. The graphs are quite similar for both meat types. The nominal price differentials have followed a rising linear trend for each meat, reflecting the steeper increases in the price of meat relative to the price of livestock over time. However, these nominal values take no account of the rising costs of providing market services, or the increased volume and perhaps quality of marketing services provided over time. Real price differentials have been calculated by adjusting the nominal price differentials by the Australian CPI (ABS, 2022) as a general measure of cost inflation in the economy. Real domestic meat price differentials have not risen much at all over the

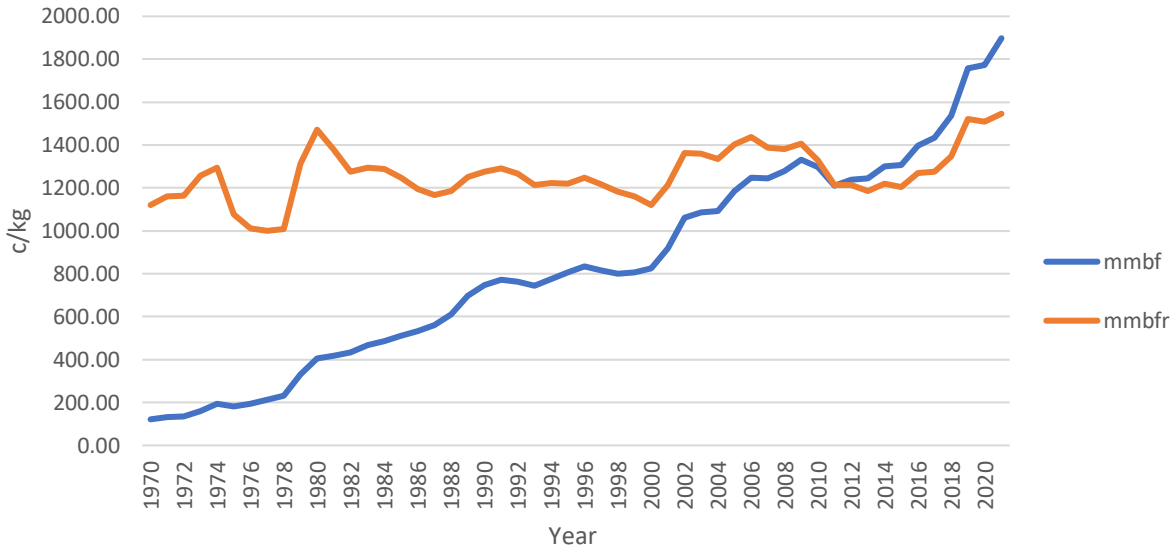
whole data period, and in fact, since the early 1980s, real price differentials have remained stable or have actually declined.

While drawing conclusions from examining graphs of prices requires extreme caution, these patterns suggest that the actors in the fresh meat value chains have not been increasing their profits over time. Popular sentiment is that rising food prices reflect the ever-increasing profit of large supermarkets. This sentiment is reflected with nominal prices of retail food growing much faster than the farmgate price. However, the data presented here suggest that the rise in nominal prices for meat products is a result of cost inflation, rather than an expansion of the margin due to increasing profits. Between individual years, there is variation in the real marketing price differentials. However, it is anticipated that this variation can be attributed to commodity price variability driven by international trade or seasonal conditions, rather than the persistent exercise of market power. This issue is addressed in the formal analysis to follow.

Unit root tests

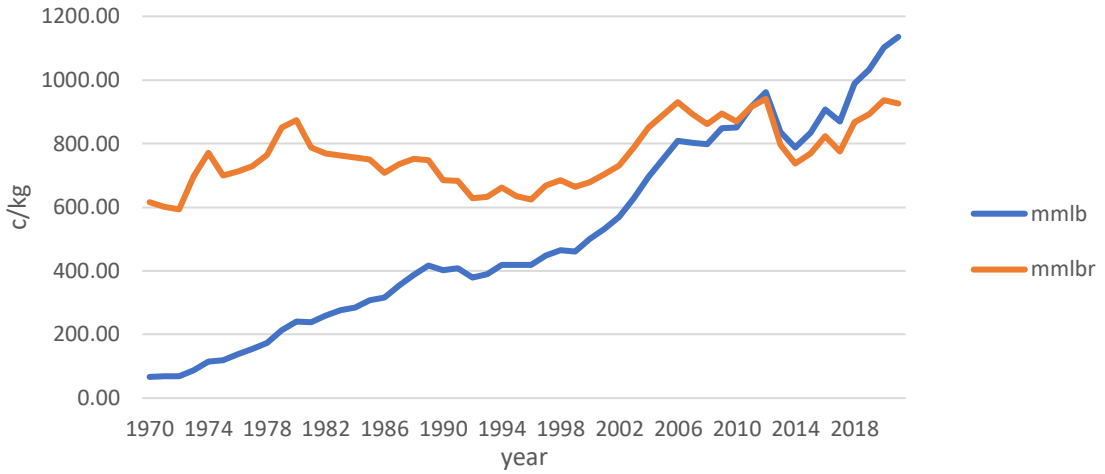
Even though real prices and costs are used, and the graphs do not suggest strong trends in the real price differentials, it is necessary to test for stationarity before proceeding further. Most of the econometric estimation techniques assume that the time series being examined are stationary, that is "the mean and variance are constant over time and the covariance between two values from the series depends only on the length of time separating the two values and not on the actual time at which the variables are observed" (Hill et al., 2001, p.335).

Figure 1 Nominal and real domestic beef farm-retail price differentials, 1970-2021 (base 2010/11)



Note. mmbf is the domestic farm-retail price differential for beef; mmbfr is mmbf divided by the CPI.

Figure 2 Nominal and real domestic lamb farm-retail price differentials, 1970-2021 (base 2010/11)



Note. mmlb is the domestic farm-retail price differential for lamb; mmlbr is mmbf divided by the CPI.

If the series are non-stationary, spurious regressions may result, where significant relationships are found when there are none. The stationarity of a time series can be tested by using a unit root test. Here the augmented Dickey-Fuller test is used which allows the addition of constant and trend variables, and where appropriate, other exogenous variables such as dummy variables (Hall and Cummins, 2003, pp.42-48). For the various series to be considered as stationary, the Dickey-Fuller tau statistic should be significantly different from zero. The results of applying these tests to the domestic market variables are shown in Table 3.

Table 3 Unit root tests for the domestic market variables, 1976-2021

Variable	Tau statistic	P value
MMBFR	-2.68	0.24
MMLBR	-3.26	0.07
DMBF	-2.77	0.21
DMLB	-2.93	0.15
DMBFI	-2.77	0.21
DMLBI	-2.88	0.17
COSTIND	-3.35	0.06

There are two weakly significant tau statistics (between the 5% and 10% significance levels) but the great majority are not significant. Given these unit root test results, the analysis cannot proceed with the variables as defined in levels without the need for further transformation. First-differencing of the data is the common response. It should be noted that this is a very different outcome from the same tests applied in Hilli and Griffith (2022), where stationarity was found for all variables. The extension of the data set, and possibly the different base of the updated CPI series, has made quite a difference.

The range of results

There are many possible equations: four meat types; three estimation methods; with none, one or more dummy variables; with or without autocorrelation; and with or without restrictions on coefficients being non-negative. Note again that a table of abbreviations is presented in Appendix 1.1 to assist in interpreting the results.

The first way that the total number of possible equations can be minimized is by checking for autocorrelation. The results presented in Appendix 1.2 for the OLSQ and AR1 versions of the same simplified equations estimated by Chung and Griffith (2009) show that for each pair of equations, the OLSQ equation is always improved by an autocorrelation correction. The Durbin-Watson statistic is substantially improved, and the adjusted R2 are not adversely affected. This is confirmed by the highly significant t statistic on the estimated rho coefficient in the AR1 versions (except for lamb), even though the rho coefficient is often negative (a common result when using first-differenced data). While not shown here for brevity, this pattern was the same for every estimated pair of equations (across both meat types, across the three estimation methods and whether or not dummy variables are included or not). An autocorrelation correction was always required. From here on, only autocorrelation-corrected equations are reported.

Next, whether or not the various dummy variables constructed to reflect different policy regimes and industry adjustments should be included in the margin equations is tested. Some of the key alternate specifications for the dummy variables are reported in Appendix 1.3 and 1.4. For beef (Appendix 1.3), DUM75 was mostly significant, DUM11 was mostly significant and the time trend variable was also always significant, and most had consistent signs. DUM95 and DUM07 were never significant and the signs were inconsistent. The preferred beef equation therefore contained TIME, DUM75 and DUM11. For lamb (Appendix 1.4), none of the dummy variables proved to have consistent signs, so the preferred lamb margin equation was the same as that reported by Chung and Griffith (2009).

Preferred unrestricted models

The preferred unrestricted equations for the beef and lamb domestic price differentials, respectively, are shown in Table 4 and Table 5, for each of the three estimation techniques. The key components of each equation are R2, Durbin Watson (DW) and the t-statistics. A coefficient is significant at the 5 per cent level where the t-statistic is greater than 1.98 (using a two-tailed test, for 47 degrees of freedom), while at the 10 per cent level the critical value is 1.67. Significant market power coefficients are shown in bolded.

For beef (Table 4), the R2 values are very high and the DW statistics are close to 2. In terms of the signs and significance levels of the estimated coefficients, all three equations show a similar pattern. The cost index and the trend variable are both positive and strongly significant, and both the included dummy variables are negative and mostly significant. The consolidation of red meat processing capacity around 2010/11 seems to have had a long-term effect of placing downward pressure on domestic beef price differentials. The coefficient on the DMBF variable is uniformly negative and insignificant, while the coefficient on the DMBFI variable is always positive but not significant. There is no evidence of any type of market power in these unrestricted beef margin equations.

For lamb (Table 5), the results are very similar to those for beef. The equation statistics are all acceptable, even with the negative rho value (which often disrupts other coefficient estimates). The cost index and the trend variable are again positive and significant, and DUM11 is again uniformly

negative and significant. The coefficients on the DMLBI variable are positive but uniformly insignificant, while those on the DMLB variable are all negative but approaching weak significance levels. There is no evidence of any type of market power in these unrestricted lamb margin equations.

Preferred restricted models

In all equations in Table 4 and Table 5, the preferred unrestricted equations showed negative coefficients on the output conjectural coefficients, some of which were significant or close to significance levels. The same equations were then tested with a non-negative restriction on the input and/or output conjectural coefficients βj and γjm. The restricted models for both LSQ and SUR techniques are shown in Table 6 and Table 7.

Every beef and lamb restricted regression equation with autocorrelation correction and imposed non-negativity showed input and output conjectural coefficients of zero. These are corner solutions. The unrestricted results indicate that these relationships are negative, so by restricting the coefficients to be non-negative the statistical procedure finds the smallest possible non-negative number, zero.

The explanatory power of both equations is little affected except that the cost index has become much more significant, but in general the coefficient restrictions do not help as the same conclusions are drawn as for the unrestricted models.

These results indicate that when looking at the whole farm-retail margin, the null hypothesis of no market power cannot be rejected in beef or lamb input or output markets. These findings confirm the earlier results of Hyde and Perloff (1996), Griffith (2000), Chung and Griffith (2009) and Hilli and Griffith (2022).

