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Re-examining Market Power in the Domestic Fresh Meat Market

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Abstract

Since previous tests for market power in the Australian domestic fresh meat market more than a decade ago, a number of major changes have occurred which warrant another assessment. Firstly, there has been considerable structural change with concerns of market power arising from consolidation in the processing sector. Secondly, competition has increased in the primary sales channel for fresh meat with the addition of new retail entrants. Thirdly, the Australian Competition and Consumer Commission and other government bodies have continued to express their interest in agricultural competitiveness in the form of numerous reviews and legal proceedings. Using the New Empirical Industrial Organisation framework, this study re-assesses the question of whether there is any market power present in the domestic fresh beef, lamb and pork markets within Australia, using data covering the period 1970-2017. Overall, the study concludes that there is consistent evidence of market power in the fresh pork input market. However, there is no evidence of market power in either the input or output markets of beef and lamb, or the pork output market. Some areas for further research are suggested.

Key words: market power, meat industry, NEIO, monopsony, monopoly

Introduction

Consumers and primary producers continue to voice frustrations about possible market power in the beef, lamb and pork industries (Twomey, 2015). These frustrations are voiced in three key contexts: processing facility ownership; conduct in the fresh meat retailing sector; and competition policy limitations. The Australian beef, lamb and pork industries have undergone considerable structural changes in recent years, giving rise to market power concerns in the processing sector. Simultaneously, the retail sector has emerged from its previous duopoly status, with new market entrants challenging the status quo in terms of competitive environment and product mix. Finally, the Australian government through the Australian Competition and Consumer Commission (ACCC) has continued to review these industries, making a series of recommendations for increased competitive behaviour in retail, processing and primary forms.

In this context, market power refers to "the ability of a firm to set and maintain a price above (if selling) or below (if buying) the level that would prevail under perfect competition" (Bonanno, Russo and Menapace, 2018, p. 6). Empirical market power studies of these markets have been completed previously (Chung and Griffith, 2009; Griffith, 2000), neither finding evidence of market power in fresh meat value chains. However, given the recent changes in market structure mentioned above

and the continuing interest of the ACCC in these industries, it is timely to undertake an update of that earlier work. The overall aim is to update Australian fresh meat industry data (beef, lamb and pork) from previous research and to use the same empirical framework to identify the presence or absence of market power in these industries.

Structural Changes in Red Meat Supply Chains

Beef and lamb processing ownership changes

Since the data was last reviewed in 2007 (Chung and Griffith, 2009), there have been substantial ownership changes in the meat processing sector, primarily relating to the slaughter and further processing of beef and lamb. In 2007, JBS was the largest processor and held 15.7 per cent of the national kill share (Meat and Livestock Australia, 2007), however, large acquisitions including Swift (Australian Meat Holdings, 2007), Tasman Group (2008), Rockdale Beef (2010) and Primo Group (2015) had increased this to 23 per cent by 2017. Further entrenching this consolidation, in 2011 Australia's second largest processor, Teys, entered into a joint venture agreement with Cargill, one of the world's largest agribusinesses. Australia's top five processors account for approximately 57 per cent of the beef processing market, as identified by ACCC (2017). And, in terms of revenue from meat processing, JBS accounts for 22.4 per cent, followed by Teys 16 per cent (Thomson, 2019).

Industry and government have expressed their concerns about these structural changes in the meat processing sector. In 2017, the ACCC conducted a *Cattle and Beef Market Study* (ACCC, 2017), and the Senate concluded an *Inquiry on the Effect of Market Consolidation on the Red Meat Processing Sector* (The Senate, 2017). Meat and Livestock Australia (MLA), also recognising the concern by industry, soon after 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).

Restructuring of agricultural value chains can be due to multiple factors. Some have argued that the market power in the supermarket sector has played a role in the structuring of agricultural value chains themselves. Richards, Bjørkhaug, Lawrence and Hickman (2013) showed that the private standards of supermarkets have forced uniformity in agricultural suppliers through food safety, environmental management and animal welfare responses. There is little doubt the burden of these standards and scale of production requirements has influenced the size and number of suppliers in Australia. Burch, Dixon, and Lawrence (2013) noted that supermarkets are no longer simple distributors of food, instead they play a key role by setting standards through their own brands, as well as influencing food consumption through convenience offerings. Sexton (2013) supported the view that agricultural restructuring may be driven by businesses seeking higher volumes of quality inputs, required for economies of scale, rather than seeking the higher economic rent on offer from reduced competition. This same effect was observed by Herrmann et al. (2017).

Pork specific challenges

Unlike the red meat sector, the Australian fresh pork industry has some unique characteristics. Major vertically integrated businesses Sunpork, Rivalea and Food Investments (George Weston Foods) combine to generate almost 25 per cent of the Australian revenue in the pork value chain (Cloutman, 2019). They also heavily rely on contract growers to supply their product, meaning the total number of pigs processed through their facilities is much larger than their market revenue share. The top largest processors are responsible for the bulk of pork processing, with seven export accredited abattoirs responsible for slaughtering 85 per cent of Australian pigs (Australian Pork Limited, 2019a).

Unlike the red meat sector, structural changes in the pork industry have not faced heavy public and government scrutiny. Instead, the focus has been on their unequal footing in international export markets and the frustrations surrounding processed pork imports since approval was granted in 1990. The Australian Bureau of Agricultural and Resource Economics (ABARES) identified that pork imports have risen drastically in recent years, from 72.6 kilo tonnes in 2000, to 327 kilo tonnes in 2017 (ABARES, 2018). Imports now comprise 45 per cent of all pork consumed in Australia (Australian Pork Limited, 2019b). Whilst processed pork imports do not compete directly with Australian fresh pork, they reduce demand for domestic pork through substitution effects (Cloutman, 2019) and form the largest competitive concern faced by the Australian pork industry.

Retail structural changes and relationships with suppliers

Fresh meat is an important revenue stream for Australian supermarkets, typically accounting for an average of 13.8 per cent of supermarket revenue (Youl, 2018), with supermarkets being the primary channel for the domestic sale of fresh meat (Youl, 2018). Since 2007, the traditional growth of the supermarket oligopoly structure has expanded from Coles and Woolworths to include well-known German supermarket chain ALDI. There is speculation that this addition, as well as the prospect of other international retailers entering the market will continue to increase competition and reduce the overall influence of the current duopoly (Youl, 2018). From 2007 to 2017, ADLI grew their total market share to 9.9 per cent of the grocery sector (Youl, 2018). Although, it is noted that Coles and Woolworths still control more than 70 per cent of the sector (ACCC, 2016b). Importantly, market analysts have noted that strong competition has kept retail prices lower in recent years (Thomson, 2019; Umberger and Griffith, 2011). Whilst this clearly benefits the consumer, its implications throughout the value chain warrant further analysis (Sutton-Brady, Kamvounias and Taylor, 2015).

