The Competitive Structure of the Australian Meat and Livestock Industries[+]

Xueyan Zhao, Garry R. Griffith and John D. Mullen[*]

Abstract

There has been a longstanding interest in the degree of competition in the Australian meat and livestock industries. Various government and industry inquiries have examined aspects of oligopsonistic pricing practices by wholesalers, processors and retailers, labour relations in meat processing, vertical integration and foreign ownership, etc. No consensus has emerged, but the suspicion of noncompetitive behaviour remains. In this paper, a model developed by Holloway based on the conjectural variations of noncompetitive firms is applied to Australian meat industry data. In the base model, the lamb industry was found to generate pricing patterns consistent with competitive market behaviour, while the beef industry was found to show very strong evidence of noncompetitive market behaviour and the pork industry showed some departure from perfect competition. Sensitivity analyses were undertaken, and the results were found to vary with differences in some of the underlying assumptions. These findings have important implications for the choice of conceptual frameworks and empirical implementations to model these industries and to assess the impacts of new technologies, policy interventions and promotion campaigns.

[+] Contributed paper prepared for presentation at the 40th Annual Conference of the Australian Agricultural and Resource Economics Society, Inc., University of Melbourne, February 13-15, 1996.

[*] The authors are with the Cooperative Research Centre for the Cattle and Beef Industry, Armidale and NSW Agriculture, Armidale and Orange respectively. The assistance of Simone Hemery in data collection and the incisive comments of Roley Piggott on an earlier draft are appreciated.

1. Introduction

There has been concern over a long period of time about the degree of competition in the Australian meat and livestock industries and the implications this has for structure, conduct and performance in these industries. A number of government, parliamentary and industry inquiries have examined aspects of oligopsonistic pricing practices by wholesalers, processors and retailers, labour relations in meat processing, vertical integration and foreign ownership, the provision and quality of market information, etc. Examples include enquiries by NSW Parliament (1972), Australian Agricultural Economics Society (NSW Branch) (1973), Australian Parliament (1973), Prices Justification Tribunal (1978), Industries Assistance Commission (1983), AACM (1990), Macquarie Consulting (1990), Australian Industrial Relations Commission (1991), Booz-Allen and Hamilton (1993) and the Industry Commission (1993). Researchers also have been concerned with this topic as reflected in extensive research on the structure and operations of the meat industry by the Bureau of Agricultural Economics and by Griffith and colleagues among others (see examples in the reference list) and in a number of postgraduate dissertations (for example, Woodward 1968; Beruldson 1970). In the early years the questions asked in the inquiries related to whether governments should intervene to modify industry structure, conduct or performance, while in later years, alongside developments in competition policy, the questions had changed to how to encourage microeconomic reform in these industries. The history of these concerns can be followed in the chapters on marketing in the various editions of the Williams collection on Australian agriculture (Watson and Parish 1982; Piggott 1992).

Meat industry structure and practices have changed considerably over the past 25 or so years, and many early criticisms are now unfounded. In particular, there are now better systems for describing products and providing this information to suppliers and purchasers of meat, and many small, old abattoirs have been closed down or rebuilt. In fact, many structural aspects of the meat industry were reported favourably upon by the Industry Commission. However, other aspects were not. The meat processing sector has been consistently singled out as a relatively high cost sector which would benefit from reform of regulatory constraint and labour relations (Griffith and Verspay 1991; IC 1993). Alternatively, many analysts now believe that the supermarkets wield an unacceptable degree of market power in these industries, and additionally, the AMLC still licences meat exporters. Hence the suspicion of noncompetitive behaviour in the meat and livestock industries remains.

On another level, a growing share of public and producer's funds have been used in recent years to finance research in the meat processing sector and promotion in retail meat markets. Mullen, Alston and Wohlgenant (1989) and Wohlgenant (1993) have demonstrated that under competitive conditions producers receive a smaller share of the benefits from processing research and promotion than they do from traditional production research activities[1]. If input suppliers to the processing sector can capture an even larger share of the benefits of new processing technology or generic promotion because of their market power, then the profitability of processing research or promotion needs to be higher to justify the investment of producer levies in these activities ahead of investment in

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[1] Similarly, processors and retailers bear a smaller share of the incidence of levies imposed at the point of sale of farm products than do producers. This arises because of input substitution between farm and non-farm inputs.

production research[2].