Table 4 Preferred unrestricted regression estimates for real domestic beef margin equations 1976 – 2021 (t-statistics are in brackets)

Constant	COSTIND	DMBF	DMBFi	TIME	DUM75	DUM11	RHO	R^2	DW
127.59	5.328	-0.361	8.791	8.347	-101.62	-125.05	0.222	0.99	2.00
(3.00)	(9.27)	(-1.46)	(0.40)	(5.50)	(-2.09)	(-2.94)	(1.45)		
127.81	5.353	-0.368	8.439	8.372	-96.767	-125.94	0.216	0.99	1.99
(2.75)	(8.48)	(-1.35)	(0.35)	(5.04)	(-1.69)	(-2.71)	(1.26)		
163.38	4.071	-0.054	34.152	5.762	--3.339	-58.171	0.323	0.99	1.87
(3.45)	(7.01)	(-0.25)	(1.59)	(3.25)	(-0.04)	(-1.22)	(2.33)		

Table 5 Preferred unrestricted regression estimates for real domestic lamb margin equations 1976 – 2021 (t-statistics are in brackets)

Constant	COSTIND	DMLB	DMLBi	TIME	DUM11	RHO	R^2
88.973	2.905	-0.579	34.477	5.281	-72.669	-0.421	0.99
(4.16)	(16.09)	(-1.94)	(0.92)	(9.42)	(-3.69)	(-3.04)	
82.080	2.871	-0.516	30.542	5.347	-71.387	-0.402	0.98
(3.66)	(14.91)	(-1.62)	(0.77)	(8.70)	(-3.30)	(-2.70)	
99.770	2.861	-0.515	32.264	4.612	-50.254	-0.377	0.99
(4.25)	(16.81)	(-1.84)	(1.00)	(8.19)	(-2.77)	(-3.15)	

Table 6 Restricted regression estimates for real domestic beef margin equations 1976 – 2021 (t-statistics are in brackets)

Constant	COSTIND	DMBF	DMBFi	TIME	DUM75	DUM11	RHO	R^2	DW
112.34	4.407	0.000	0.000	7.315	-119.94	-99.612	0.161	0.99	1.98
(2.90)	(74.56)	(0.00)	(0.00)	(5.07)	(-2.23)	(-2.40)	(0.94)		
100.92	4.462	0.000	-13.227	7.655	-115.19	-108.86	0.153	0.99	1.99
(2.42)	(14.91)	(0.00)	(-0.68)	(5.07)	(-2.18)	(-2.53)	(0.90)		
112.34	4.407	0.000	0.000	7.315	-119.94	-99.617	0.153	0.99	1.73
(3.31)	(80.72)	(0.00)	(0.00)	(5.78)	(-1.78)	(-2.74)	(1.06)		

Notes: (a) when both beef coefficients are restricted (b) when only one beef coefficient is restricted

Table 7 Restricted regression estimates for real domestic lamb margin equations 1976 – 2021 (t-statistics are in brackets)

Constant	Costind	DMLB	DMLBi	TIME	DUM11	RHO	R^2
51.685	2.571	0.000	0.000	5.005	-45.216	-0.324	0.98
(3.02)	(35.02)	(0.00)	(0.00)	(8.20)	(-2.35)	(-2.11)	
51.685	2.571	0.000	0.000	5.005	-45.216	-0.325	0.99
(3.00)	(36.64)	(0.00)	(0.00)	(8.27)	(-2.56)	(-2.58)	

Notes: (a) when both coefficients are restricted

Of note across both the meat types is the fact that imposing the non-negativity restriction on either or both of the market power coefficients does not lead to any different implications than from the unrestricted models.

Finally, the consistent significance of the time variable in the beef and lamb equations suggests the possibility of other structural influences on domestic meat price differentials not picked up by the current set of included explanatory variables. As mentioned previously, changes in quality attributes of the meat types (via schemes such as MSA) may be a possible avenue for further research.

6.2 Short-term analysis of price transmission

Data for price transmission analysis

The data required and sourced for this part of the project is indicated below (further detail is provided in Appendix 2.1). The data required were obtained from public sources. The opportunity was provided for the Committee to provide input into the data list.

Data for the analysis comprised:

- Price of slaughter cattle for domestic and export markets, at farm gate (possibly by type)
- Price of sheep and lambs, at farm gate (possibly by type)
- Prices of beef at retail, price of lamb at retail
- Prices of beef at export, prices of lamb and mutton at export
- Total beef production, total lamb and mutton production
- Prices of non-agricultural inputs (processing and retailing costs) – usually labour, energy and interest costs
- Measures of climate events

Since the focus of this analysis is on short-term price transmission, the data set did not need to be extended back to the early 1970s as required for the cycles and long-term transmission analyses. Quarterly or monthly data from 2000 onwards would be quite sufficient statistically. Most of the data are expected to be available in the MLA statistics database, ABARES Australian Commodity Statistics, and ABS and BOM websites.

Using this data, we modelled short-term price transmission in the farm-retail margin or the farm-export margin. If we wish to split these margins into say farm-processor and processor-retail, we would need a measure of the prices of beef, lamb and mutton at the processor level. Data is no longer available on this publicly.

Method

Based on the results of the literature review, a staged approach to modelling short-term price transmission in the Australian beef and sheep meat industries was developed. This involved:

- collection of the required data series
- assessment of the stationarity of these series
- assessment of the causal relationships between the price series
- estimation of the relevant price transmission models
- reporting and interpreting the results
- drawing implications for industry.

An initial investigation was undertaken of the key sources of agricultural sector data - the MLA statistics database, ABARES Australian Commodity Statistics, and ABS and BOM websites. Since the focus is on short-term price transmission, the data set does not need to be extended back to the early 1970s as required for the price and quantity cycles' analyses. Quarterly or monthly data from 2000 onwards would be quite sufficient statistically. This fitted in perfectly with what was available on the MLA database, with most of the data available there commencing in 2000. Many of the prices were available on a weekly basis with potential aggregations up to annual averages. However, two of the crucial series, the retail price of beef and the retail price of lamb in the domestic market, are only available on a quarterly basis. This constraint determined that quarterly data would be the focus of this study. Further, average export prices were not available of a quarterly basis in readily available sources.

Given these constraints, the following quarterly series were able to be sourced:

- The National Young Cattle Index (nyci), the National Heavy Steer Index (nhsi), the National Trade Lamb Index (ntli), and the National Merino Lamb Index (nmli), MLA, 2000:1 to 2024:2
- Prices of beef at retail and price of lamb at retail, MLA, 2000:1 to 2024:2
- US import price for beef (NZ boneless CIF 90CL), MLA, 2000:1 to 2024:2
- US wholesale price for beef (42% and 72% trim combo), MLA, 2017:1 to 2024:2
- US indicator farm prices for beef (Bonner and breaker cows), MLA, 2010:3 to 2024:2
- Total beef production, total lamb production and mutton production, ABS, 2000:1 to 2024:2
- A wage rate index, ABS, 2000:1 to 2024:2
- An electricity price index, ABS, 2000:1 to 2024:2
- An interest rate, RBA, 2000:1 to 2024:2
- AU/US exchange rate, RBA, 2000:1 to 2024:2
- Consumer price index, Australia, all capitals, all sectors, 2000:1 to 2024:2

Two sets of data suggested in the initial proposal were unable to be sourced from readily available public sources. First, there was no readily available quarterly data on lamb or mutton export prices, as either fob Australian ports or cif in importing countries.

Second, in the initial proposal, it was also suggested that measures of climate events could be incorporated into these models. However, closer examination of the BOM data confirmed that while short-term data on various climate events could be accessed for individual weather stations, there were no readily available aggregated indexes on a quarterly basis for Australia or even individual states. The relationship between weather and yardings, slaughterings and prices will be covered in the individual processer/regional component of the project.

The same variable naming conventions are used in the graphs and computer output as in previous milestone reports in this project. Thus, pa is farm price, pr is retail price, mm is price differential, pd is production, bf is beef, lb is lamb au is Australia, etc. For example, pfbfau is the retail price of beef in Australia. The suffix r means real price. The variable pabfau is the same as the nyci, while the variable palbau is the same as the ntli. The two price series nhsi and nmli are used as alternate representations of the farm price in the calculations of the price differentials and modelling. Where necessary, the prefix d means the first difference.

Following common practice (Hilli and Griffith, 2023), the three individual cost components (wages, electricity and interest charges) are combined into a single cost index with weightings of 0.75, 0.10 and 0.15, respectively.

Two sets of analyses are conducted, the first relating to the domestic beef and lamb market and the second relating to the beef export market.

7.2.2 Results

Domestic value chain price transmission

Data description

First, in this section on domestic value chain price transmission, the relevant data series are summarised and graphed to provide a visual representation of the trends and patterns. Simple correlation coefficients are also calculated and reported in the results below.

In Table 8 is shown the summary statistics of the data used in the domestic value chain price transmission models. These are the real farm price options, the real retail prices, the real price differential options, and the cost and throughput variables. Immediately evident from the coefficients of variation is that both the beef and lamb farm price variables are 2-3 times more volatile than the respective retail prices or the price differentials. This is indicative of consistent actions by value chain participants to keep prices to consumers relatively stable. Also of note is that the price series is considerably more variable than the throughput series, indicative that there are other factors influencing variations in prices than just variations in supply.

Table 8 Summary statistics for the domestic value chain price transmission variables, 2000:1 to 2024:2

	Mean	Std Dev	Minimum	Maximum	COV
PABFAUR	2.39258	0.81714	1.41728	5.16888	0.34
NHSIR	2.22369	0.51440	1.59184	3.73726	0.23
PALBAUR	4.91819	1.19404	2.09145	7.80261	0.24
NMLIR	4.04804	1.34490	1.31468	6.92830	0.33
PRBFAUR	17.34417	1.61759	14.44407	21.22734	0.09
PRLBAUR	13.29412	1.50027	9.04945	15.93963	0.11
MMBFAURA	14.95160	1.15620	12.54055	17.62404	0.07
MMBFAURI	15.12048	1.30202	12.54738	17.88349	0.09
MMLBAURA	8.37593	0.93334	6.23616	10.84016	0.11
MMLBAURI	9.24608	0.93232	7.48472	11.96831	0.10
COST	0.92387	0.05034	0.84064	0.99856	0.05
PDBFAU	536531	50249	434175	678127	0.09
PDLBAU	112291	21145	70757	177147	0.18

The nominal retail prices, the nominal farm prices and the nominal and real price differentials for beef and lamb are shown in Figure 3, Figure 4 and Figure 5 respectively.

In Figure 3, the retail prices of pork and chicken are included as any discussion of how retail prices are formed and behave has to take account of the whole meat demand system (and increasingly other protein sources too). The very stable chicken and pork prices provide a strong constraint against which beef and lamb retailers can set prices, with chicken now the dominant meat consumed.

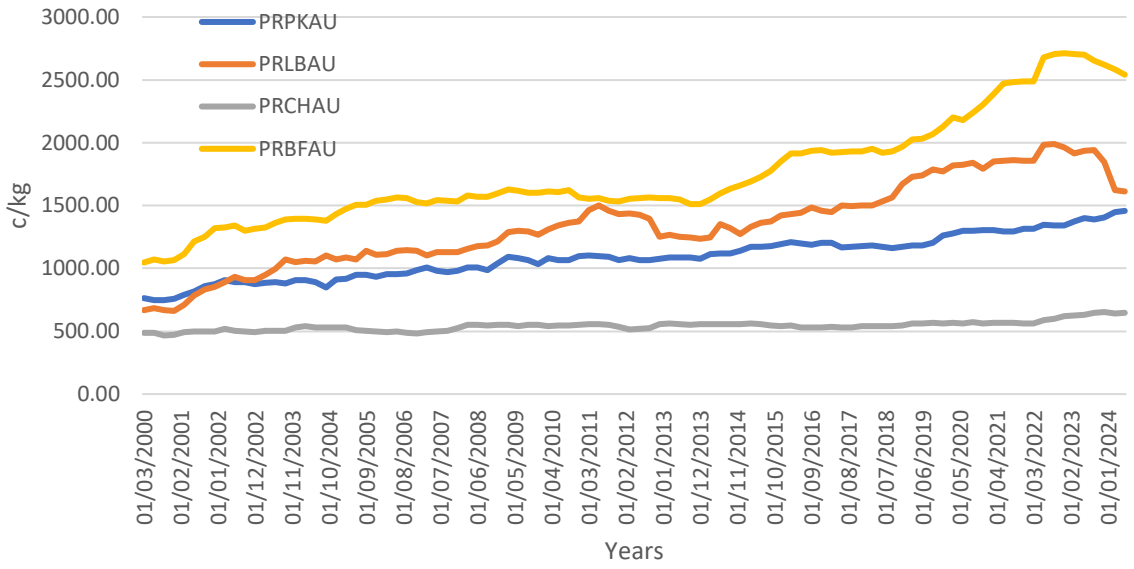


Figure 3 Retail prices of beef, lamb, pork and chicken, Australia, 2000:1 to 2024:2

All of the farm prices shown in Figure 4 are obviously more volatile. The young cattle and heavy steer beef prices have been very closely aligned except for the 2020-2023 period. The trade lamb and merino lamb prices have also been closely aligned over most of the data period. The strong seasonal pattern in lamb farm prices found in the short-term cycles work is evident in this shorter data set, as is the approximately 4-year cycle found in beef farm prices.