Previously, Australian grocery competition policy has been a strongly contested debate (Griffith, 2004; Smith, 2006). In the years prior to 2006, the ACCC continued to express interest in the grocery sector, in part due to public concern. At this time, Round (2006) stressed the importance in assessing the conduct of supermarkets, rather than their structure, and predicted the Australian retail climate was conducive to add another retailer. Fast-forward more than ten years and the competitive environment is further enhanced through the expansion of ALDI. Despite this expansion and increase in competition, concerns remain about the power of major supermarkets and their potential to influence their suppliers and to earn supernormal profits. Grimmer (2018) argued the conduct of Coles and Woolworths positioned suppliers as “diminished stakeholders” largely based on the ACCC cases of unconscionable conduct presented between 2011 and 2014. Sutton-Brady et al. (2015) also recognised this imbalance in power, noting that there is a general finding of power asymmetry across the grocery sector in Australia. This kind of power imbalance is beneficial to consumers through competitive lowering of prices, however it places risks on the long-term sustainability of domestic suppliers.

In addition to structural changes in the context of the Australian retail environment, the product mix of these supermarkets have also changed drastically; Australian supermarkets have heavily increased their dependence on own-brand products. ALDI has hinged their success through the development of their own brands. Coles and Woolworths have followed, expanding their current own-brand portfolio to an estimated 20 per cent (2018), midway to a targeted 40 per cent portfolio of own-brand products by 2023 (Youl, 2018). In a fruit and vegetable context, Hattersley, Isaacs and Burch (2013) highlighted the recent growth of own-brand products in Australia, noting the rise in food imports and that own brands are a key tool in supermarkets exercising market power which compete directly with traditional food suppliers. An extension of supermarkets dealing directly with farm suppliers is the opportunity for coercion or abuse of relative power imbalances. This poses the opportunity for supermarkets to influence suppliers directly, imposing their own terms (Richards et al., 2013). Whilst it is acknowledged that suppliers have the opportunity to reject these terms, the environment in Australia which includes just a few large retailers, can mean the producers feel as though they have limited options. Davey and Richards (2013) further recognised this unequal distribution of power, highlighting the influence of supermarkets through their role of enforcing standards.

Changes in Competition Policy

Over the past decade, Australia's competition policy agenda has altered the regulatory environment for agriculture. Following deregulation and the implementation of a free-trade agenda, Australian agricultural producers receive very little financially motivated market protections. They have responded by restructuring their industries, however competition policy continues to play a significant role in domestic power distribution.

At a broad sector level, the Australian Government has recently recognised the need to continue investing in agricultural competitiveness. In the *Agricultural Competitiveness White Paper* (Department of Agriculture, 2014a) a focus was placed on reduced regulation for agricultural operations, increased investment in the ACCC for agricultural investigations and increased access to premium markets through improved traceability and export biosecurity.

However, since the commencement of a deregulation agenda, government review or intervention has been required on multiple occasions at the industry level. Chung and Griffith (2009) recognised the significant interest of government bodies and the ACCC in the Australian meat industries (ACCC, 2002, 2004, 2007, 2008). Since then, such reviews have continued. The ACCC (2017) advised a list of 15 recommendations to increase competitiveness and transparency in the industry. The Senate decided that the structural changes to the red meat processing sector warranted an Inquiry to assess the effect of market consolidation (The Senate, 2017). The ACCC has also launched several cases against major retailers. In the period from 2011 to 2014, two separate unconscionable conduct cases were launched (ACCC, 2014; ACCC, 2015) against major meat retailers for their conduct towards suppliers.

Deregulation and trade agreements

Since 1995 Australia has sought to remove fresh meat tariffs and border protection measures, without compromising essential biosecurity protections (Department of Agriculture, 2014b). Australia has been strong in their implementation of deregulation and endorsement of free trade principles, including reducing import tariffs, encouraging privatisation, reducing government support programs and overall industry subsidies (Australian Pork Limited, 2017). In terms of free trade agreements for fresh meat, Australia has signed substantial free trade agreements with China, Japan, Korea and the Association of Southeast Asian Nations (ASEAN) as well as the Australia-New

Zealand Free Trade Agreement.

The global fairness of trade can be challenging for Australian meat producers and the competitiveness of Australian products in international markets has inherent consequences for domestic price (Griffith, 2000). Unfortunately, in the context of pork at least, the global implementation of a deregulation agenda has not always matched the public rhetoric "our (Australia's) trading partners have been playing a double game – loudly boosting free trade in public, while quietly maintaining a system of state support for domestic industry at the expense of outside competitors" (Australian Pork Limited, 2017, p. 3). In the pork context, only 8 per cent of total production is exported despite Australia having key free trade agreements with large pork markets throughout South-East Asia (Australian Pork Limited, 2017). Australia's inability to export pork successfully is largely due to price competitiveness of other pork producing nations, Canada, Denmark, the United States and Brazil, which receive subsidies of up to 79 per cent (AgriFutures, 2017). These countries also continue to demonstrate the need for government intervention in their policies (Russo, Sexton and Goodhue, 2011) and vocalise their desire for support.

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. Most 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 the importing nation. To extend this to Australian pork, although there are no fresh pork imports in Australia, the strength of large pork exporters into processed markets has the potential to influence the domestic pork market in a negative manner. The influence on the fresh pork market occurs through the end user. Cheap processed pork is able to substitute for fresh pork in numerous manufacturing contexts (Cloutman, 2019).

Competition law and industry codes

As previously mentioned, direct supermarket interactions with suppliers presents opportunities for misconduct (Hattersley et al., 2013; Sexton, 2013). In an agricultural context, supplier relationships with Australian supermarkets have increasingly relied on voluntary codes of conduct. However, in an extensive review of Australian and United Kingdom supermarket relationships with suppliers, Taylor (2013) has argued the need for mandatory codes of conduct is well founded. In particular, he noted the Australian market context is incapable of fairly sharing profits between the supermarkets and consumers without government intervention. Empirical research has shown the current low-price environment is highly beneficial to consumers (Umberger and Griffith, 2011), however, poses considerable challenges for producers, particularly smaller producers with lower economies of scale. Importantly, Taylor (2013) also challenged the long-term sustainability of the current environment for suppliers, recognising that limited margins are challenging over the longer term; this sentiment could also be extended to the increasing environmental and global price volatility challenging agriculture. Such volatility is already pressuring primary agricultural producers (Department of Agriculture, 2014a).