Following an earlier application by Freebairn, Davis and Edwards (1982)[3], a number of recent evaluations of the distribution of benefits from research and promotion activities in the Australian livestock industries have used equilibrium displacement modelling (EDM) (see for example, Mullen et al 1989; Morris et al 1992; Piggott 1992; Mullen and Alston 1994; Piggott, Piggott and Wright 1995; Hill et al 1995,1996; Zhao et al 1995). In all of these studies, a competitive market has been assumed. However Freebairn et al (1982, p.43) suggested how imperfect competition might be modelled, and as a qualification of their assessment of the impact of a new lamb technology using an EDM framework, Mullen and Alston (1994, p 60) specifically recommended that "...an assessment has to be made of the competitive nature of the marketing chain in the lamb industry."

Hence, whether our interests lie with general questions of structure, conduct and performance within livestock industries or with more specific questions about the distribution of the benefits from new production and processing technologies and from promotion, it is critical to know whether the Australian meat and livestock industries can be characterised as perfectly competitive. In this paper, a model developed by Holloway (1991), based on the conjectural variations of noncompetitive firms, is applied to Australian meat industry data to examine this issue.

2. The Conceptual Model

Gardner (1975) developed a model of equilibrium in a food marketing system based on perfect competition. This model has been widely used to examine aspects of the economic behaviour of food markets (Fisher 1981; Wohlgenant 1989).

Holloway (1991) extended Gardner's model to a conjectural-variations oligopoly with endogenous entry of firms. For this type of industry behaviour "...it is assumed that, when making their output decisions, firms form beliefs about the extent to which these decisions affect the quantity decisions of other firms in the industry and therefore, the industry price, which is common to all firms." (Holloway 1991, p.980). In this context, an important parameter is θ_i, the elasticity of total industry output conjectured by each identical firm i with respect to changes in its own output level. Under the assumptions of Cournot conjecture and "that firms possess identical technologies and produce a homogenous product" (p.980). Holloway concentrates on 'symmetric equilibria' in which:

(1) $\theta_i = \theta$ and $x_i = x/n$, $(i = 1, ..., n)$

That is, each firm has the same conjectural elasticity and produces the same level of output. Given an industry demand curve, an aggregate output identity as the sum of each firm's output and the firm's

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[2] Presuming that when there is a lack of competition in processing, the distribution of benefits from new technology and promotion are skewed further away from producers.

[3] They did not allow for input substitution and arrived at the result that producers received the same share of benefits from all types of innovation and promotion.

conjecture function, its first order condition for profit maximisation can be written as:

(2) $P_x(1 + \theta_i/\eta) = C(P_a,P_b)$

where P_x is the retail price of the food product x, η is the own-price elasticity of demand for x at retail, and C( ) is the firm's marginal cost defined over P_a and P_b which are the prices of the farm commodity input a and a marketing services input b, used to produce x. If $\theta_i = \theta = 0$ (from equation (1)), then equation (2) represents the perfectly competitive solution of price equal to marginal cost; if $\theta_i = \theta = 1$, equation (2) represents the monopoly solution of marginal revenue equal to marginal cost. Thus the value of θ indicates the degree of competition in the market for product x. The hypothesis to be tested therefore is H_0: $\theta = 0$.

Unfortunately, θ cannot be measured directly so alternative procedures have to be used to develop tests on measurable parameters which are inferred from particular values of θ. Holloway did this by extending Gardner's equilibrium model of a food marketing system to allow the possibility that $\theta > 0$ and then deriving a set of conditions for empirically measurable parameters such that $\theta = 0$. This equilibrium model included the industry demand curve for x, the aggregate output identity for x, the equilibrium condition in equation (2), a firm entry condition, two firm input demand schedules for a and b, two aggregate input quantity identities, and two inverse supply functions for the prices of a and b, P_a and P_b. This ten equation model was then expressed in proportional changes denoted by the superscript (*) to allow solution for a new equilibrium following some displacement caused by a shift in an exogenous variable (Holloway's equations (11) to (20), p. 982).