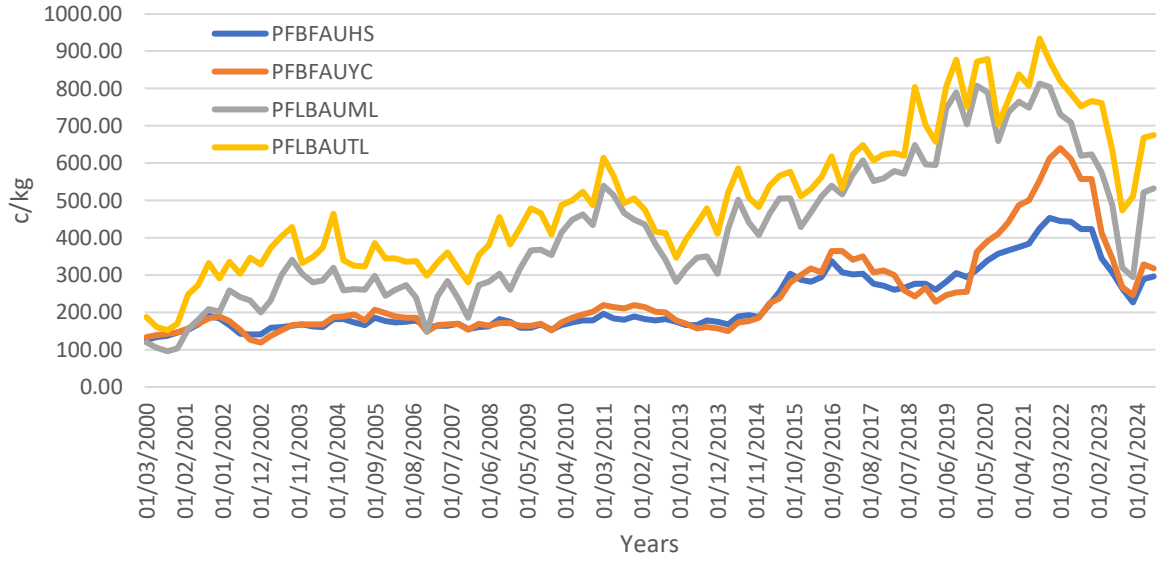


Figure 4 Farm prices of beef and lamb, Australia, 2000:1 to 2024:2

The price differentials shown in Figure 5 follow the same general pattern as found in the longer-term price transmission work. That is, an expansion in the nominal price differential over time as new and more costly market services are added to the cost of livestock, but an almost flat real price differential over this 25-year period as general cost inflation is taken out and as the effects of ongoing technical change improve productivity and reduce costs.

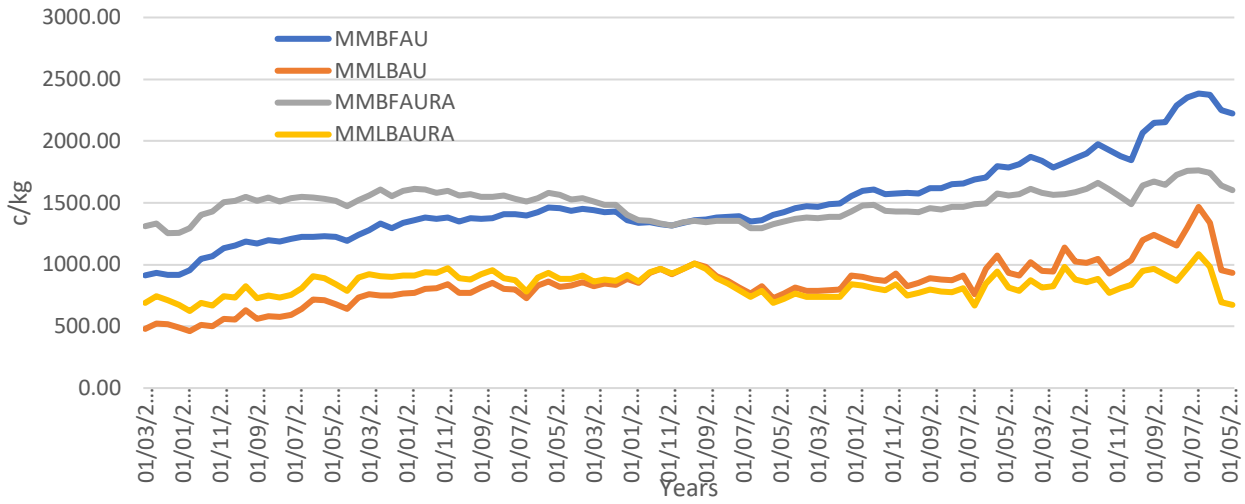


Figure 5 Farm to retail price differentials of beef and lamb, Australia, 2000:1 to 2024:2

The correlations between all of the domestic value chain variables are shown in Table 9. The two measures for the beef farm price are very highly correlated (0.95) as are the two measures for the lamb farm price (0.96), and with only one option for retail prices, this means that the two measures for the beef price differential and the two measures for the lamb price differential are also very highly correlated (0.96 and 0.92 respectively). Using either measure should produce approximately the same results.

The farm and retail prices of beef and the farm and retail prices of lamb are both moderately to highly correlated (0.74 and 0.78), so there is a tendency for both prices to move together in the longer term over the period of this data set. The beef price differentials are positively but weakly correlated with farm prices and positively and strongly correlated with retail prices, but while the lamb price differentials are also moderately positively correlated with retail prices, they are very weakly negatively correlated with farm lamb prices.

The cost and throughput variables are only weakly related to their respective price differentials.

Table 9 Correlation matrix, domestic value chain variables, 2000:1 to 2024:2

	PABFAUR	NHSIR	PALBAUR	NMLIR	PRBFAUR
PABFAUR	1.00000				
NHSIR	0.94922	1.0000			
PALBAUR	0.60859	0.67771	1.0000		
NMLIR	0.61934	0.67135	0.96482	1.0000	
PRBFAUR	0.73669	0.71264	0.50510	0.44045	1.00000
PRLBAUR	0.53388	0.51176	0.78303	0.79058	0.62919
MMBFAURA	0.32393	0.32617	0.27655	0.17850	0.87840
MMBFAURI	0.54023	0.49029	0.35977	0.28197	0.96082
MMLBAURA	0.079600	-0.044395	-0.020661	0.036480	0.36519
MMLBAURI	-0.034303	-0.14493	-0.13176	-0.17035	0.37712
COST	0.33748	0.38403	0.63230	0.71173	0.12417
PDBFAU	-0.42919	-0.28340	0.014146	0.021038	-0.34876
PDLBAU	0.37026	0.36663	0.32838	0.38350	0.40188

	PRLBAUR	MMBFAURA	MMBFAURI	MMLBAURA	MMLBAURI
PRLBAUR	1.00000				
MMBFAURA	0.50296	1.00000			
MMBFAURI	0.57951	0.96244	1.00000		
MMLBAURA	0.60567	0.45467	0.47125	1.0000	
MMLBAURI	0.46873	0.55186	0.52578	0.92201	1.00000
COST	0.54670	-0.064795	0.0025416	0.069862	-0.14696
PDBFAU	-0.12842	-0.18460	-0.32132	-0.22452	-0.23699
PDLBAU	0.34704	0.30057	0.35444	0.13774	0.0052321

	COST	PDBFAU	PDLBAU
COST	1.0000		
PDBFAU	0.38191	1.00000	
PDLBAU	0.72438	0.34819	1.00000

Stationarity tests

Each of the relevant series is then checked for ‘stationarity’. Even though real prices are used, it is necessary to test for stationarity before proceeding further. Most econometric estimation techniques assume that the time series being examined are stationary, that is “the mean and variance are constant over time and the covariance between two values from the series depends only on the length of time separating the two values and not on the actual time at which the variables are observed” (Hill et al., 2001, p.335). If the series are non-stationary, ‘spurious’ regressions may result, where significant relationships are found when there are none.

The stationarity of a time series can be tested by using a ‘unit root’ test. Three different test statistics are available in the TSP 4.5 software package (Hall and Cummins, 2003) and are used here – the augmented Dickey-Fuller test, the Weighted Symmetric test, and the Phillips-Perron test. All allow the addition of constant and trend variables, and where appropriate, other exogenous variables such as dummy variables (Hall and Cummins, 2003, pp.42-48). ‘Augmenting’ lags can be specified to control for additional serial correlation. Here, based on the results from the cycles part of the project showing a 4-year cycle, lags up to 16 are included as we are using quarterly data points. For the various series to be considered as stationary, the selected test statistics should be significantly different from zero (p values less than 0.05). The results of applying these tests are shown below in Table 10, Table 11 and Table 12.

Table 10 Summary of unit root tests, real retail prices, 2000:1 to 2024:2

	Test Statistics			
Test	PRBFAUR	PRLBAUR	PRPKAUR	PRCKAUR
Wtd.Sym.	-1.95974	-2.16754	-3.46136	-2.40595
Dickey-F	-2.36115	-1.72200	-2.94915	-2.14319
Phillips	-6.55653	-7.35179	-15.23246	-18.24159
	P-values			
	PRBFAUR	PRLBAUR	PRPKAUR	PRCKAUR
Wtd.Sym.	0.67538	0.52786	0.022854	0.35411
Dickey-F	0.40047	0.74110	0.14686	0.52184
Phillips	0.70066	0.63587	0.17770	0.099929

Table 11 Summary of unit root tests, real farm prices, 2000:1 to 2024:2

	Test Statistics			
Test	PABFAUR	PALBAUR	NHSIR	NMLIR
Wtd.Sym.	-3.48011	-3.91143	-3.06194	-2.95777
Dickey-F	-3.51111	-3.68089	-3.23719	-2.94375
Phillips	-14.19877	-24.59828	-11.94783	-14.30849
	P-values			
	PABFAUR	PALBAUR	NHSIR	NMLIR
Wtd.Sym.	0.021636	0.0060556	0.071644	0.095319
Dickey-F	0.038217	0.023647	0.077244	0.14849
Phillips	0.21501	0.027545	0.31885	0.21070

Table 12 Summary of unit root tests, real price differentials, 2000:1 to 2024:2

	Test Statistics			
Test	MMBFAURA	MMLBAURA	MMBFAURI	MMLBAURI
Wtd.Sym.	-1.97604	-2.09298	-1.68510	-2.00262
Dickey-F	-2.35610	-2.68526	-2.13957	-2.68019
Phillips	-7.44128	-24.33439	-6.06094	-18.32169
	P-values			
	MMBFAURA	MMLBAURA	MMBFAURI	MMLBAURI
Wtd.Sym.	0.66461	0.58283	0.82542	0.64668
Dickey-F	0.40320	0.24225	0.52388	0.24440
Phillips	0.62861	0.02910	0.74058	0.098374

Both of the real retail prices are non-stationary, all but one of the real price differentials are non-stationary, and the majority of the real farm prices are non-stationary. For consistency, all subsequent analyses are done using the first differenced data to guarantee stationarity.

Causality analyses

The causal flow of information in a market indicates which factors cause an initial disequilibrium and which factors respond to such a disruption. In a price transmission analysis, that means which supply or demand curve shifts first and which supply or demand curve shifts subsequently, indicating the form of price transmission model to be used. For example, in a domestic value chain, do the shocks that cause price changes originally come from disruptions in supply (the farm price) or in demand (the retail price). As indicated in the literature review above, different price transmission models are appropriate for these two types of situations.

Causality may be tested in many ways. Two of the most commonly used methods are the Granger method and the Sims method, named after two prominent theoretical econometricians (Hill et al., 2001). As an example, let us assume we wish to find out whether changes in the farm price of lamb "cause" changes in the retail price of lamb, or vice versa. To do the Granger test, we estimate an equation explaining the farm price of lamb by its own lagged values, and by the retail price of lamb and its own lagged values. Then we omit the lagged values of the retail price and test whether there is any change in the explanatory power of the equation using an F test. If there is, the lagged values of the retail price contain some useful information about the farm price, in addition to the lagged values of the farm price, and we say the retail price "causes" the farm price. Then we reverse the equations and estimate the retail price as a function of the farm price and do the same test. In this way we can say whether there is causation one way or the other (if one test is significant and the other is not), whether there is no causation (neither test is significant), or whether the two prices are jointly determined (both tests are significant).

The Sims test is similar, except that instead of testing for the exclusion of lagged values of retail prices in the above example, we test for the exclusion of future values of the retail price. If the future values as a group are significant, compared to when they are excluded, then the current farm price "causes" the retail price. The Sims test is a bit more difficult to interpret.