Irrespective of whether supermarkets possess and use market power, a common solution to the prospect of misuse of market power is the introduction of an Industry Code of Conduct. In 2015, the Food and Grocery Code of Conduct was introduced, prescribing transparency and behavioural conduct procedures for supermarket interaction with food and grocery suppliers. Beaton-Wells and

Paul-Taylor (2018) conducted a review of the Food and Grocery Code of Conduct, recognising the preliminary transparency benefits of the code and raised concerns over the efficacy of the dispute resolution process. In 2018, a review of the effectiveness of the code indicated that overall the code has drastically increased equity in relationships with suppliers and transparency throughout the supply chain (Department of Treasury, 2018). However, it is noted the current code is voluntary, not mandatory, and although breach of the code for participating retailers will attract the mandate of the *Competition and Consumer Act 2010* (Cth), only signatories to the code are bound, with some market participants commenting this creates inequality throughout the retail sector (Department of Treasury, 2018).

In the context of supplier relationships with processors, increasing concentration in the processing sector, combined with the regional nature of these relationships, poses risks for suppliers. Unlike market power risks in a supermarket context, the processing sector lacks an Industry Code of Conduct for their relationships with suppliers. In a pork context, industry vertical integration reduced these risks for a large part of the industry. However, in a red meat context, direct supply agreements with the processors, a common sales channel, highlights this risk, with past processing failures highlighting the need for an Industry Code of Conduct (Twomey, 2015). These risks became a reality for dairy farmers in 2016 with the 'dairy crisis' (Victorian Farmers Federation, 2016). Since then, the industry has sought to resolve the perceived imbalance in bargaining power with a Mandatory Code of Conduct (ACCC, 2018).

Approaches to Measuring Market Power

As markets become more complex, there are opportunities to rely on new market power frameworks. Bonanno et al. (2018) completed a thorough review of modern approaches to market power assessment, noting that as the dimensions of agricultural relationships change, including expansion of vertical relationships and non-traditional procurement schemes, agricultural economists will need to consider new market power assessments. Until now, market power models have typically included methods such as the Structure-Conduct Performance (SCP) paradigm and the NEIO framework (Bonanno et al., 2018). In departing from the commonly applied NEIO framework, Bonanno et al. (2018) rely heavily on the research of Mérel and Sexton (2017) which attempted to show that monopsony behaviour can support market access and an overall market surplus. However, accounting for differentiated products within the market, as well as the uniqueness of contracts in place, is inherently complex. McCorriston (2014) agrees with the structural premises proposed by Bonanno et al. (2018), 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 is a similar proposition to the limitations recognised in industry texts (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 limited examples in Australian fresh meat, however, there are numerous international case studies of successful market power assessments (Ahn and Nayga, 2016; Umar Muazu, Abidin Mohamed, Shamsuddin and Abdulatif, 2016).

New Empirical Industrial Organisation (NEIO) framework

For the purpose of consistency with previous research (Chung and Griffith, 2009; Griffith, 2000) this study uses the NEIO framework applied by O'Donnell (1999) to assess market power. The NEIO framework has been applied in numerous scenarios similar to this present study (Chung and Griffith, 2009; Griffith, 2000; Hyde and Perloff, 1996; Sexton, 2013) to assess the economic competitiveness in agricultural or food sectors.

Access to data has limited Australian empirical research into fresh meat market power. Hyde and Perloff (1996) estimated market power in Australian retail fresh meat markets, finding Australian retail in this context is competitive and that market power has not been increasing over time. Griffith (2000) found markets were competitive for beef, lamb and pork. Similarly, Chung and Griffith (2009) updated the earlier datasets and modelling and found a similar outcome. More detailed empirical research into market power in fresh agricultural products is very limited. Freebairn (2018) used a long run static equilibrium model and showed there is limited opportunity for monopsony behaviour, largely due to the elasticity of the farm input supply curve.

As mentioned, some researchers have expressed concern about the NEIO Framework, including the frequency of positive market power outcomes in NEIO-based studies (Sheldon, 2017). Sheldon (2017) pointed out that Sexton (2013) tackled this limitation, highlighting the success of the framework, relying on the premise that whilst a deadweight loss itself may be limited, the consequences to the underlying markets of this deadweight loss can be substantial. This is noteworthy given the low margin, economy of scale driven environment, on which many agricultural enterprises depend. Industry benchmark texts (Kaiser and Suzuki, 2017; Perloff et al., 2007) have further highlighted NEIO limitations, particularly regarding its ability to include horizontal and vertical competition in bilateral oligopoly structures. Lastly, it is worth noting that whilst the NEIO framework, can be successful in identifying market power, it fails to identify the source of market power, forcing authors to speculate (Digal and Ahmadi–Esfahani, 2002).

Method

Applying the NEIO framework

The NEIO framework (Chung and Griffith, 2009) is an approach based on real marketing margins. In equation 1, the contributors to the marketing margin can be broken down into the following key components (O'Donnell, 1999): the marketing services cost, referring to the cost of transitioning the product from raw commodity into saleable retail product; any financial benefits from non-competitive behaviour in the output market; and any financial benefits from non-competitive behaviour in the input market.

The equation for this model as presented by Chung and Griffith (2009, p.222) 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;
m_j = industry marketing margin, $p_j – w_j$;
p_j = price of the food output j;
w_j = price of the agricultural input j;
a_j = constant term;
c_{jk} = coefficient of the price of non-agricultural inputs (marketing services) k that contributes to food output j;
z_k = price of non-agricultural inputs k (and trend, seasonal and dummy variables where required);
q_j = quantity of the food output j;
β_j = coefficient of a term which includes the output conjectural elasticity;
γ_{jm} = coefficient of a term which includes the input conjectural elasticity;
x_m = quantity of agricultural input m.

This equation therefore measures the factors explaining variation in the industry marketing margin,

mj. The terms βj (output conjectural coefficient) and γjm (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, as well as cjk, must be non-negative if market power is present[1]. Restrictions may be necessary to constrain the signs of these coefficients to be non-negative. All prices and costs are defined in real terms.

The null hypothesis tested is that there is no market power present in the domestic beef, pork or lamb industries in Australia, between the period 1970 to 2017. This means that the βj and γjm terms must not be significantly positively different from zero.

Data

In these tests annual data are mostly used as the underlying models are set up to reflect medium to longer term equilibrium conditions. The data required falls into two categories, meat data and general data. Meat data includes the saleyard price reflecting the farmgate return (for each meat category), retail price, domestic consumption as representative of throughput in the domestic value chain and CPI for food to account for inflation over the period 1970–2017. General data is used to account for the cost of marketing services in identifying real marketing margins. The sources for both sets of data are outlined in Table 1. Variable definitions are given in Appendix Table 1.

Three individual inputs (wages, interest rate and electricity) 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. Thus, they developed an index for these costs, as originally recommended by Zhao, Griffith, and Mullen (1998). For consistency, this paper has also used the same indexing calculations. The aggregate index is formed from: (0.75*Wage) + (0.1*Electricity) + (0.15*Interest), with a base of 1990.