To simplify his system of equations and facilitate the development of testable hypotheses about the level of competition, Holloway made three assumptions about parameter relationships commonly made in past studies (in particular Wohlgenant 1989; Gardner 1975; Freebairn, Davis and Edwards 1983). These are (i) that the supply of the farm commodity a^* is predetermined during a year and hence is exogenous, (ii) that the supply of marketing inputs is perfectly elastic (which means P_b^* is exogenous), and (iii) that the retail demand shift variable N^* can be expressed as a linear combination of the elasticities and values of individual demand shifters such as income, population, prices of competitive goods, etc.

Holloway then focused on Gardner's retail-farm price ratio $R = P_x / P_a$. In proportional change terms and in relation to one of the exogenous variables, say N^*, this ratio can be expressed as:

(3) $R^*/ N^* = (P_x^*/ N^*) - (P_a^*/ N^*)$ or as

$$E_{R,N} = E_{Px,N} - E_{Pa,N}$$

These last three expressions are elasticities of the retail-farm price ratio, the retail price and the farm price, respectively, with respect to the exogenous demand shift variable N^*. Similar expressions to those in equation (3) exist for the other exogenous variables a^* and P_b^*, to give $E_{R,a}$ and $E_{R,Pb}$, respectively. These expressions can be written in expanded form in terms of all the parameters of the model including θ (Holloway's equations (21) to (23), p. 983), and from these can be derived testable hypotheses about how farm and retail prices and the price spread respond to changes in demand and supply conditions were the market competitive, ie were $\theta = 0$.

Necessary and (almost) sufficient conditions for perfect competition in food markets are found to be:

(4) $\quad E_{P_x,N} = -E_{P_x,a}$

(5) $\quad E_{P_a,N} = -E_{P_a,a}$

(6) $\quad E_{R,N} = -E_{R,a}$

Thus under perfect competition, and the three assumptions listed above, the proportional effects on the retail price, the farm price and their ratio of shifts in retail level demand and farm level supply are equal in magnitude and opposite in sign (Holloway 1991, p.984). It can be shown that the farm price and ratio conditions (5) and (6) are sufficient to infer $\theta = 0$[4]. For the retail price, condition (4) is sufficient for $\sigma\theta = 0$ where σ is the elasticity of substitution between the farm input and the marketing input. Thus, if there is independent evidence that $\sigma \neq 0$, condition (4) is sufficient for competition. Holloway also showed that $E_{P_x,P_b} \neq 0$ infers $\sigma \neq 0$, where E_{P_x,P_b} is the proportional effect on the retail price with respect to a change in the price of marketing services. Thus

(7) $\quad E_{P_x,P_b} \neq 0$

is a joint sufficient condition, together with (4), to infer competition in the retail price equation.

Therefore "... a test of competition reduces to a test of the validity of a linear restriction imposed across the coefficients of N^* and a^* in a regression on R^*" (Holloway 1991, p.984), or equivalently on P_x^* or P_a^*, and to a test of the significance of the coefficient on P_b^* in a regression on P_x^*.

In Holloway's notation, the models to be estimated therefore are:

(8) $\quad P_x^* = \beta_{xN}N^* + \beta_{xa}a^* + \beta_{xb}P_b^* + \epsilon_x$

(9) $\quad P_a^* = \beta_{aN}N^* + \beta_{aa}a^* + \beta_{ab}P_b^* + \epsilon_a$

(10) $\quad R^* = \beta_{RN}N^* + \beta_{Ra}a^* + \beta_{Rb}P_b^* + \epsilon_R$

where the βs are coefficients to be estimated and all variables are defined in the current period. The conditions for competition outlined in equations (4) to (7) amount to tests of

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[4] Holloway did not recognise that (6) is sufficient to infer competition. Examining the proof of Holloway's proposition (p.985), it can be shown that (6) is sufficient for $\theta(\sigma\omega_b-\eta)/((\theta+\eta)\Phi)=0$. Following Holloway's reasoning for $(\theta+\eta)\neq 0$ and $\Phi\neq 0$, we have $\theta(\sigma\omega_b-\eta)=0$. Note that $\sigma\omega_b\geq 0$, and $\eta\leq 0$, so the term $(\sigma\omega_b-\eta)$ must be non-negative. Thus the only possibility of $\sigma\omega_b-\eta=0$ is when both $\sigma=0$ and $\eta=0$. However Holloway has showed that a perfectly inelastic demand $\eta=0$ infers $\theta=0$. Thus (6) is sufficient to infer $\theta=0$, or perfect competition.