In this study we use the Granger method to test for the causal structure between prices at the farm and retail market levels. An example of the full regression output for the test of whether or not the retail price of lamb "causes" the farm price of lamb is provided in Appendix 2. In the first regression in the appendix, the change in the current real farm price of lamb (dpalbaur) is explained by four lagged own values, the change in the current real retail price of lamb (dprlbaur) and four lagged values of the retail price. Note that we have to use first differences based on the unit root tests, and the selection of 4 lags was based on the short run cycles results where in most of the variables analysed there was a strong seasonal cycle in the data. In the regression output, two of the own lagged values are significant, the current retail price variable is significant but none of the lagged retail prices are significant at the 0.05 level. The adjusted R2 value indicates only 21 per cent of the variation in the dependent variable is explained by this set of regressors, so there are many other variables not included in the equation that influence the farm price of lamb. Other equation statistics are acceptable.

In the second regression, the lagged retail price variables are omitted. The R2 value is about the same and not much else changes either. The calculated F statistic that is shown (F=1.46) is for the test of whether the excluded variables as a group (the lagged retail prices) had a significant effect on the overall explanatory power of the equation. With the number of observations large in this case (greater than 90), the critical value for the F statistic is around 1.66, which confirms that the retail price of lamb does not "cause" the farm price of lamb, as tested using the Granger method.

The summary results from all of the F tests are reported in Table 13. All four test results confirm that the direction of causation in both domestic beef and lamb value chains is bilateral, that is that changes in prices at the farm level "cause" changes in retail prices, and simultaneously, changes in prices at the retail level "cause" changes in prices at the farm level. Thus joint determination of farm and retail prices. However the stronger statistical associations are that in all cases farm price causes retail price. None of the tests suggest that retail prices unilaterally "cause" farm prices.

This means that the traditional way of thinking about price levelling can be applied in this study, that is that price differentials respond to changes in input prices. This accords with all of the previous research results on this issue (Marceau, 1967; Griffith, 1974; Naughtin and Quilkey, 1979; Griffith, Green, & Duff, 1991; Piper, 1992; Woodlock, 1995).

Table 13 F tests for the Granger causality models

Meat	Dependent variable	Independent variable	Hypothesis	F statistic	Decision	Interpretation
lamb	dpalbaur	dprlbaur	Retail causes farm	1.46	Do not reject	Retail price does cause farm price
	dprlbaur	dpalbaur	Farm causes retail	10.82	Do not reject	Farm price does cause retail price
lamb	dnmli	dprlbaur	Retail causes farm	1.54	Do not reject	Retail price does cause farm price
	dprlbaur	dnmli	Farm causes retail	9.25	Do not reject	Farm price does cause retail price
beef	dpabfaur	dprbfaur	Retail causes farm	1.62	Do not reject	Retail price does cause farm price
	dprbfaur	dpabfaur	Farm causes retail	3.53	Do not reject	Farm price does cause retail price
beef	dnhsi	dprlbaur	Retail causes farm	4.90	Do not reject	Retail price does cause farm price
	dprlbaur	dnhsi	Farm causes retail	12.86	Do not reject	Farm price does cause retail price

For n=100 approximately, the critical F value is approximately 1.39 at the 95 per cent probability level.

Price levelling and price averaging models

The results of estimating the traditional price levelling and price averaging models are shown below. The 'traditional' price levelling specification is used based on the causality tests, and the data are first differenced based on the unit root tests.

Beef price differential

The estimated beef price differential model is shown in Figure 6.

Figure 6 The estimated beef price differential model

```
Dependent variable: DMMBFAURA
 Current sample:  2000:3 to 2024:2
 Number of observations:  96

        Mean of dep. var. = .028080
   Std. dev. of dep. var. = .390375
 Sum of squared residuals = 8.19970
    Variance of residuals = .096467
 Std. error of regression = .310592
                R-squared = .433617
       Adjusted R-squared = .366983
             LM het. test = .033065 [.856]
          Durbin-Watson = 2.02872 [.155,.903]
             Durbin's h = -1.48035 [.139]
         Durbin's h alt. = -.860967 [.389]
        Jarque-Bera test = 19.2683 [.000]
         Ramsey's RESET2 = .625534 [.431]
         F (zero slopes) = 6.50750 [.000]
          Schwarz B.I.C. = 43.2300
          Log likelihood = -18.1261

                Estimated     Standard
 Variable      Coefficient      Error       t-statistic   P-value
 C              .034838        .213192       .163412       [.871]
 DUMQ1          .091912        .096580       .951670       [.344]
 DUMQ2          .109618        .125142       .875950       [.384]
 DUMQ3         -.146479        .102368      -1.43091       [.156]
 DPABFAUR      -.692502        .154002      -4.49670       [.000]
 DPABFAUR(-1)   .365764        .149503       2.44653       [.016]
 DMMLBAURA      .170637        .053214       3.20662       [.002]
 DCOST         2.43856         6.08749       .400586       [.690]
 DPDBFAU       -.137895E-05    .140790E-05   -.979439       [.330]
 TIME          -.159792E-03    .116897E-02   -.136694       [.892]
 DMMBFAURA(-1)  .250446        .097154       2.57781       [.012]
```

Changes in the current real farm-retail price differential for beef (DMMBFAURA) are explained by a constant term (C), quarterly dummy variables given we are using quarterly data (DUMQ1, DUMQ2, DUMQ3), changes in the current (DPABFAUR) and one-period lagged ((DPABFAUR(-1)) real farm price, changes in the current real farm-retail price differential for lamb (DPALBAURA), changes in the current cost index (DCOST), changes in the throughput of beef (DPDBFAU), a trend variable (TIME), and a lagged dependent variable ((DMMBFAURA(-1)). The current and lagged farm price allows a test of whether price levelling is evident or not, and the current price differential for lamb allows a test for whether price averaging is evident or not. The cost and throughput variables are included to calibrate the model against the theoretical concepts of marginal cost and equilibrium quantity, and the trend variable is included to pick up any longer-term structural changes in the beef market such as changes in quality over time (eg MSA), and the lagged dependent variable is included to allow a test of a partial adjustment hypothesis (the dependent variable only adjusts 'partially' to any change in any of the independent variables - indicative of a general preference for stability).

This equation explains 37 per cent of the variation in changes in the real price differential for beef and the tests for autocorrelation are acceptable.

As indicated by the P value, none of the quarterly dummy variables, or the cost, throughput or trend variables are significant. The results for the cost and throughput variables reflect the low levels of correlation shown in Table 9.

The lagged dependent variable is positive and significant, suggesting a conscious policy to keep the beef price differential stable.

Further, on top of this general preference for stability, there is clear evidence of price levelling, where changes in the current price differential are negatively and significantly related to changes in the current farm price. This means that if there is an increase in the farm price in the current quarter, the price differential contracts so that the full effect of the change in the price of the input (cattle) is not passed on in a change in the price of the output (beef offered to consumers). Thus, the retail price is more stable than the farm price. However, this is only a short-term response, as in the next quarter part of that contraction in the price differential is given up and the price differential moves in the same direction as the farm price. If there is a fall in the farm price, the price differential expands and again the retail price is more stable than the farm price. This evidence matches that found in previous research.

In the price differential models, the price variables are all measured in c/kg, so the coefficients on those variables in these equations can be interpreted as per unit changes. Thus, if the farm price increases by say 10c/kg in the current quarter and everything else is unchanged, the price differential is reduced by about 7c/kg (the coefficient -0.693) and only 3c/kg of the original price rise is passed on as an increase in the retail price in the current quarter. In the next quarter, however, the price differential is increased by about 4c/kg (the coefficient 0.366), so roughly half of the first-round levelling is recouped. By the end of the second quarter, around three-quarters of the original farm price increase is passed on to retail prices. Further small increases will occur over a longer time period due to the effect of the positive and significant lagged dependent variable in the beef price differential equation.

There is no evidence of price averaging across beef and lamb price differentials in this data set, in fact, the opposite. The significant positive coefficient on the real lamb price differential variable suggests a strong complementary relationship between beef and lamb price differentials, where they both rise or fall together. Previous research results relating to price averaging were mixed, with some suggesting averaging and some suggesting complementarity, as found here.

Lamb price differential

The estimated lamb price differential model is shown in Figure 7. Changes in the current real farm-retail price differential for lamb are explained by the same set of factors as for beef.

Figure 7 The estimated lamb price differential model

```
Dependent variable: DMMLBAURA
Current sample:  2000:3 to 2024:2
Number of observations:  96

       Mean of dep. var. = -.718286E-02
  Std. dev. of dep. var. = .690577
Sum of squared residuals = 12.1651
   Variance of residuals = .143119
Std. error of regression = .378310
               R-squared = .731486
      Adjusted R-squared = .699896
            LM het. test = 12.2481 [.000]
           Durbin-Watson = 2.20237 [.441,.985]
              Durbin's h = -11.1313 [.000]
         Durbin's h alt. = -2.09135 [.036]
        Jarque-Bera test = 37.1290 [.000]
         Ramsey's RESET2 = 1.45335 [.231]
         F (zero slopes) = 23.1557 [.000]
          Schwarz B.I.C. = 62.1647
          Log likelihood = -37.0607

                Estimated    Standard
Variable       Coefficient     Error       t-statistic   P-value
C              .244583       .261035       .936974       [.351]
DUMQ1          .258308       .131316       1.96706       [.052]
DUMQ2          .214556       .123207       1.74143       [.085]
DUMQ3          .121731       .130746       .931054       [.354]
DPALBAUR       -.836426      .104882       -7.97489      [.000]
DPALBAUR(-1)   .284077       .115676       2.45580       [.016]
DMMBFAURA      .382592       .112628       3.39694       [.001]
DCOST          3.13306       7.45809       .420088       [.675]
DPDLBAU        -.287670E-05  .630365E-05   -.456354      [.649]
TIME           -.231814E-02  .146519E-02   -1.58214      [.117]
DMMLBAURA(-1)  .108174       .101646       1.06422       [.290]
```

This equation explains around 70 per cent of the variation in changes in the real price differential for lamb and the tests for autocorrelation are acceptable.

As with beef, none of the quarterly dummy variables, or the cost, throughput or trend variables are significant, and in addition, the lagged dependent variable is not significant for the case of lamb. However, two of the quarterly dummy variables are significant at a lower standard of proof.

There is again clear evidence of price levelling, where changes in the current price differential are negatively and significantly related to changes in the current farm price. An increase in the farm price in the current quarter is associated with a contraction of the price differential, so that the retail price is more stable than the farm price, and vice versa for a fall in the farm price. Again, this is only a short-term response, as in the next quarter, part of that contraction in the price differential is given up and the price differential moves in the same direction as the farm price.

In the lamb price differential model, if the farm price increases by say 10 c/kg in the current quarter and everything else is unchanged, the price differential is reduced by more than 8c/kg (the coefficient -0.836) and less than 2c/kg of the original price rise is passed on as an increase in the retail price in the current quarter. In the next quarter, however, the price differential is increased by about 3c/kg (the coefficient 0.284), so roughly a third of the first-round levelling is recouped. By the end of the second quarter, around half of the original farm price increase is passed on to retail prices. In the lamb market, the lagged dependent variable is positive but not significant, so there are no ongoing adjustments in the size of the lamb price differential equation. For lamb, the price levelling impact is large but short-lived, whereas for beef the levelling is of smaller magnitude but the adjustments are spread over a longer time frame.

Further, there is no evidence of price averaging across beef and lamb price differentials. The significant positive coefficient on the real lamb price differential variable suggests a complementary relationship between beef and lamb price differentials, where they both rise or fall together. This matches the beef result.

Alternate equation specifications

First, the beef and lamb price levelling and price averaging models reported above were re-estimated using alternate measures of the price differentials (DMMBFAURI and DMMLBAURI) calculated from the alternate representations of the beef farm price (nhsi) and the lamb farm price (nmli). The results of these re-estimates are shown in Appendix 2.

For the beef price differential equation, there is nothing different apart from one of the seasonal dummy variables now significant. There is no change to the interpretation of the presence of price levelling and the absence of price averaging.

The same is true for the lamb price differential equation, with price levelling confirmed and price averaging not confirmed.

Second, given the results of the unit root tests shown in Table 4, and the interpretation that a few of the variables were already stationary, the beef and lamb price differential models were rerun in levels rather than in first differences. These results are shown in Appendix 2.

Compared to the beef price differential equation reported above, the first equation in Appendix 2 shows some differences. The R2 value is much higher at 0.92, and the lagged dependent variable and the cost variable are now both significant. Price levelling is again confirmed, but now the positive association between beef and lamb price differentials is not significant and the throughput variable is significant.

Compared to the lamb price differential equation reported above, the second equation in Appendix 2 again shows some differences. The R2 value is a little higher at 0.88, and the significant lagged dependent variable coefficient is much higher. Price levelling is again confirmed, as is the absence of price averaging.