Table 1. Sources of data required for estimating equation (1)

Meat Data	General Data
Retail Price (1970–2017) (ABARES, 2018)	Interest Rates (ABARES, 2018)
Saleyard Price (1970 – 2017) (ABARES, 2018)	Wage Price Index (ABS, 2019b)
Domestic Demand (ABARES, 2018)	Electricity Cost Index (ABS, 2019a)
CPI Food (1970 – 2017) (ABS, 2019a)	CPI Food (1970 – 2017) (ABS, 2019a)

[1] The coefficients Bj and γjm are respectively products of the slope of the product demand curves and the output market conjectural elasticity, and of the slope of the input supply curves and the input market conjectural elasticity. Given the assumed signs of the slopes and the conjectural elasticities, both Bj and γjm need to be non-negative. See the derivation in O'Donnell (1999, pp.4-8).

In addition, a number of dummy variables were constructed to reflect the previous discussion about changes in industry structure and in the policy environment. 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. Similarly, Dum90 represents the period after which imports of pig meat for further processing were allowed and formed a significant part of the domestic pig meat industry; 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. Although not discussed above but 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 until 1978. A considerable quantity of beef exports destined for Japan had to be redirected to the domestic market with consequent reduction in prices (ABARE, 1988). Dum75 takes the value one from 1975 to 1978 inclusive, and zero otherwise.

Dum95 and Dum07 apply to all three meat types, Dum90 applies only to pig meat, Dum75 applies only to beef and Dum11 applies only to beef and lamb.

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

Estimation techniques

A number of linear and non-linear single equation models and seemingly unrelated regressions (SUR) 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 a 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. It 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 inter-related. 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.

Results

Summary statistics

Summary statistics for the calculated real marketing margins are given in Table 2. The average real margins for lamb and pork are similar at around 450c/kg, while the average real margin for beef is considerably higher at around 730c/kg. All the margins are relatively stable as shown by the coefficient of variation, however the margin for beef is the most stable and the margin for lamb is the least stable.

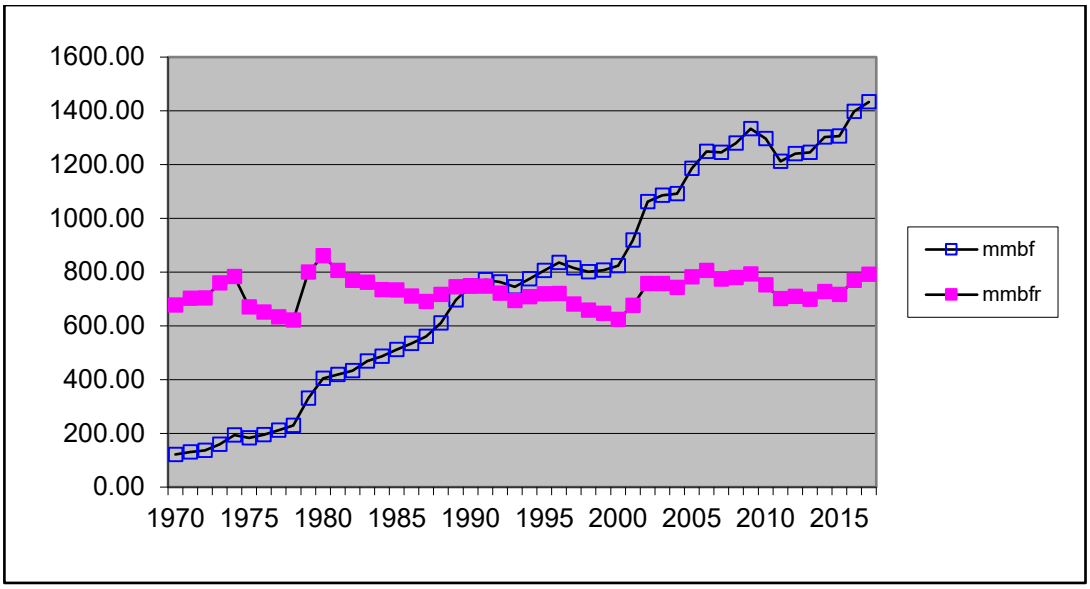
Table 2. Summary of real marketing margins from 1970 – 2017 (real 1990 cents per kg of retail product)

	Mean	SD	Minimum	Maximum	Coefficient of Variation (CV)
Beef	728.7	52.5	621.5	860.2	0.072
Lamb	441.3	52.7	358.8	550.3	0.119
Pork	458.7	42.2	382.7	560.5	0.092

Trends

The real and nominal margins over the data period for beef, lamb and pork are plotted in Figures 1-3 respectively. The nominal margins have followed a rising linear trend for each meat, reflecting the more rapid increase in the price of meat relative to the price of livestock. However, the nominal assessment takes no account for inflation. Real margins have been calculated by adjusting the nominal margins by the food CPI (ABS, 2019a). When comparing the nominal and real marketing margins, real margins have not risen, instead showing a flat trend and in some instances the real margin has actually declined. For example, the marketing margin for beef in Figure 1 was lower in 2017 than it was in 1980, in terms of 1990 monetary values. Similar patterns are evident for lamb and pork.

Figure 1. Nominal and real beef marketing margins, 1970-2017 (real 1990 cents per kg of retail product)



These patterns suggest that the actors in the fresh meat value chains are not increasing their profits. 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 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 margins. However, it is anticipated that this variation can be attributed to commodity price variability driven by international trade or seasonal conditions, rather than market power occurring in those years. The structural nature of market power is typically defined by longer terms than year to year fluctuations.

Figure 2. Nominal and real lamb marketing margins, 1970-2017
(real 1990 cents per kg of retail product)