(4)' $\beta_{xN} = -\beta_{xa}$ and

(7)' $\beta_{xb} \neq 0$

in equation (8), and of

(5)' $\beta_{aN} = -\beta_{aa}$ and

(6)' $\beta_{RN} = -\beta_{Ra}$

in equation (9) and (10), respectively.

Empirically, if any of the F-tests for the restrictions embedded in hypotheses (4)'-(6)', that the demand shift and supply shift variables be equal but of opposite sign, are significant, which implies at least one piece of evidence against competition, then a conclusion of non-competition can be made for that industry. On the other hand, if none of the F-tests for (4)'-(6)' are significant **and** the t-test for (7)' is significant, then the empirical data is consistent with competition and the hypothesis of perfect competition is not rejected. However, if all the F-tests are insignificant and the t-test for (7)' is insignificant as well, then a conclusion of competition can only be made cautiously. But, if there was independent evidence of $\sigma \neq 0$, the competition conclusion would be favoured, especially if hypotheses (5)' and (6)' for the farm and ratio equations (9) and (10) were not rejected.

3. Data

The three meat commodities beef, lamb and pigmeat were chosen for analysis. To estimate equations (8) to (10) for each meat, data are required on farm and retail prices, farm level quantities, the cost of marketing services, retail prices of competing goods, population, income, and a set of cross-price and income elasticities of demand. Annual data were thought to be appropriate given the emphasis on long run static market equilibrium in the EDM framework.

3.1 Data sources

In terms of the raw data needed, farm prices of beef cattle, lambs and pigs in units of c/kg estimated dressed carcase weight and the retail prices of beef, lamb, pork and chicken in units of c/kg retail cut weight were obtained from ABARE (1995) and ABS (1993b). The quantities produced of beef and veal, lamb and pigmeat in units of thousand tonnes were obtained from AMLC (1993). Household disposable income ($m.) and population (millions) were obtained from various ABS publications (ABS 1993a,c). Data were collected for the period 1968 to 1992.

3.2 Data transformations

Two quite important data adjustments were required. First, Wohlgenant (1989) and Holloway (1991) used farm prices for livestock adjusted for byproduct values, and that procedure was followed here. Although prices for individual byproducts such as hides, skins, tallow and meat meal are published

(AMLC 1995), in Australia there is no published index of aggregate byproduct values for each species considered here. However Griffith has calculated such values on a monthly basis for the period 1980 to 1988 to generate meat price spread series (Griffith, Green and Duff 1991). These byproduct values were compared with the published farm price series in various ways to provide a predictive relationship for extrapolating byproduct values prior to 1980 and after 1988. Various regression models produced unreasonable predictions, so the ratio of the byproduct value to the farm price was calculated for each meat, and the resulting values for 1980-1982 were averaged and extrapolated for 1968 to 1979, while the values for 1986-1988 were averaged and extrapolated for 1989 to 1992. The subsequent byproduct values were deducted from the farm price taking account of the dressing percentages of each meat. These new data are provided in Appendix 1.

Similarly in Australia there is no published index of marketing costs for meat products. A price index of materials used in the food, beverages and tobacco subdivision of the manufacturing industry (ABS 1992a) has been calculated since 1984/85, however this index includes the cost of the raw materials (our a) as well as the cost of the processing inputs (our b). In previous work (Griffith 1974; Griffith, Green and Duff 1991) a wage rate has been used as a proxy for all such costs because over half of meat processing and retailing costs were labour costs (AAES 1973; PJT 1978; IAC 1983), however this ignores the possibility of variation in other types of input prices. The best approach seemed to be to obtain time series on the main cost components of meat retailing and processing firms, and then derive an index. Some financial data for the meat processing sector are available (ABS 1990, Tables 5 and 6), but not in the detail required, while there are no ABS data specifically on meat retailing firms. Information from the ABS (1994) industry performance data for Retail Trade (Table 32) and Manufacturing (Table 16) was examined and it was found that excluding raw materials the cost proportions were labour (about 75% over the period 1990/91 to 1993/94), depreciation (about 10%), interest (about 10%) and other operating expenses (mainly power - about 5%). In food retailing in particular (ABS 1992b, Table 2), the cost proportions were labour (about 45% over the year 1991/92), depreciation (about 4%), interest (about 6%), rent, leasing and hiring (about 15%) and other operating expenses (mainly power - about 30%). Thus the relevant wage rate (ABS 1993d), a price index for electricity (ABS 1992a) and an overdraft rate (ABARE 1995) were converted into common-based indexes and combined using two sets of weights estimated from the data above (75:10:15 and 50:20:30) to form two indexes of marketing and processing costs (see Appendix 2).