Other evidence

Some additional evidence on the relative stability of farm and retail prices is available from running autocorrelation and partial autocorrelation functions, as done in the different parts of the cycle analyses.

The autocorrelation and partial autocorrelation functions for the farm and retail prices of beef are shown in Figure 8 and Figure 9 respectively, while those for lamb are shown in Figure 10 and Figure 11.

Figure 8 Autocorrelation and partial autocorrelation functions for the real farm price of beef, 2000:1 to 2024:2

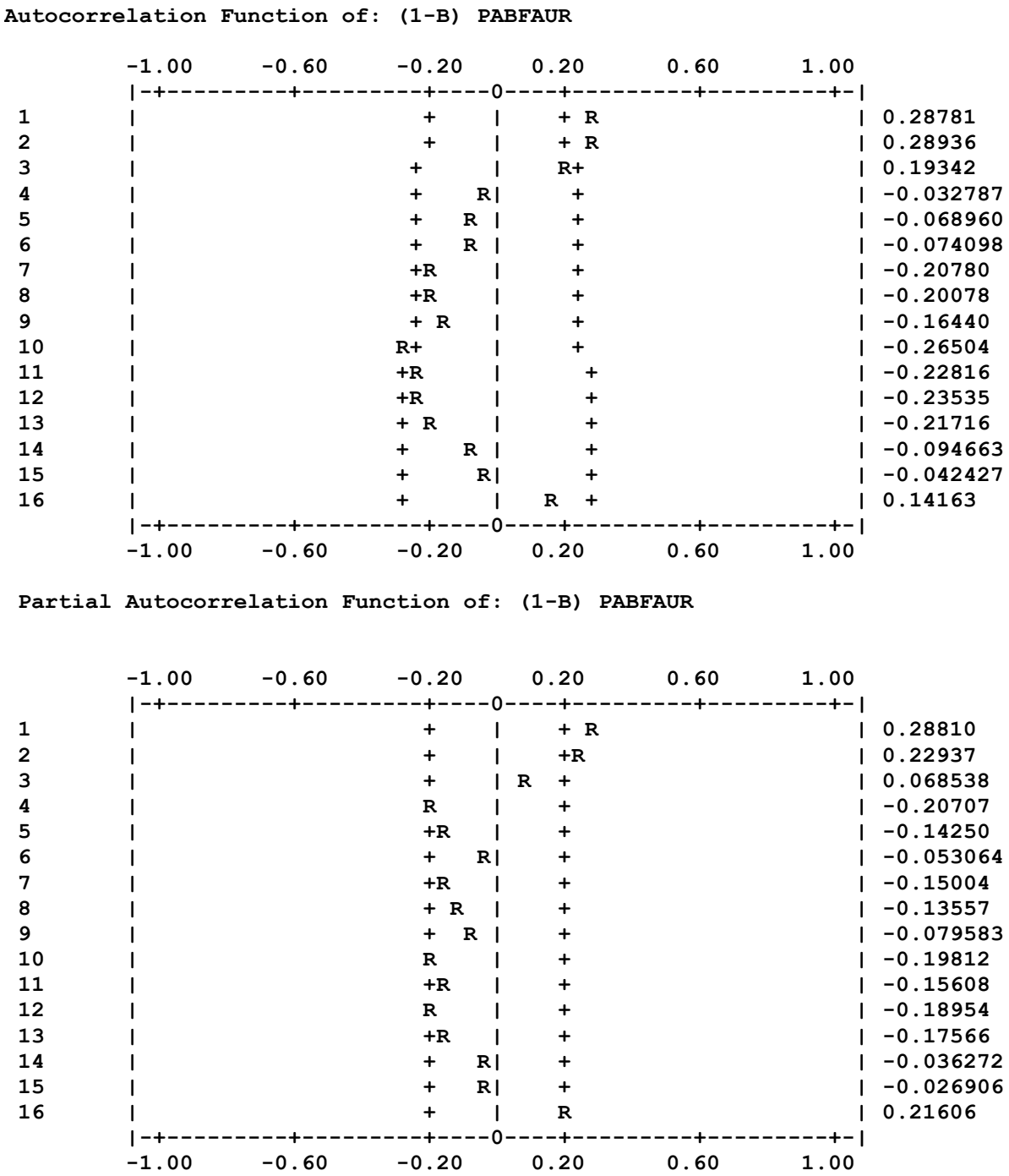


Figure 9 Autocorrelation and partial autocorrelation functions for the real retail price of beef, 2000:1 to 2024:2

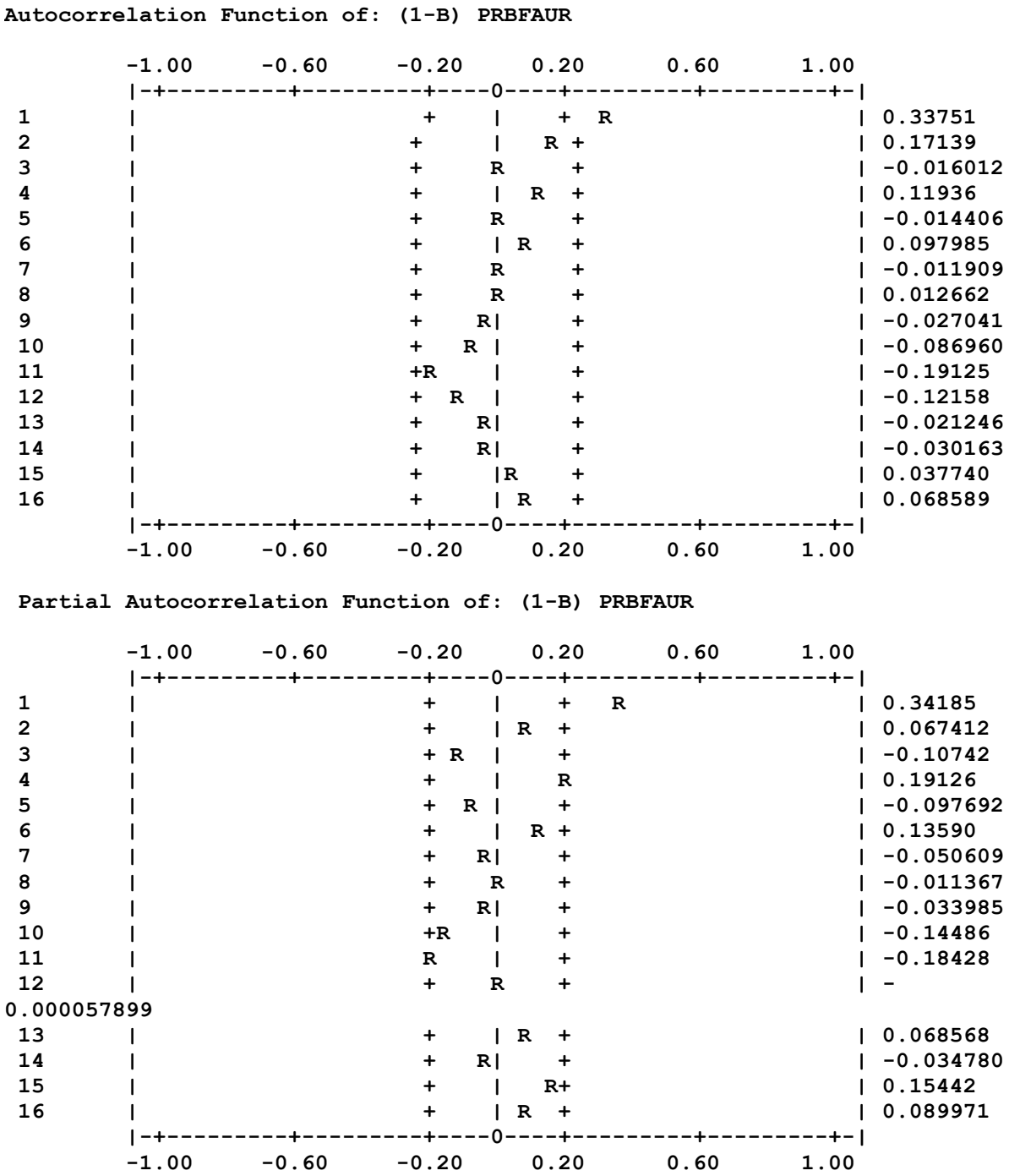


Figure 10 Autocorrelation and partial autocorrelation functions for the real farm price of lamb, 2000:1 to 2024:2

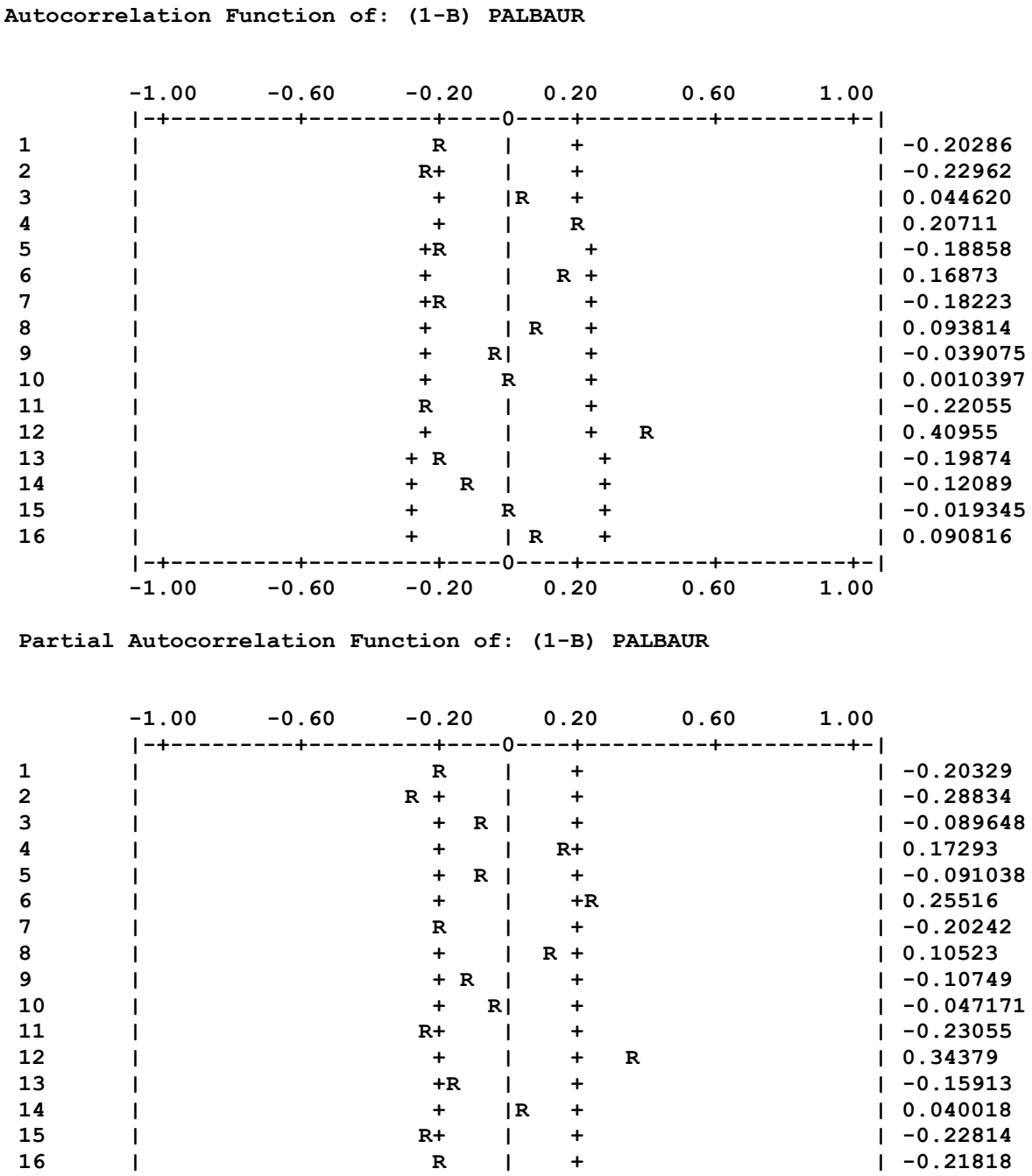
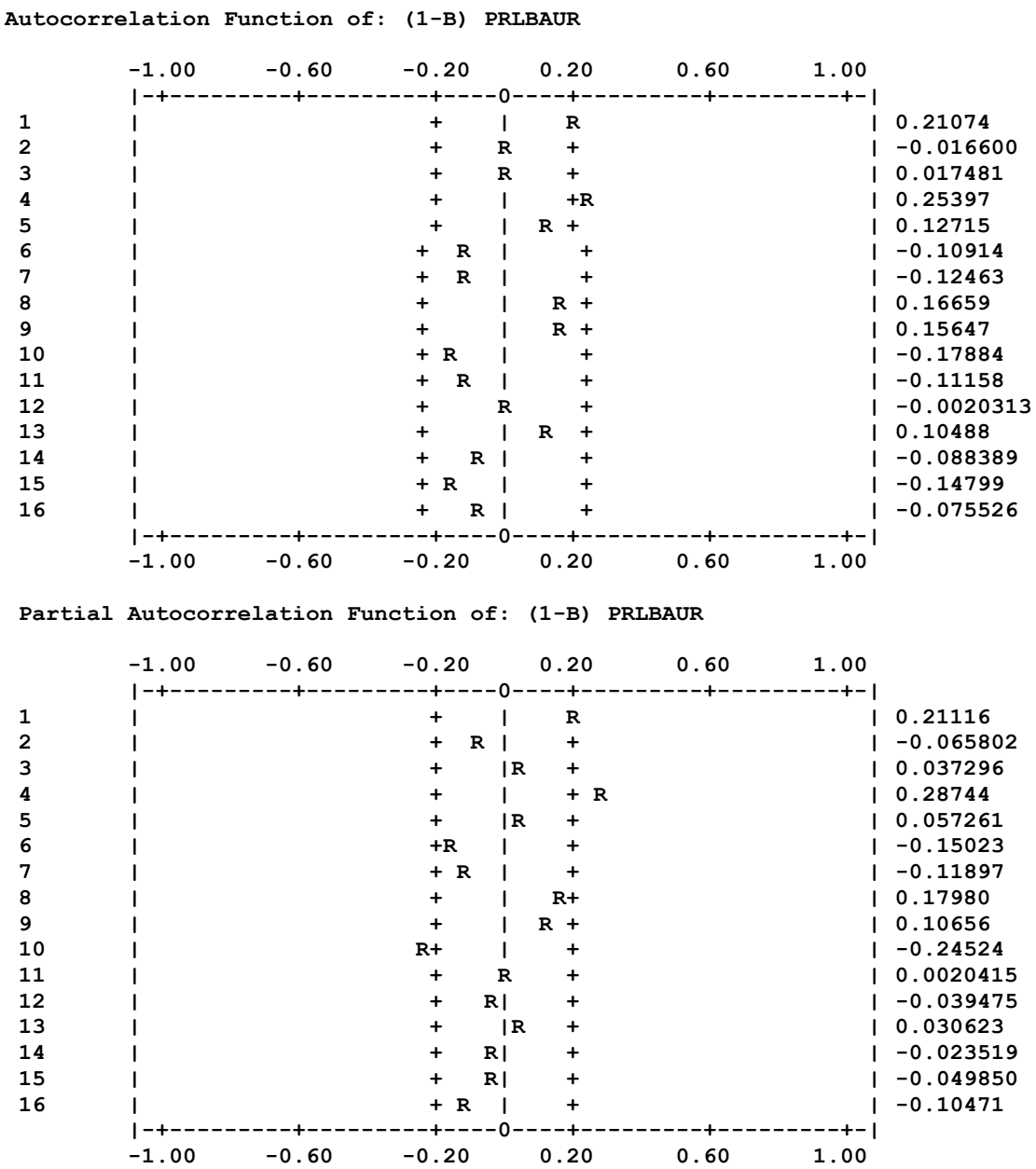