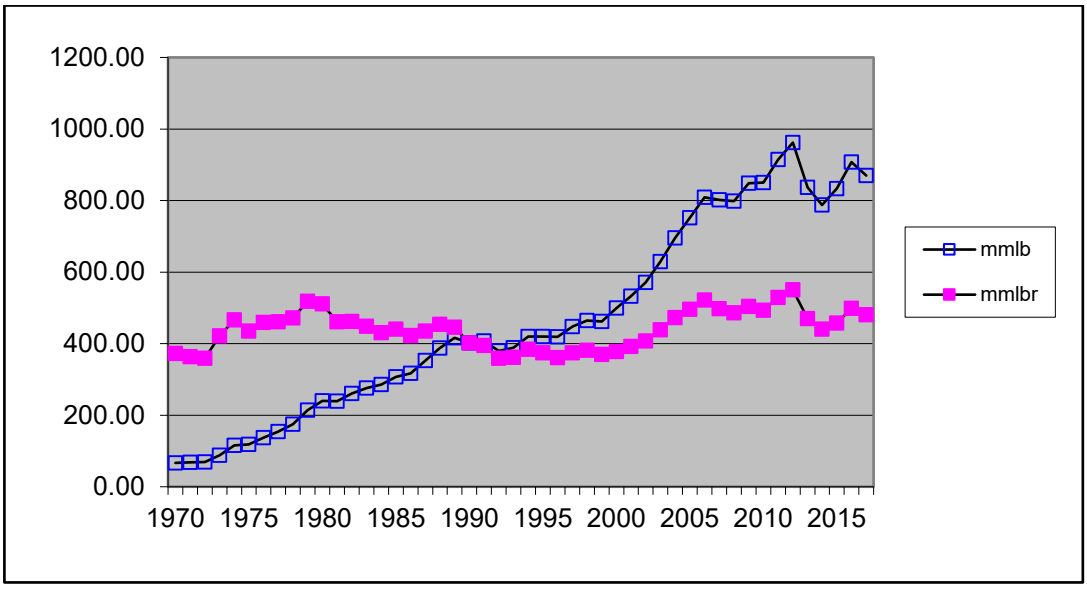
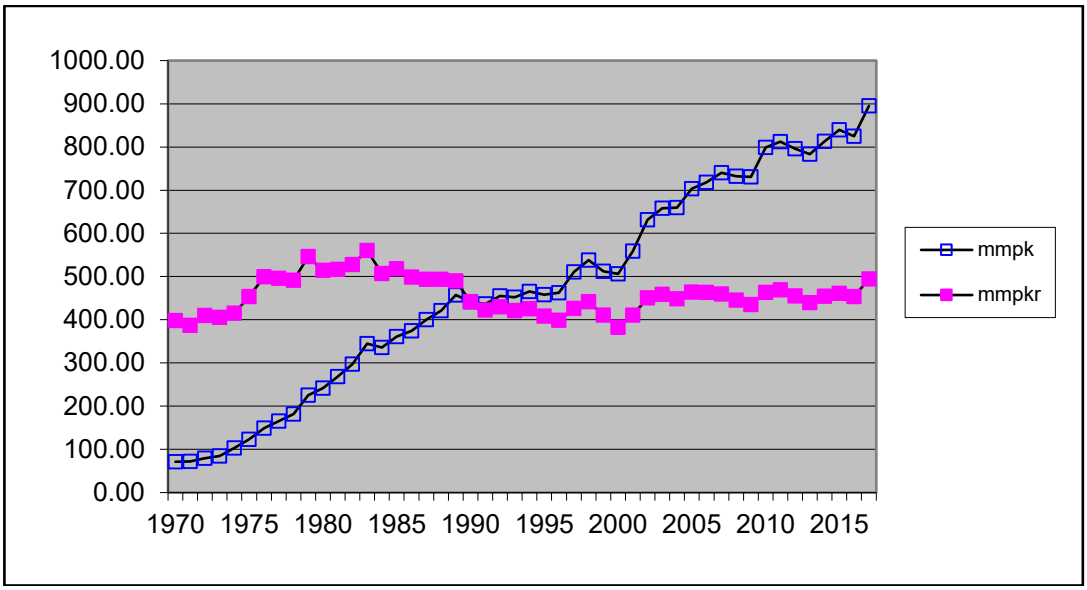


Figure 3. Nominal and real pork marketing margins, 1970-2017
(real 1990 cents per kg of retail product)



Unit root tests

Even though real prices and costs are used, and the graphs do not suggest strong trends, it is necessary to test for stationarity before proceeding further. Most of 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. High R^2 values together with low Durbin-Watson statistics are common indicators of non-stationarity.

The stationarity of a time series can be tested by using a unit root test. Here we use the augmented Dickey-Fuller test 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 are shown in Table 3.

Table 3. Unit root tests, 1970-2017

Variable	Tau statistic	P value	Optimal lag length
MMBFR	-4.739	0.0006	3
MMLBR	-3.542	0.035	2
MMPKR	-3.383	0.054	2
DMBF	-4.969	0.0002	3
DMLB	-4.035	0.008	3
DMPK	-4.875	0.0003	2
DMBFI	-4.833	0.0004	3
DMLBI	-3.229	0.079	2
DMPKI	-4.622	0.0009	2
COSTIND	-5.565	0.0000	3

Given these unit root test results, the analysis can proceed with the variables as defined without the need for further transformation.

The range of results

There are many possible equations: three 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 Table 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 Table 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 as is the adjusted R^2. This is confirmed by the highly significant t statistic on the estimated rho coefficient in the AR1 versions. While not shown, this pattern was the same for every estimated pair of equations (across the three 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.

The next task is to test whether or not the various dummy variables constructed to reflect different policy regimes and industry adjustments should be included in the margin equations or not. Some of the key alternate specifications for the dummy variables are reported in Appendix Tables 3, 4 and 5. For beef (Appendix Table 3), DUM75 was always significant, DUM11 was mostly significant and the time trend variable was also always significant, and all 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 Table 4), none of the dummy variables proved significant, so the preferred lamb margin equation was the same as that reported by Chung and Griffith (2009). Finally for pork (Appendix Table 5), DUM95 and DUM07 were consistently insignificant, while DUM90 was always significant and TIME was mostly significant. The preferred

pork equation therefore contained TIME and DUM90.

Preferred unrestricted models

The preferred unrestricted equations for the beef, lamb and pork margins, respectively, are shown in Tables 4, 5 and 6, for each of the three estimation techniques. The key components of each equation are R^2, Durbin Watson (DW) and the t-statistics. A coefficient is significant at the 5 per cent level where the t-statistic is greater than 2.01 (using a two tailed test, for 47 degrees of freedom), while at the 10 per cent level the critical value is 1.67.

For beef (Table 4), all three equations show a similar pattern. The cost index is positive and significant, the trend variable is positive and mostly significant, and both the included dummy variables are negative and significant. The coefficient on the DMBF variable is uniformly significant but always negative, while the coefficient on the DMBFI variable is always positive but only significant when estimated using the SUR technique.

For lamb, the results are similar to those for beef. The cost index is again positive and significant, and the trend variable is positive and mostly significant. However the coefficients on the DMLB and DMLBI variables are uniformly insignificant.

For pork, the results are quite different. Neither the cost index nor the trend variable shows any significance, but the DUM90 variable is consistently negative and significant. In this case the DMPK variable is negative and mostly significant, while the DMPKI variable is positive and significant under all three estimation methods.

Preferred restricted models

The preferred unrestricted equations typically demonstrated a combination of low t-statistics or negative coefficients on the input and output conjectural coefficients. The same equations were also tested with a non-negative restriction on the input and output conjectural coefficients βj and γjm. The restricted models for both LSQ and SUR techniques are shown in Tables 7, 8 and 9, where the restriction may be placed on just one coefficient if it is typically negative when unrestricted, or both.