3.3 Demand elasticities

Finally, a set of cross-price and income elasticities was required to calculate the aggregate demand shift variable N^*. Initially, a survey of previous empirical estimates was undertaken (Lubett and Griffith 1995). This survey revealed that most of the estimated elasticity values were based on quarterly data, and those that were based on annual data were quite dated (the most recent being BAE 1985 and Murray 1984, and the BAE market share equations do not provide explicit cross-price elasticities). As elasticity values tend to change over time (Goddard and Griffith 1992), it was decided to estimate the required elasticities using the most recent data available. A set of linear demand functions in the logs of the variables were specified and estimated as a SUR system. Restrictions due to homogeneity and symmetry were tested and rejected, so more complicated demand systems models were not pursued. The estimated model and elasticities are provided in Appendix 3.

4. Results

4.1 Base model results

The results of estimating equations (8) - (10) for the base model are reported in Tables 1 and 2. The models were estimated by OLS in SHAZAM and checked in TSP. The base model has farm prices adjusted for byproduct values as in Appendix 1, the first marketing cost index as in Appendix 2 and the base estimated elasticities as in Appendix 3. The unrestricted estimates are provided in Table 1. The R^2 were reasonable, although those for the ratio variables were lower, especially for pigmeat. The DW estimates for the beef equations indicated two instances of significant autocorrelation (retail and farm prices), while the ratio equation had a borderline DW statistic. Hence, the three equations were re-estimated with an autocorrelation correction. The coefficient on the demand shift variable was positive and significant in all farm and retail price equations, while the coeffficient on the farm supply shift variable was negative and significant in the lamb and pigmeat equations but not significant in either of the beef equations. In the ratio equations, the signs were reversed and the number of significant variables was much reduced. In terms of magnitudes the lamb and pigmeat retail demand and farm supply coefficients appeared to be of similar order, but those for beef did not.

Table 1: Unrestricted Estimates of the Base Retail Price, Farm Price and Ratio Equations

		Elasticity				
Meat type	Dependent variable	Retail demand	Farm supply	Marketing cost	R^2	DW
Beef	Retail	1.102**	-0.056	-1.684**	0.78	1.74
		(8.41)	(-0.67)	(-5.43)		ρ=0.64
	Farm	2.411**	0.077	-5.669**	0.70	1.67
		(6.61)	(0.33)	(-6.61)		ρ=0.62
	Ratio	-1.220**	-0.115	3.404**	0.59	1.73
		(-4.40)	(-0.58)	(5.41)		ρ=0.33
Lamb	Retail	0.720**	-0.715**	-0.133	0.90	2.13
		(11.24)	(-8.37)	(-1.31)		
	Farm	0.972**	-1.609**	-0.889*	0.64	2.54
		(3.90)	(-4.83)	(-2.23)		
	Ratio	-0.253	0.894**	0.756*	0.34	2.66
		(-1.14)	(3.01)	(2.13)		
Pigmeat	Retail	0.817**	-0.628**	0.267**	0.87	2.22
		(8.59)	(-7.71)	(2.91)		
	Farm	0.948**	-1.057**	0.100	0.57	2.42
		(3.21)	(-4.18)	(0.35)		
	Ratio	-0.130	0.429	0.166	0.09	2.52
		(-0.45)	(1.74)	(0.60)		

Values in parentheses are t statistics.

Critical t values are $t_{0.10}(21)=1.72$; $t_{0.05}(21)=2.08$; $t_{0.01}(21)=2.83$.
** significant at 1%; * significant at 5%.