Figure 11 Autocorrelation and partial autocorrelation functions for the real retail price of lamb, 2000:1 to 2024:2



Comparison of Figures 6 and 7, and 8 and 9, reveal that there are different regular patterns in the farm and retail price series. There are more instances of regular cyclical patterns in the farm prices, but most of the longer-term cycles are dampened in the retail prices. This is not definitive evidence, but it does corroborate the findings of the correlation and regression analyses and it does match the visual impression given by the differences between Figure 3 and Figure 4.

Export value chain price transmission

As noted above, quarterly export price series for beef, lamb or mutton, could not be readily accessed. Thus a farm-to-export price differential could not be calculated for these products. Further, a specific price series for lamb and mutton in an importing country could not be obtained, so here we are just reporting the relationships between a number of different beef prices in Australia and in the United States.

Some of these series are quite short. In particular, the two United States farm price indicator series only commenced in 2010, while the two United States wholesale price indicator series only commenced in 2015 or in 2017. In Tables 7 and 8 below, the summary statistics are calculated only for the number of observations common for all series.

Data description

As for the domestic value chain price transmission, the relevant data series are summarised and graphed to provide a visual representation of the trends and patterns. Simple correlation coefficients are also calculated and reported in the results below.

The summary statistics are shown in Table 14 for the most recent seven years only.

Table 14 Summary statistics for the export value chain price transmission variables, 2017:1 to 2024:2

	Mean	Std Dev	Minimum	Maximum	COV
PABFAUR	3.19914	1.10690	1.80775	5.16888	0.34
PALBAUR	6.17205	1.16347	3.49342	7.80261	0.19
PFBFUS85R	3.10467	0.72441	2.25436	4.73103	0.23
PFBFUS75R	3.16422	0.71452	2.29934	4.81518	0.23
PWBFUS42R	1.44249	0.56496	0.71362	2.82654	0.39
PWBFUS72R	2.18651	0.48560	1.31011	3.25580	0.22
PMBFUSR	6.11610	0.67764	4.90382	7.38093	0.11

The two United States farm price series, the two United States wholesale price series and the Australian farm price series all have similar levels of variability as measured by the coefficient of variation. However, the United States import price series has a much lower level of variability.

The correlation coefficients between these series are shown in Table 15. The two United States farm price series are strongly positively correlated (0.99), as are the two United States wholesale price series (0.87). The import price series is moderately correlated with United States wholesale prices (0.42 and 0.39) but is only weakly correlated with United States farm prices for beef (0.09 and 0.15). Similarly, United States farm and wholesale prices are only weakly correlated (0.07 to 0.14). Australian farm prices are moderately correlated with both United States import and wholesale prices (around 0.5) but are negatively correlated with United States farm prices. This latter result matches the results of the beef cycles comparison where Australian and United States farm prices for cattle were found to move in opposite directions in recent years.

Table 15 Correlation matrix, export value chain price transmission variables, 2017:1 to 2024:2

	PABFAUR	PALBAUR	PFBFUS85R	PFBFUS75R
PABFAUR	1.00000			
PALBAUR	0.44615	1.00000		
PFBFUS85R	-0.13164	-0.75757	1.0000	
PFBFUS75R	-0.11731	-0.73889	0.99248	1.00000
PWBFUS42R	0.46560	0.022853	0.14548	0.14227
PWBFUS72R	0.56496	0.10279	0.068330	0.075542
PMBFUSR	0.47231	0.19630	0.094467	0.15197

	PWBFUS42R	PWBFUS72R	PMBFUSR
PWBFUS42R	1.00000		
PWBFUS72R	0.86551	1.0000	
PMBFUSR	0.41783	0.38767	1.0000

The beef export value chain price data is shown in Figure 12 and Table 13.

Figure 12 Australian and United States real farm prices for cattle, 2000:1 to 2024:2

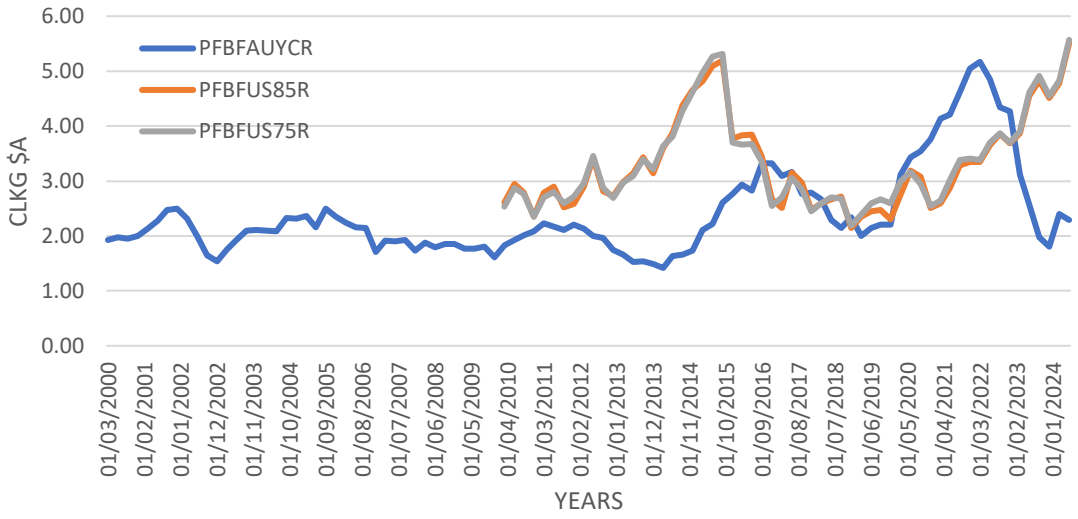
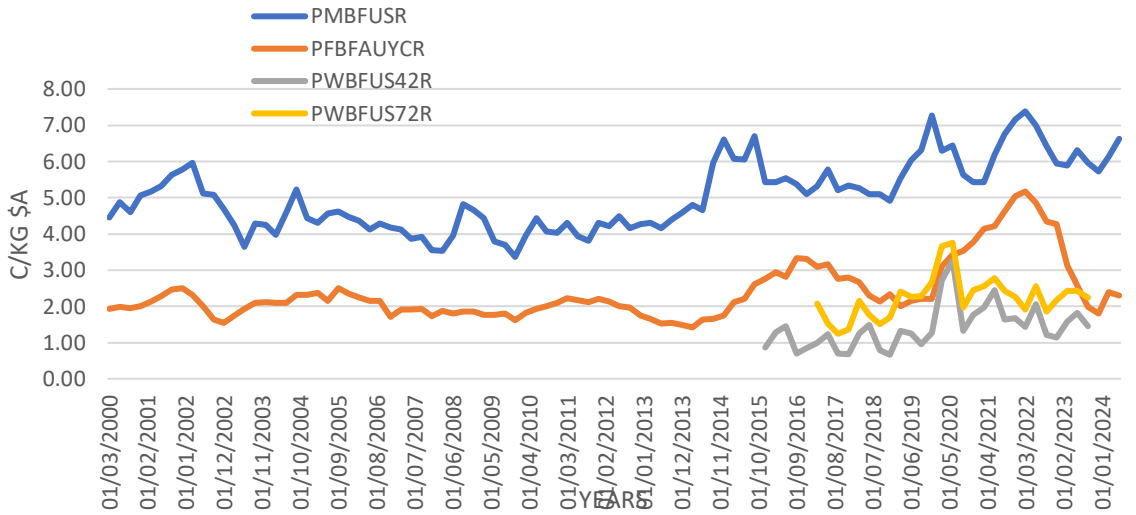


Figure 13 Australian real farm price for cattle and United States real wholesale and import prices for beef, 2000:1 to 2024:2



In Figure 9 it is evident that there is no longer a close relationship between Australian and United States cattle prices as found in earlier work. There are some time periods when both sets of prices are trending in the same direction, but equally, there are other periods when the prices are moving in the opposite direction. These results confirm the correlation results and also match the patterns in prices over the longer term found in the initial beef cycle part of the current project.

In Figure 10, there seems to be a close relationship between Australian farm prices and United States beef import prices over the whole 25 years of data available, and also with United States wholesale prices for the most recent seven years or so. This matches the moderate positive correlations found in Table 8.

Stationarity tests

Each of the relevant series is then checked for 'stationarity'. Even though real prices are used, some of the graphs suggest strong trends, so it is necessary to test for stationarity before proceeding further. Most econometric estimation techniques assume that the time series being examined are stationary, that is "the mean and variance are constant over time and the covariance between two values from the series depends only on the length of time separating the two values and not on the actual time at which the variables are observed" (Hill et al., 2001, p.335). If the series are non-stationary, 'spurious' regressions may result, where significant relationships are found when there are none.

The stationarity of a time series can be tested by using a 'unit root' test. Three different test statistics are available in the TSP 4.5 software package (Hall and Cummins, 2003) and are used here – the augmented Dickey-Fuller test, the Weighted Symmetric test, and the Phillips-Perron test. All allow the addition of constant and trend variables, and where appropriate, other exogenous variables such as dummy variables (Hall and Cummins, 2003, pp.42-48). 'Augmenting' lags can be specified to control for additional serial correlation. Here, based on the results from the cycles part of the project showing a 4-year cycle, lags up to 16 are included as we are using quarterly data points. For the various series to be considered stationary, the selected test statistics should be significantly different from zero (p values less than 0.05). The results of applying these tests are shown below.