Every beef and lamb restricted regression with autocorrelation correction and imposed non-negativity showed input and output conjectural coefficients of zero. These are corner solutions. The unrestricted results indicate that many of these relationships are negative, so by restricting the coefficients to be non-negative the procedure finds the smallest possible non-negative number, zero. The explanatory power of the beef equations in particular is also severely compromised. The cost index is still positive and marginally significant, but each of the other variables has lost a substantial degree of influence on MMBF. Additionally the R^2 value has been reduced. The lamb equations are less effected.

For pork, corner solutions are again evident for the coefficients on the DMPK variable, but three of the four coefficients on the DMPKI variable remain positive and significant.

These results indicate that the null hypothesis of no market power cannot be rejected in beef, lamb or pork output markets, or beef or lamb input markets. These findings confirm the earlier results of both Chung and Griffith (2009) and Griffith (2000).

However, there is now a strong indication of market power in the fresh pork input market. This finding is quite different from that of the earlier studies.

Table 4. Preferred unrestricted regression estimates for real beef margin equations 1970 – 2017 (t-statistics are in brackets)

Constant	COSTIND	DMBF	DMBFi	TIME	DUM75	DUM11	RHO	R^2	DW	Method
672.33	1.207	-0.240	8.316	3.488	-118.01	-59.65	0.824	0.69	1.42	OLS-AR1
(7.68)	(2.60)	(-1.76)	(1.01)	(2.09)	(-3.37)	(-2.11)	(8.13)			
752.19	1.539	-0.327	7.791	1.938	-99.34	-52.75	0.753	0.72	1.38	LSQ-AR1
(7.29)	(3.09)	(-2.18)	(0.93)	(1.15)	(-2.62)	(-1.76)	(7.93)			
705.38	1.619	-0.329	**14.094**	2.643	-104.22	-68.66	0.721	0.75	1.31	SUR-AR1
(8.26)	(3.65)	(-2.83)	**(2.20)**	(1.92)	(-3.59)	(-3.07)	(8.94)			

Table 5. Preferred unrestricted regression estimates for real lamb margin equations 1970 – 2017 (t-statistics are in brackets)

Constant	COSTIND	DMLB	DMLBi	TIME	RHO	R^2	DW	Method
272.62	1.100	-0.094	4.765	3.190	0.795	0.74	1.61	OLS-AR1
(2.95)	(2.57)	(-0.40)	(0.32)	(2.54)	(8.60)			
306.72	1.113	-0.098	3.362	2.064	0.760	0.76	1.70	LSQ-AR1
(2.88)	(2.65)	(-0.40)	(0.21)	(1.36)	(7.56)			
281.97	1.204	-0.117	9.734	2.442	0.720	0.78	1.56	SUR-AR1
(3.09)	(3.08)	(-0.56)	(0.72)	(1.96)	(8.37)			

Table 6. Preferred unrestricted regression estimates for real pork margin equations 1970 – 2017 (t-statistics are in brackets)

Constant	COSTIND	DMPK	DMPKi	TIME	DUM90	RHO	R^2	DW	Method
526.32	-0.369	-0.433	**44.37**	3.547	-76.36	0.867	0.77	2.04	OLS-AR1
(9.73)	(-1.26)	(-2.39)	**(3.55)**	(1.66)	(-3.58)	(10.61)			
549.34	-0.230	-0.265	**41.80**	0.371	-79.06	0.754	0.78	2.10	LSQ-AR1
(11.08)	(-0.75)	(-1.32)	**(3.06)**	(0.15)	(-3.60)	(7.99)			
548.78	-0.172	-0.391	**45.11**	1.727	-79.93	0.743	0.75	1.31	SUR-AR1
(12.19)	(-0.62)	(-2.39)	**(4.02)**	(0.85)	(-4.54)	(9.15)			

Table 7. Restricted regression estimates for real beef margin equations 1970 – 2017 (t-statistics are in brackets)

Constant	COSTIND	DMBF	DMBFi	TIME	DUM75	DUM11	RHO	R^2	DW	Method
591.01	1.115	0.000	0.000	1.958	-133.01	-43.80	0.703	0.68	1.53	LSQ-AR1 (a)
(7.50)	(2.39)	(0.00)	(0.00)	(1.24)	(-5.69)	(-1.43)	(5.99)			
590.94	1.185	0.000	-3.815	2.165	-116.88	-41.82	0.680	0.68	1.53	LSQ-AR1 (b)
(7.56)	(2.56)	(0.00)	(-0.51)	(1.40)	(-3.05)	(-4.51)	(5.69)			
565.66	1.209	0.000	0.000	2.612	-119.39	-61.57	0.687	0.73	1.51	SUR-AR1 (a)
(8.10)	(2.86)	(0.00)	(0.00)	(1.93)	-6.34)	(-2.52)	(6.82)			
564.61	1.197	0.000	0.959	2.581	-123.03	-61.17	0.692	0.73	1.51	SUR-AR1 (b)
(7.93)	(2.80)	(0.00)	(0.16)	(1.86)	(-3.97)	(-2.45)	(6.87)			

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

Table 8. Restricted regression estimates for real lamb margin equations 1970 – 2017 (t-statistics are in brackets)

Constant	Costind	DMLB	DMLBi	TIME	RHO	R^2	DW	Method
276.70	1.152	0.000	0.000	2.212	0.768	0.76	1.66	LSQ-AR1
(3.92)	(2.89)	(0.00)	(0.00)	(1.54)	(7.97)			
259.90	1.226	0.000	0.000	2.505	0.717	0.78	1.58	SUR-AR1
(4.30)	(3.36)	(0.00)	(0.00)	(2.20)	(8.34)			

Table 9. Restricted regression estimates for real pork margin equations 1970 – 2017 (t-statistics are in brackets)

Constant	COSTIND	DMPK	DMPKi	TIME	DUM90	RHO	R^2	DW	Method
518.67	-0.266	0.000	0.000	0.819	-75.95	0.687	0.73	2.00	LSQ-AR1
(10.27)	(-0.80)	(0.000)	(0.000)	(0.77)	(-3.25)	(6.36)			
536.01	-0.286	0.000	**31.11**	-2.133	-72.15	0.729	0.78	2.14	LSQ-AR1
(11.07)	(-0.91)	(0.00)	**(2.72)**	(-1.47)	(-3.38)	(7.88)			
531.87	-0.255	0.000	**5.638**	-2.285	-66.778	0.720	0.81	2.10	SUR-AR1
(12.06)	(-0.89)	(0.00)	**(6.57)**	(-1.82)	(-3.72)	(9.20)			(a)
532.03	-0.255	0.000	**31.835**	-2.294	-66.67	0.721	0.81	2.10	SUR-AR1
(12.06)	(-0.89)	(0.00)	**(3.29)**	(-1.82)	(-3.71)	(9.20)			(b)

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

Discussion and Conclusions

The new results from the present study show evidence of market power in fresh pork input markets (Table 9) when the Dum90 variable is included to account for the change of government regulation allowing processed pork inputs in 1990. Australian pork producers have been assertive in their claims that pork imports are a significant competitive challenge for the domestic industry. Whilst biosecurity concerns prevent fresh pork imports, the influence of processed pork imports on the Australian fresh market occurs through the influence of substitution effects.