The restrictions from equations (4)'-(6)', that the coefficients for the demand shift and supply shift variables are equal but of opposite sign, were applied and the results are provided in Table 2, along with the F value for these restrictions. Again the beef equations were estimated with an autocorrelation correction, and the restriction was strongly rejected at the 1% level for each of these equations. This is very strong evidence that the beef market is non-competitive.

The restriction was not rejected at the 5% level for any of the lamb equations. These results imply competitive behaviour in the lamb market. Recall, however, that this test is not sufficient enough for the retail price equation, and to confirm the implication of competition the marketing cost variable must be significant. The result for the retail price equation in Table 2 showed that the marketing cost variable was not significant at the 5% or 10% levels. However others (Mullen and Alston 1994) have assumed that there are opportunities for substitution between animals and other inputs in the production of retail lamb. Given this, the very similar estimates of the unrestricted coefficients in Table 1 and the insignificance of the F-tests in both farm and ratio equations, a perfect competition conclusion for the lamb industry was favoured. This implication is strengthened by the fact that the R^2 for these equations are quite close to those in Table 1. For the pigmeat price equations the F test

Table 2: Restricted Estimates of the Base Retail Price, Farm Price and Ratio Equations

Meat type	Dependent variable	Elasticity Retail demand	Farm supply	Marketing cost	R^2	F(1,21)
Beef	Retail	0.488	-0.488	-0.263	0.48	33.12**
		(5.26)	(-5.26)	(-1.04)		
	Farm	0.889	-0.889	-1.906**	0.41	24.12**
		(3.70)	(-3.70)	(-2.88)		
	Ratio	-0.404	0.404	1.633**	0.38	11.48**
		(-2.48)	(2.48)	(3.67)		
Lamb	Retail	0.718	-0.718	-0.132	0.90	0.002
		(14.36)	(-14.36)	(-1.43)		
	Farm	1.201	-1.201	-1.120**	0.60	2.34
		(5.84)	(-5.84)	(-2.95)		
	Ratio	-0.483	0.483	0.988**	0.25	2.99
		(-2.60)	(2.60)	(2.88)		
Pigmeat	Retail	0.694	-0.694	0.364**	0.84	4.41*
		(8.60)	(-8.60)	(4.26)		
	Farm	1.019	-1.019	0.045	0.56	0.15
		(4.46)	(-4.46)	(0.18)		
	Ratio	-0.324	0.324	0.320	0.04	1.19
		(-1.42)	(1.42)	(1.32)		

Values in parentheses are t statistics.

Critical F values are $F_{0.10}(1,21)=2.96$; $F_{0.05}(1,21)=4.32$; $F_{0.01}(1,21)=8.02$.

Critical t values are $t_{0.10}(21)=1.72$; $t_{0.05}(21)=2.08$; $t_{0.01}(21)=2.83$.

** significant at 1%; * significant at 5%.

is just significant at the 5% level for the retail equation and not significant for the farm and ratio equations. This indicates weak evidence of a departure from competition.

Thus in the base model, the beef market was shown to be non-competitive, the lamb market was shown to be competitive and there was mixed evidence for the pigmeat market although the result for the retail price equation was sufficient to formally reject perfect competition.

4.2 Effect of data transformations

In section 3.2 above some quite laborious transformations to the raw data series, on the basis of incomplete information, were detailed so that variables in the form used by Holloway (1991), and previously, Wohlgenant (1989) could be constructed. Do these transformations effect the results? If they do, then it may be worthwhile to invest resources to properly construct the required series such as the byproduct values. If they do not, then resources may be saved by using suitable proxy variables.

In Table 3 are reported the results from re-estimating the base model using three alternative data series, as described below as Models 1-3. Compared with the results of the base model, these alternative data series seem not to have any appreciable effect on the F test results or the conclusions drawn. For the pigmeat retail price equation under Model 3 the F test was not significant at the 5% level, whereas in the base model it was, but it was only marginally below the critical value.