Table 16 Summary of unit root tests, export value chain price transmission variables, 2017:1 to 2024:2

Test Statistics

	PFBFUS85R	PFBFUS75R	PWBFUS42R	PWBFUS72R	PMBFUSR
Wtd.Sym.	-1.20243	-1.39167	-1.67830	-2.55307	-2.49455
Dickey-F	-1.06096	-2.07468	-1.15188	-2.46057	-1.06446
Phillips	-3.41463	-3.52487	-12.83945	-16.67117	-3.67241

P-values

	PFBFUS85R	PFBFUS75R	PWBFUS42R	PWBFUS72R	PMBFUSR
Wtd.Sym.	0.95240	0.91913	0.82833	0.26100	0.29612
Dickey-F	0.93533	0.56024	0.91991	0.34795	0.93479
Phillips	0.91806	0.91257	0.27399	0.13541	0.90492

All of the real export value chain prices are non-stationary, so all subsequent analyses are done using the first differenced data.

Causality analyses

Here we ask the question, do the shocks that cause price changes originally come from disruptions in supply (the farm price) or in export demand (the export price or the price in a major market). As mentioned above, different price transmission models are appropriate for these two types of situations.

We again use the Granger test. We estimate an equation explaining the farm price of beef by its own lagged values and by the 'export' price of beef and its lagged values. Then we omit the lagged values of the export price and use an F test to say whether there is any change in the explanatory power of the equation. If there is, the lagged values of the export price contain some useful information about the farm price, in addition to the lagged values of the farm price, and we say the export price "causes" the farm price. Then we reverse the equations and estimate the export price as a function of the farm price and do the same F test. In this way we can say whether there is causation one way or the other (if one test is significant and the other is not), whether there is no causation (neither test is significant), or whether the two prices are jointly determined (both tests are significant). Note that we have to use first differences based on the unit root tests, and the selection of 4 lags was based on the short run cycles results where in most of the variables analysed there was a strong seasonal cycle in the data.

The summary results from all of the F tests are reported in Figure 12.

Table 17 F tests for the beef export value chain Granger causality models

Dependent variable	Independent variable	Hypothesis	F statistic	Decision	Interpretation
dpalbaur	dpfbfus85r	US farm causes AU farm	0.45	Reject	US farm price does not cause AU farm price
dpfbfus85r	dpalbaur	AU farm causes US farml	0.70	Reject	AU farm price does not cause US farm price
dpalbaur	dpfbfus75r	US farm causes AU farm	0.48	Reject	US farm price does not cause AU farm price
dpfbfus75r	dpalbaur	AU farm causes US farml	0.75	Reject	AU farm price does not cause US farm price
dpalbaur	dpwbfus42r	US wholesale causes AU farm	1.88	Reject	US wholesale price does not cause AU farm price
dpwbfus42r	dpalbaur	AU farm causes US wholesale	0.45	Reject	AU farm price does not cause US wholesale price
dpalbaur	dpwbfus72r	US wholesale causes AU farm	1.52	Reject	US wholesale price does not cause AU farm price
dpwbfus72r	dpalbaur	AU farm causes US wholesale	0.91	Reject	AU farm price does not cause US wholesale price
dpalbaur	dpmbfusr	US import causes AU farm	0.71	Reject	US import price does not cause AU farm price
dpmbfusr	dpalbaur	AU farm causes US import	1.14	Reject	AU farm price does not cause US import price

The critical F value is approximately 1.39 at the 95 per cent probability level for the import price test (n=93 and 97); approximately 1.58 for the farm price tests (n=51 and 55), and approximately 1.96 for the wholesale price tests (n=20 and 25).

All of these tests reject any significant degree of causation between Australian farm prices for cattle and the United States farm, wholesale or import prices. Statistically, the prices of cattle and beef in the United States and Australia are determined independently of each other.

7 Discussion

Long-term analysis of price transmission

The literature review conducted for the analysis of price transmission found that first, there is a well-established body of theory and empirical measures that have been used to assess market power in the Australian meat industries; second, no evidence of market power has been found in either the beef or lamb domestic markets.

The price transmission analysis undertaken in this project has been found as follows. First, in relation to the 'market power' variables, the key results of the study indicate that the null hypothesis of no market power cannot be rejected in beef or lamb in either input or output markets. These findings confirm the earlier results of Hyde and Perloff (1996), Griffith (2000), Chung and Griffith (2009) and Hilli and Griffith (2022).

Second, in relation to other explanatory variables, the costs of providing marketing services are strongly significant positive influences on the domestic price differentials for beef and lamb, and there are significant measurable effects in the various price differential equations from past policy or industry decisions – the 1975-78 curtailment of Australian beef imports by Japan; and the negative effect on price differentials due to the consolidation of industry processing capacity in the red meat industries around 2011.

The inability to reject the null hypothesis for beef and lamb could have occurred for a variety of reasons.

However, the general picture of real marketing price differentials for beef and lamb indicate a reasonably flat and consistent trend for each meat, and in some cases, the real marketing price differentials had declined. The consistency of real marketing price differentials over time, despite the significant structural changes to these industries, suggests an absence of market power.

Short-term analysis of price transmission

The literature review of short-term price transmission has established that there is a well-established body of theory and empirical measures that have been used to assess short-term price transmission in the Australian meat industries. There has been consistent evidence of price levelling, price averaging and price asymmetry, but all of this evidence finds that these practices are short-term phenomena – over one or a few months at most – and that retail prices tend to revert to trends in farm prices over the longer term. According to the most recent study (Woodlock, 1995, 68) "While price levelling has been confirmed, it has also been found that this behaviour is confined to short periods of time and that the margin, and therefore wholesale and retail prices in general, do respond to changes in the farm gate price of meat."

The most recent set of empirical results is now more than 30 years old. Quarterly data for the period 2000 to 2024 were collected to re-evaluate these conclusions.

Coefficients of variation calculated from the domestic value chain part of the data show that both the beef and lamb farm price variables are 2-3 times more volatile than the respective retail prices or the price differentials. This is indicative of consistent actions by value chain participants to keep prices to consumers relatively stable. Also of note is that the price series are considerably more variable than

the throughput series, indicative that there are other factors influencing variations in prices than just variations in supply. These differences in relative volatility are also evident from graphs of the respective series.

All of the four Granger test results confirm that the direction of causation in both domestic beef and lamb value chains is bilateral, that causality is that changes in prices at the farm level "cause" changes in retail prices, and simultaneously, changes in prices at the retail level "cause" changes in prices at the farm level. However, the stronger statistical associations are that in all cases farm price causes retail price. None of the tests suggest that retail prices unilaterally "cause" farm prices. This means that the traditional way of thinking about price transmission (farm to retail) can be applied in this study.

The calculated real price differentials for beef and lamb are both very stable with little trend evident. In the estimated regression models, none of the cost, throughput or trend variables are significant but a lagged dependent variable is positive and significant, suggesting a conscious policy to keep the beef price differential stable. Further, on top of this general preference for stability, there is clear evidence of price levelling in both types of meat, where changes in the current price differential are negatively and significantly related to changes in the current farm price. Thus, the retail price is more stable than the farm price. However, this is only a short-term response, as in the next quarter part of that contraction in the price differential is given up and the price differential moves in the same direction as the farm price. This matches previous research, however, there is no evidence of price averaging across beef and lamb price differentials in this data set which is different from previous research.

The long-term analysis of price transmission in the project confirmed the absence of long-term market power and emphasised the stability of real marketing price differentials over time. This analysis of short-term price transmission has confirmed that retail prices are more stable than farm prices due to price levelling. Changes in farm prices are partially passed on to retail prices over time, indicating a preference for stability. In the case of beef, for example, by the end of the second quarter, around three-quarters of the original farm price increase is passed on to retail prices. Further small increases will occur over a longer time period. However, as the long-term analysis in the first stage of the price transmission analysis indicated, the increased farm price is fully passed on over a period of a year. These findings are consistent with the conclusion reached by other analyses. Meat and Livestock Australia (MLA 2023) in observing price transmission noted that the reduction in average retail price of red meat lags prices paid to producers by approximately eight months. Similar conclusions on price levelling have been observed by the Australian Meat Industry Council (2024)

It is worthwhile noting that price levelling indicates a preference for price stability and mitigates the impacts of farm price volatility on consumer behaviour and preferences for meat from prices rising and falling significantly on a short-term basis. To illustrate this, this research finds that both the beef and lamb farm price variables are 2-3 times more volatile than the respective retail prices or the price differentials.

In terms of the export value chain for beef, the correlation analysis showed that Australian farm prices are moderately correlated with both United States import and wholesale prices (around 0.5), but are negatively correlated with United States farm prices. This latter result matches the results of the beef cycles comparison where Australian and United States farm prices for cattle were found to move in opposite directions in recent years.

This was confirmed in the graphical analysis which showed that there is no longer a close relationship between Australian and United States cattle prices as found in earlier work. There are some time periods when both sets of prices are trending in the same direction, but equally, there are other

periods when the prices are moving in the opposite direction. In the graphs, there seems to be a close relationship between Australian farm prices and United States beef import prices over the whole 25 years of data available, and also with United States wholesale prices for the most recent seven years or so. This matches the moderate positive correlations.

Finally, in the causality analysis done on the export value chain variables, all of the tests reject any significant degree of causation between Australian farm prices for cattle and United States farm, wholesale or import prices. Statistically, the prices of cattle and beef in the United States and Australia are determined independently of each other.

This project has come about because of concern about the need to explain to stakeholders the basis of price transmission in the industry. There is a need for objective, economic analysis of price transmission, to address subjective views on the nature of the industry and its market which can fail to reflect the industry's competitive market conditions.

This research will help to improve the understanding by stakeholders, including livestock producers, industry organisations, consumers and regulators, of the nature and functioning of the red meat processing industry and the key factors influencing its competitive environment.

8 Conclusions and recommendations

Key findings indicate that over a period of a year, prices are efficiently transmitted along the beef and sheep meat supply chains from producer to retailer. There is no indication of increased price differentials between the farm and retail stages of the chain that are not explained by cost increases, suggesting price changes at one end of the chain are being fully reflected at the other. This finding is consistent with previous studies suggesting there is no significant market power in either input or output markets for beef or lamb. This implies that consumers are not suffering from changes in prices along the chain, which is the primary focus of interest for competition and consumer laws. Moreover, the fact that price transmission is efficient indicates that price transparency is sufficient to enable efficient operation of the market.

The findings within this report lead to the following recommendations:

- The findings indicating the absence of market power should be brought to the attention of meat and livestock industry stakeholders.
- The findings should in particular be brought to the attention of the authorities undertaking reviews of competition in relevant inquiries, including that relating to the grocery sector of which the meat processing industry is a part.
- The collaboration should explore the risk management options currently available to supply chain participants, and the potential for future development of risk management approaches and instruments, in order to better address the inherent volatility and uncertainty associated with the short-term ups and downs and hence to ensure mutually beneficial outcomes for chain participants in terms of productivity, profitability and long-term industry growth.

The above recommendations are in addition to the following recommendations from Part 1 of the project (analysis of market cycles).

- The findings indicating the existence of much shorter-term market ups and downs in the Australian beef industry rather than longer-term cycles in the US industry, and the absence of cyclical behaviour in lamb, should be brought to the attention of meat and livestock industry stakeholders.
- The meat and livestock industries should consider undertaking a collaborative research and engagement initiative to examine the implications of this finding for the industry's supply chain.