The Australian pork industry is truly deregulated, receiving limited government subsidy for the production of domestic fresh pork. Some of the world's largest pork producers (many of which export processed pork into Australia) receive significant subsidies for the production of pork, whilst Australia receives only matched government funding for research and development. In 2014, Australian Pork Limited quantified the subsidies of competing pork industries. They found substantial subsidies, led by Brazil US$3.56/kg, United States US$2.42/kg, Canada US$1.11/kg and Denmark US$0.67/kg (Australian Pork Limited, 2017). Three of these countries have contributed to the growth in imported pork consumption, now comprising a total of 45 per cent of all domestic pork consumption (Australian Pork Limited, 2019a). It seems reasonable to suggest that this may be a contributing factor to the market power present within the fresh Australian pork input market.

However, as discussed earlier, a major limitation of the NEIO framework is its inability to identify the source of market power. In the fresh pork market, the role of processed pork imports in the domestic fresh pork market has been highlighted. Evenso, there is the possibility that market power in the fresh pork market derives from other sources. Unlike the beef and lamb industries, pork is almost wholly intensive, relying on large economies of scale. It also has limited export markets as well as a high dependence on grain, labour and energy. These influences have been highlighted in previous ACCC reports into the pig meat industry.

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 margins for beef and lamb shown in Figures 1 and 2 indicate a reasonably flat and consistent trend for each meat, and in some cases, the real marketing margins had declined. The consistency of real marketing margins over time, despite the significant structural changes to these industries, suggests an absence of market power. In the past, researchers have commented that the rise in nominal marketing margins have not directly correlated with a rise in farmgate prices (Griffith, 2004) and at times, the poor correlation between farmgate prices and rising food prices at the supermarket shelf has contributed to the perception of market power (ACCC, 2007). However, as this real marketing margin approach demonstrates, this perception is not always accurate.

Recommendations in ACCC (2017) noted that the circumstances for the exertion of market power through processing consolidation are limited. Recent mergers such as the JBS acquisition of Primo Foods, have passed ACCC assessment and are not proving to be anti-competitive. Instead the study noted that abattoirs purchase their cattle within a 400 km radius and that purchasers are typically regional, as opposed to national or state (ACCC, 2017, p. 4). In this sense, future processing consolidation in some specific 400 km radiuses would drastically decrease competition and will be closely assessed by the ACCC before receiving approval.

During the same timeframe, The Senate (2017) recognised market power and consolidation as key pillars of their process, however, again the spread of interest was somewhat narrow with the focus of market power highlighted through buyer collusion, initially promoted from the Barnawartha saleyard concern in 2015. The Senate sought to understand "the impact of the red-meat processor

consolidation on market competition, creation of regional monopolies and returns to farm gate" (The Senate, 2017, p1). However, recommendations centred on components of price transparency and the role of industry bodies in the value chain, rather than seeking to empirically understand the potential sources of market power.

The last component of government interest has addressed the influence of supermarket interactions with suppliers. Legal cases launched in 2014 and 2015 (ACCC, 2014; ACCC, 2015) demonstrated the risk of unconscionable conduct from supermarkets in their interactions with suppliers. These cases have not explicitly focussed on fresh meat and it is noteworthy to recognise the narrowness of these claims. Whilst they are demonstrative of the risk involved in supply agreements with large supermarkets, cases of unconscionable conduct have been confined to a specific set of circumstances in each respective year and are not necessarily reflective of widespread unconscionable conduct.

Information required to assess market power at the individual business level is unavailable. The ACCC (2017) and The Senate (2017) noted that the absence of industry margins and operating costs of key industry participants, including fresh meat retailing, made it difficult to conduct a true market power assessment. The absence of detailed information also impacts the present study's assessment of market power. The data utilised in this model is relatively high-level. That is, relying on overall average retail prices of end products and the average farmgate price (Table 1). Whilst, the marketing services cost recognises the cost of transforming the raw commodity into the retail product, specific margins throughout the value chain are unknown. Throughout the recent reports (ACCC, 2017; The Senate, 2017), stakeholders highlighted the potential margin benefit processors could garner through market consolidation. While in this study the null hypothesis of a competitive market for beef and lamb could not be rejected in aggregate, no comment can be made about the null hypothesis in relation to specific regions or specific parts of the value chain. Future studies should consider region specific assessment of market power as well as examination of market power at different levels of the value chain.

Further, Australia operates in a trade focused environment. In a red meat context, Australian exports 61 per cent of total lamb production, 71 per cent of total beef production (Meat and Livestock Australia, 2018) and 8 per cent of total pork production (Australian Pork Limited, 2017). In addition, a significant share of processed pigmeat consumed in Australia is imported. The model in the present study takes no account for trade activity, relying solely on domestic demand data. The significance of this export orientation has potential implications for domestic price and the corresponding competitive environment (Ahn and Nayga, 2016). The biosecurity driven import restrictions on fresh beef, lamb and pork helps shelter domestic price from imports. Further work is required to investigate the extent to which export market specifications differ from domestic market specifications (for example, due to breed differences, the ability to finish animals on grass or grain, and the nature of quality assurance schemes such as MSA), and the implications for price transmission processes and the ability to separate market outlets. The exploratory study by Zhao et al. (1998) in a beef context may be worth revisiting.

Finally, despite a lack of evidence of market power in the present study, the increasing market consolidation in the red meat sectors still presents increasing risks for suppliers. Similar to the supermarket sector, increasing price pressures put suppliers in inherently vulnerable positions, particularly in regional environments where sales channels are limited (ACCC, 2017). In the dairy context, the limitations in sales channels established through rigid contracts with processors was recognised following the 2016 'dairy crisis' and the ACCC proposed a Mandatory Industry Code of Conduct, governing behaviour in dairy supply agreements to processors (ACCC, 2018). See also ACCC (2016a) in relation to horticulture. The red meat processing sector might consider a similar Code of

Conduct, as further consolidation in red meat processing could leave suppliers at greater risk of misconduct.

Relatedly, Russo and Goodhue (2018) presented a solution to account for the deficiencies in traditional market power models such as the NEIO framework. The premise included the volatility in farmgate prices compared to food prices and the consequences of supermarket pricing campaigns such as loss leadership. Australian farmgate prices have suffered considerable volatility in recent years and in a domestic context are heavily dependent on supermarket channels (Youl, 2018). Future research could consider placing a heavier weight of the implications of both market volatility and pricing campaigns on supermarket suppliers.