Table 3: F test Results for Alternative Models

Meat type	Depend. variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Beef	Retail	13.75**	14.38**	11.81**		1.08	33.75**
	Farm	10.59**	13.13**	9.88**		0.04	26.65**
	Ratio	6.97*	9.05**	6.88*		0.03	18.65**
Lamb	Retail	0.002	0.007	0.000			
	Farm	2.45	2.17	2.54			
	Ratio	3.28	2.80	3.20			
Pigmeat	Retail	4.41*	5.13*	4.11	12.02**		
	Farm	0.22	0.30	0.075	0.38		
	Ratio	1.50	1.69	0.91	0.44		

Critical F values are $F_{0.10}(1,21)=2.96$; $F_{0.05}(1,21)=4.32$; $F_{0.01}(1,21)=8.02$.
** significant at 1%; * significant at 5%.

Model 1: farm prices not adjusted for byproduct values
Model 2: alternate weights in the cost index (50:20:30 instead of 75:10:15)
Model 3: wage rate only as proxy for full cost index
Model 4: pork production only instead of pigmeat production
Model 5: production for domestic beef market only
Model 6: accounting for beef export demand

4.3 Effect of market definition

Two important assumptions of the Gardner (1976), Wohlgenant (1989) and Holloway (1991) analyses were that the market under consideration was for an homogenous product and that the product was produced and consumed domestically.

With respect to the first assumption, market pigs for all uses are of similar weight but there are two distinct retail product groups - fresh pork and processed bacon and ham. According to Holloway (p.988), due to "a duality between equilibria in a homogenous-product setting and equilibria in a differentiated-products model", the current framework is still capable of indicating the "direction of many effects" for the nonhomogenous product situation. Even so, if we consider the market for nonhomogenous total 'pig meat', an aggregate retail price for 'pig meat' is not available due to lack of data on retail ham prices. Additionally, knowledge of cross-price and income elasticities of retail demand for bacon and ham is limited, which makes it difficult to calculate demand shifters for bacon and ham (N^*), and therefore for total pig meat demand. In the base model, total pig production, destined for both fresh and processed products, is used to represent the farm supply, and the best available retail price, for fresh pork, is used.

To investigate whether this specification had any effect on the results, an alternative model was estimated where the proportion of total pigmeat consumption in the two product groups was used to transform the farm supply variable in equations (8)-(10) to attempt to reflect production for the fresh pork market only. Trade in pigmeat is insignificant for Australia so amounts consumed closely reflect amounts produced. This result is reported as Model 4 in Table 3. This specification was very similar to the base model, and supported the original conclusions drawn. However a more detailed analysis of fresh pork and processed pigmeat as separate markets, with different prices, farm supply and demand shifters, would be needed to make stronger conclusions.

With respect to the second assumption, Holloway (1991, p.989) recognised that international trade plays an important role in many food-marketing systems, but argued that the complexities of introducing a foreign marketing sector were outside the scope of his paper. While ignoring trade effects may not significantly influence analyses of United States food markets, this may not be the case for the Australian extensive livestock industries. For example, exports of beef and veal from the United States averaged about 7% of production in the last three years (and imports averaged about 10%), while for Australia exports of beef and veal exceeded 64% of production in the same period (AMLC 1996). Exports of Australian lamb averaged over 20% of output in the last three years. Thus the production of beef in Australia, and to a lesser extent lamb, is driven by both domestic and export demand. However the demand shifter N^* in the base model was constructed from domestic market information only. Demand forces coming from overseas markets were not accounted for.

Two alternative models were estimated in an attempt to measure beef market behavior in a consistent way. The first alternative concentrated on the domestic beef market only. Beef cattle farm price, domestic beef retail price and a domestic retail demand shifter, calculated from Australian data on income, population, domestic retail prices of other competing meat products and elasticities, were used, as in the base model. Farm production destined for the domestic market (farm supply in equations (8)-(10)), was based on the quantity consumed domestically. While there is some degree of substitution possible between enduses of beef, increasingly animals destined for the domestic butcher and supermarket trade are differentiated from animals destined for the various overseas target markets (see for example the various market segmentation diagrams based on weight and fat ranges published in MRC and AMLC publications, and producer advisory material (NSW Agriculture 1994,1995)).