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Appendices

Appendix 1 Long-Term Analysis

i. Variable definitions

Abbreviation	Definition
BF	Beef
LB	Lamb
PRBF	Retail Prices for Australian Beef (ABARES, 2022)
PFBF	Saleyard Prices for Australian Beef (ABARES, 2022)
PRLB	Retail Prices for Australian Lamb (ABARES, 2022)
PFLB	Saleyard Prices for Australian Lamb (ABARES, 2022)
MMBF	Nominal Beef Farm-Retail Price Differential (PRBF– PFBF)
MMLB	Nominal Lamb Farm-Retail Price Differential (PRLB – PFLB)
MMBFR	Real Beef Farm-Retail Price Differential (MMBF/CPI)
MMLBR	Real Lamb Farm-Retail Price Differential (MMLB/CPI)
DMBF	Domestic Demand for Australian Beef (ABARES, 2022)
DMLB	Domestic Demand for Australian Lamb (ABARES, 2022)
DMBFI	DMBF/(PFBF/CPI)
DMLBI	DMLB/(PFLB/CPI)
TIME	Trend Variable (1970=1, 1971=2, etc)
WAGE	Australian Wage Rate Index (ABS, 2024b)
ELECT	Australian Electricity Cost Index (ABS, 2024a)
INT	Australian Interest Rate, 90-day bank bills (ABARES, 2022)
COSTIND	Marketing Cost Index = (0.75 * WAGE) + (0.1* ELECT) + (0.15*INT)

ii. OLSQ and AR1 estimates of the real domestic beef and lamb price differential equations, 1976-2021

Constant	COSTIND	DMBF	DMBFi	TIME	RHO	R^2	DW
133.11	4.638	-0.113	5.853	5.936	-	0.98	1.04
(2.66)	(6.56)	(-0.33)	(0.17)	(6.52)			
142.49	5.118	-0.337	17.925	6.494	0.495	0.99	2.03
(2.83)	(9.20)	(-1.44)	(0.84)	(4.63)	(3.75)		
		DMLB	DMLBi				
80.047	2.625	-0.121	13.958	3.854	-	0.98	2.33
(2.65)	(14.18)	(-0.39)	(0.47)	(6.40)			
80.495	2.593	-0.068	3.288	3.836	-0.207	0.98	1.83
(3.19)	(15.38)	(-0.24)	(0.09)	(7.97)	(-1.32)		

iii. AR1 estimates for real domestic beef price differential equations 1976 – 2021

Constant	COSTIND	DMBF	DMBFi	TIME	DUM75	DUM95	DUM07	DUM11	RHO
142.49	5.118	-0.337	17.925	6.494					0.495
(2.83)	(9.20)	(-1.44)	(0.84)	(4.63)					(3.75)
339.08	5.049	-0.271	98.886		-200.68				0.675
(8.26)	(9.15)	(-1.19)	(0.44)		(-2.95)				(5.51)
244.63	5.099	-0.294	10.453			131.90			0.572
(5.25)	(8.86)	(-1.22)	(0.47)			(2.89)			(4.17)
306.97	5.151	-0.367	21.257				69.977		0.734
(5.97)	(9.16)	(-1.59)	(1.02)				(1.11)		(6.27)
322.36	5.123	-0.344	18.761					17.791	0.777
(5.28)	(8.48)	(-1.42)	(0.92)					(0.23)	(6.19)
264.08	4.970	-0.220	3.830		-182.93	101.62	25.999	-15.670	0.454
(6.64)	(8.54)	(-0.90)	(0.18)		(-3.29)	(2.47)	(0.50)	(-0.29)	(3.20)
57.449	5.358	-0.376	10.564	12.971	-60.527	-63.771	-81.240	-125.17	0.072
(1.18)	(9.39)	(-1.49)	(0.45)	(5.03)	(-1.30)	(-1.52)	(-2.08)	(-3.00)	(0.46)

Notes: t-statistics are in brackets

iv. AR1 estimates for real domestic lamb price differential equations 1976 – 2021

Constant	COSTIND	DMLB	DMLBi	TIME	DUM95	DUM07	DUM11	RHO	I
80.047	2.625	-0.121	13.958	3.854				-0.207	0
(2.65)	(14.18)	(-0.39)	(0.47)	(6.40)				(-1.32)	
148.07	2.734	-0.318	26.900		92.851			-0.010	0
(6.01)	(14.59)	(-1.01)	(0.83)		(5.69)			(-0.07)	
143.94	2.454	0.150	-3.029			89.575		0.137	0
(4.48)	(9.94)	(0.37)	(-0.08)			(3.66)		(0.86)	
166.00	2.588	-0.069	13.501				77.122	0.360	0
(4.92)	(10.27)	(-0.17)	(0.42)				(2.33)	(2.51)	
81.102	2.946	-0.636	26.150	6.677	-30.089	-8.322	-86.962	-0.482	0
(3.72)	(15.00)	(-1.98)	(0.64)	(5.35)	(-1.34)	(-0.38)	(-3.97)	(-3.35)	

Notes: t-statistics are in brackets

Appendix 2 Short-Term Analysis

i. Examples of Granger causality regressions

Dependent variable: DPALBAUR
Current sample: 2001:2 to 2024:2
Number of observations: 93
Mean of dep. var. = .016237
Std. dev. of dep. var. = .649909
Sum of squared residuals = 27.7774
Variance of residuals = .334668
Std. error of regression = .578505
R-squared = .285177
Adjusted R-squared = .207666
LM het. test = .760035 [.383]
Durbin-Watson = 2.00177 [.149,.855]
Durbin's h alt. = .787164 [.431]
Jarque-Bera test = 1.46945 [.480]
Ramsey's RESET2 = 2.67534 [.106]
F (zero slopes) = 3.67918 [.001]
Schwarz B.I.C. = 98.4348
Log likelihood = -75.7718

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
C	.021756	.061442	.354085	[.724]
DPALBAUR(-1)	-.349839	.118510	-2.95198	[.004]
DPALBAUR(-2)	-.423603	.131410	-3.22353	[.002]
DPALBAUR(-3)	-.186398	.148154	-1.25813	[.212]
DPALBAUR(-4)	.032483	.133203	.243863	[.808]
DPRLBAUR	.558988	.175910	3.17770	[.002]
DPRLBAUR(-1)	-.166099	.157851	-1.05225	[.296]
DPRLBAUR(-2)	.320333	.176960	1.81020	[.074]
DPRLBAUR(-3)	-.124657	.185165	-.673223	[.503]
DPRLBAUR(-4)	-.050532	.171212	-.295142	[.769]

Dependent variable: DPALBAUR
Current sample: 2001:1 to 2024:2
Number of observations: 94
Mean of dep. var. = .027102
Std. dev. of dep. var. = .654933
Sum of squared residuals = 29.7289
Variance of residuals = .337829
Std. error of regression = .581230
R-squared = .254748
Adjusted R-squared = .212405
LM het. test = .107802 [.743]
Durbin-Watson = 1.91833 [.170,.562]
Durbin's h alt. = .772355 [.440]
Jarque-Bera test = 1.85282 [.396]
Ramsey's RESET2 = 4.59179 [.035]
F (zero slopes) = 6.01618 [.000]
Schwarz B.I.C. = 92.9049
Log likelihood = -79.2750

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
C	.031686	.060183	.526490	[.600]
DPALBAUR(-1)	-.402930	.105025	-3.83650	[.000]
DPALBAUR(-2)	-.385931	.108688	-3.55082	[.001]
DPALBAUR(-3)	-.183490	.111628	-1.64376	[.104]

ii. Alternate calculations of the price differentials

Price levelling and averaging model, alternate measure of beef farm price (nhsi)

```
Dependent variable: DMMBFAURI
 Current sample:  2000:3 to 2024:2
 Number of observations:  96

        Mean of dep. var. = .028919
   Std. dev. of dep. var. = .384620
 Sum of squared residuals = 8.26066
    Variance of residuals = .097184
 Std. error of regression = .311744
                R-squared = .412203
       Adjusted R-squared = .343051
             LM het. test = .741904 [.389]
          Durbin-Watson = 2.18899 [.415,.982]
             Durbin's h = -3.47956 [.001]
         Durbin's h alt. = -2.34995 [.019]
          Jarque-Bera test = 15.9675 [.000]
          Ramsey's RESET2 = .233074 [.631]
          F (zero slopes) = 5.96078 [.000]
           Schwarz B.I.C. = 43.5855
           Log likelihood = -18.4816

                Estimated    Standard
Variable       Coefficient     Error       t-statistic   P-value
C              .032849       .216019       .152065       [.879]
DUMQ1          .118450       .100040       1.18403       [.240]
DUMQ2          .121754       .136705       .890637       [.376]
DUMQ3          -.232211      .110844       -2.09493      [.039]
DNHSIR         -.613631      .243519       -2.51985      [.014]
DNHSIR(-1)     .638668       .223735       2.85457       [.005]
DMMLBAURI      .166758       .064029       2.60443       [.011]
DCOST          2.61469       6.28385       .416097       [.678]
DPDBFAU        -.184224E-05  .134703E-05   -1.36763      [.175]
TIME           -.877889E-04  .117518E-02   -.074703      [.941]
DMMBFAURI(-1)  .278022       .094937       2.92850       [.004]
```

Price levelling and averaging model, alternate measure of lamb farm price (nmli)

```
Dependent variable: DMMLBAURI
Current sample:  2000:3 to 2024:2
Number of observations:  96

       Mean of dep. var. = -.459585E-02
  Std. dev. of dep. var. = .620574
Sum of squared residuals = 11.1227
   Variance of residuals = .130855
Std. error of regression = .361739
               R-squared = .695982
      Adjusted R-squared = .660215
            LM het. test = 30.1221 [.000]
         Durbin-Watson = 2.13546 [.315,.967]
            Durbin's h = -2.47035 [.013]
        Durbin's h alt. = -1.20716 [.227]
         Jarque-Bera test = 15.4444 [.000]
         Ramsey's RESET2 = 15.4658 [.000]
         F (zero slopes) = 19.4589 [.000]
          Schwarz B.I.C. = 57.8647
          Log likelihood = -32.7608

               Estimated    Standard
Variable      Coefficient     Error       t-statistic   P-value
C             .234289       .249369       .939530       [.350]
DUMQ1         .224142       .125946       1.77967       [.079]
DUMQ2         .234598       .121956       1.92363       [.058]
DUMQ3         .156951       .130213       1.20535       [.231]
DNMLIR        -.910228      .094689       -9.61282      [.000]
DNMLIR(-1)    .245002       .119630       2.04801       [.044]
DMMBFAURI     .502484       .112069       4.48370       [.000]
DCOST         5.46271       7.13846       .765251       [.446]
DPDLBAU       -.719578E-05  .490815E-05   -1.46609      [.146]
TIME          -.228027E-02  .140544E-02   -1.62246      [.108]
DMMLBAURI(-1) .039334       .098167       .400685       [.690]
```

iii. Using variables in levels rather than in differences

```
Dependent variable: MMBFAURA
 Current sample:  2000:2 to 2024:2
 Number of observations:  97

        Mean of dep. var. = 14.9708
   Std. dev. of dep. var. = 1.14641
 Sum of squared residuals = 9.10598
    Variance of residuals = .105884
 Std. error of regression = .325397
                R-squared = .927827
       Adjusted R-squared = .919435
             LM het. test = .361713 [.548]
            Durbin-Watson = 1.49986 [.000,.083]
               Durbin's h = 2.82513 [.005]
         Durbin's h alt. = 2.60388 [.009]
          Jarque-Bera test = .665363 [.717]
           Ramsey's RESET2 = 1.30809 [.256]
           F (zero slopes) = 110.558 [.000]
            Schwarz B.I.C. = 48.0576
            Log likelihood = -22.8967

                Estimated    Standard
 Variable      Coefficient     Error       t-statistic   P-value
 C             -.111752      2.08233       -.053667      [.957]
 DUMQ1          .088936       .098575       .902212      [.369]
 DUMQ2          .022946       .096431       .237955      [.812]
 DUMQ3         -.206323       .097765      -2.11039      [.038]
 PABFAUR       -.462894       .148771      -3.11146      [.003]
 PABFAUR(-1)    .722017       .153008       4.71882      [.000]
 MMLBAURA       .058887       .047178       1.24818      [.215]
 COST          -.171403      2.26732       -.075597      [.940]
 PDBFAU         .260333E-05   .123490E-05   2.10813      [.038]
 TIME          -.491915E-02   .483781E-02  -1.01681      [.312]
 MMBFAURA(-1)   .909545       .051661       17.6060      [.000]


                                    Equation  18
                                    ============

                        Method of estimation = Ordinary Least Squares


 Dependent variable: MMLBAURA
 Current sample:  2000:2 to 2024:2
 Number of observations:  97

        Mean of dep. var. = 8.39121
   Std. dev. of dep. var. = .925782
 Sum of squared residuals = 9.22325
    Variance of residuals = .107247
 Std. error of regression = .327486
                R-squared = .887903
       Adjusted R-squared = .874868
             LM het. test = .358519 [.549]
            Durbin-Watson = 1.95799 [.087,.826]
               Durbin's h = .216109 [.829]
         Durbin's h alt. = .214736 [.830]
          Jarque-Bera test = 5.05437 [.080]
           Ramsey's RESET2 = 1.88975 [.173]
           F (zero slopes) = 68.1190 [.000]
            Schwarz B.I.C. = 48.6783
```