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Appendix Table 1. Variable definitions

Abbreviation	Definition
BF	Beef
LB	Lamb
PK	Pork
PRBF	Retail Prices for Australian Beef
PFBF	Saleyard Prices for Australian Beef
PRLB	Retail Prices for Australian Lamb
PFLB	Saleyard Prices for Australian Lamb
PRPK	Retail Prices for Australian Pork
PFPK	Saleyard Prices for Australian Pork
MMBF	Nominal Beef Marketing Margin (PRBF – PFBF)
MMLB	Nominal Lamb Marketing Margin (PRLB – PFLB)
MMPK	Nominal Pork Marketing Margin (PRPK – PFPK)
MMBFR	Real Beef Marketing Margin (MMBF/FCPI)
MMLBR	Real Lamb Marketing Margin (MMLB/FCPI)
MMPKR	Real Pork Marketing Margin (MMPK/FCPI)
DMBF	Domestic Demand for Australian Beef
DMLB	Domestic Demand for Australian Lamb
DMPK	Domestic Demand for Australian Pork
DMBFI	DMBF/PFBF
DMLBI	DMLB/PFLB
DMPKI	DMPK/PFPK
TIME	Trend Variable
COSTIND	Marketing Cost Index = (0.75 * WAGE) + (0.1* ELECT) + (0.15*INT)
WAGE	Australian Wage Rate Index
ELECT	Australian Electricity Cost Index
INT	Australian Interest Rate, 90 day bank bills

Source: taken from previous research (Chung and Griffith, 2009; Griffith, 2000)

Appendix Table 2. OLSQ and AR1 estimates of the beef, lamb and pork margin equations, 1970-2017

Constant	COSTIND	DMBF	DMBFi	TIME	RHO	R^2	DW
615.14	0.684	0.142	-27.932	1.810	-	0.31	0.82
(7.78)	(1.74)	(0.96)	(-2.97)	(2.30)			
720.05	1.352	-0.265	-7.146	2.952	0.739	0.56	1.46
(7.54)	(2.60)	(-1.60)	(-0.82)	(2.06)	(6.21)		
		DMLB	**DMLBi**				
221.73	1.428	0.055	-18.799	3.490	-	0.45	0.55
(2.06)	(3.19)	(0.18)	(-0.78)	(3.44)			
272.62	1.100	-0.094	4.765	3.190	0.795	0.74	1.61
(2.95)	(2.57)	(-0.40)	(0.32)	(2.54)	(8.60)		
		DMPK	**DMPKi**				
353.32	0.912	-0.154	-14.507	3.866	-	0.05	0.53
(6.07)	(1.85)	(-.53)	(-0.52)	(1.17)			
489.12	-0.271	-0.263	36.470	0.851	0.907	0.71	1.90
(7.24)	(-0.83)	(-1.32)	(2.66)	(0.35)	(15.34)		

Appendix Table 3. AR1 estimates for real beef margin equations 1970 – 2017

Constant	COSTIND	DMBF	DMBFi	TIME	DUM75	DUM95	DUM07	DUM11	RHO	R^2	DW
720.05	1.352	-0.265	-7.146	2.952					0.739	0.56	1.46
(7.54)	(2.60)	(-1.60)	(-0.82)	(2.078)					(6.21)		
752.15	0.674	-0.168	9.665		-143.86				0.811	0.64	1.32
(9.54)	(1.66)	(-1.17)	(1.13)		(-4.13)				(8.27)		
808.18	0.915	-0.233	-9.100			32.308			0.755	0.45	1.42
(9.21)	(1.83)	(-1.36)	(-1.01)			(1.17)			(5.97)		
838.52	0.838	-0.252	-8.080				7.949		0.775	0.48	1.39
(9.99)	(1.36)	(-1.39)	(-0.86)				(0.24)		(4.74)		
848.52	1.306	-0.344	-4.969					-56.922	0.917	0.47	1.45
(9.11)	(2.09)	(-2.22)	(-0.61)					(-1.57)	(9.31)		
659.90	1.239	-0.252	9.578	4.539	-121.04	-10.120	-28.531	-59.154	0.842	0.69	1.39
(7.47)	(2.62)	(-1.93)	(1.19)	(2.25)	(-3.49)	(-0.35)	(-1.02)	(-2.10)	(8.46)		

Notes: t-statistics are in brackets

Appendix Table 4. AR1 estimates for real lamb margin equations 1970 – 2017

Constant	COSTIND	DMLB	DMLBi	TIME	DUM95	DUM07	DUM11	RHO	R^2	DW
272.62	1.100	-0.094	4.765	3.190				0.795	0.74	1.61
(2.95)	(2.57)	(-0.40)	(0.32)	(2.54)				(8.60)		
398.64	0.680	-0.157	6.657		-3.068			0.896	0.67	1.56
(4.57)	(1.62)	(-0.64)	(0.44)		(-0.44)			(10.39)		
392.41	0.707	-0.142	6.716			-10.87		0.910	0.66	1.54
(4.58)	(1.69)	(-0.58)	(0.45)			(-0.37)		(11.00)		
378.12	0.658	-0.096	4.654				38.98	0.874	0.69	1.55
(4.76)	(1.67)	(-0.40)	(0.31)				(1.55)	(10.52)		
272.95	0.989	-0.100	3.103	3.988	-24.787	-24.052	20.987	0.813	0.74	1.63
(2.96)	(2.56)	(-0.42)	(0.21)	(2.39)	(-0.89)	(-0.96)	(0.80)	(8.82)		

Notes: t-statistics are in brackets

Appendix Table 5. AR1 estimates for real pork margin equations 1970 – 2017

Constant	COSTIND	DMPK	DMPKi	TIME	DUM90	DUM95	DUM07	RHO	R^2	DW
489.12	-0.271	-0.263	36.470	0.851				0.907	0.71	1.90
(7.24)	(-0.83)	(-1.32)	(2.66)	(0.35)				(15.34)		
539.81	-0.481	-0.207	41.06		-63.509			0.865	0.73	1.89
(9.87)	(-1.67)	(-1.63)	(3.23)		(-3.21)			(10.90)		
494.34	-0.284	-0.189	35.095			-15.565		0.892	0.70	1.86
(8.02)	(-0.90)	(-1.28)	(2.56)			(-0.72)		(13.88)		
488.49	-0.292	-0.190	36.23				-10.84	0.905	0.71	1.87
(7.42)	(-0.92)	(-1.22)	(2.66)				(-0.46)	(15.79)		
516.18	-0.321	-0.418	43.66	4.112	-78.14	-21.76	-5.286	0.840	0.76	2.05
(9.69)	(-1.08)	(-2.19)	(3.49)	(1.91)	(-3.55)	(-1.07)	(-0.25)	(8.25)		

Notes: t-statistics are in brackets