The second alternative was an initial attempt to explicitly model both domestic and overseas markets. The retail demand shifter N^* was a weighted average of two components: the impact from shifts in the domestic market (N_D^*) and the impact from shifts in overseas markets (N_E^*).[5] The domestic shifter N_D^* was the same as in the base model. Data for cattle farm price and total farm production were the same as in the base model. The beef retail price was calculated as the weighted average of domestic retail price and export price for Australian beef, with the weights being the proportion of domestic and export consumptions for each year. The US market was used to represent overseas market demand, as exports to the US account for about 34% of total Australian exports for beef, second only to Japan (42%)(AMLC 1996). The price received in the US market was used to represent the average overseas price for Australian beef, and the export shifter was a linear combination of the US prices of competing meat products, income and population, and relevant elasticities reported in US meat demand studies (Wohlgenant 1989).

These results are reported as Models 5 and 6 in Table 3. Compared to the results of the base model, these alternative specifications did seem to have an appreciable effect on the F test results and the conclusions drawn. For the case where only the domestic beef market was modelled, the F tests were very insignificant in all the equations, while for the second case the F values were even larger than in the base model, thus reinforcing the result from the base model. The implication here is that the way the relevant market is defined has a major effect on the results. These results suggest that the domestic beef market was characterised by competitive behaviour but the export beef market was not.

However, to model international trade properly, we need to go back to the structural model and disaggregate the retail demand into domestic and export components. A set of new equivalent conditions for $\theta = 0$ may then be derived in terms of domestic retail price, export price, domestic and export demand shifters, etc. This could be a very difficult excercise as Holloway recognised. The question also remains as how to empirically characterise the export market properly when many destinations are involved with very different market situations and when the data for some of these countries are limited.

5. Conclusions and Implications

In this paper, a model developed by Holloway based on the conjectural variations of noncompetitive firms was used to assess the level of competition in Australian meat industries. In the base model, the

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[5] $N^* = \rho_D N_D^* + (1-\rho_D) N_E^*$, where ρ_D and $(1-\rho_D)$ are proportions of domestic and export consumption.

lamb industry was found to generate pricing patterns consistent with competitive market behaviour, while the beef industry was found to show very strong evidence of noncompetitive market behaviour and the pork industry showed some departure from competition.

Sensitivity analyses were undertaken with respect to a number of the assumed data transformations and parameter values[6]. In general, the specification of the farm and marketing input prices did not seem to have any appreciable effect on the conclusions drawn. Therefore published farm level prices and a wage rate respectively may be used without loss of information if construction of a farm price net of byproducts and an index of marketing costs are expensive to assemble. Similarly the results were insensitive to whether the farm supply of pigmeat was represented by total pig production or disaggregated to an estimate of the supply of pigmeat to the fresh pork sector.

The results were sensitive to the specification of the domestic and export markets for beef. When the domestic beef market was completely quarantined from the export market, the farm supply of beef being defined as only that destined for the domestic market, there was little evidence of non-competitive behaviour in any of the three beef equations. However when the export market was explicitly accounted for, there was evidence that the export market appears to be non-competitive. The implication here is that the way export products are modelled has a major effect on the results, and in this particular instance, this means the domestic beef market is consistent with competitive behaviour but the export beef market is not.

Thus in this paper some strong evidence has been presented which suggests that the lamb industry may be competitive, and that the beef industry, particularly its export sector, may not be. There was some weak evidence that the pigmeat industry may not be competitive. These findings raise some interesting questions:

- why is the beef industry different from the other industries?
- what factors contribute to this apparent monopoly power in the beef industry?
- how is the beef industry best modelled in the future?

Turning to the first question, while the beef and lamb industries are far more extensive than the pig industry, the three share processing inputs and would appear to rely on few specialised inputs. They share the common feature that there are barriers to entry into processing partly arising from fixed assets and partly from statutory regulation of capacity. The industries face similar issues of union power in processing. It would seem that the key difference is that the beef industry is far more reliant

[6] Some experiments were also done to investigate whether different elasticity values from those used in the base model to calculate N* would result in different test results. Two alternative sets of elasticities were constructed from the literature and incorporated instead of the base model elasticities. These alternative values did seem to have an appreciable effect on the conclusions drawn. Fo[illegible]ample, using one set of elasticities, all three meat markets would be concluded to be non-competitive. Howe[illegible]s are noted for illustrative purposes only as there is some concern that elasticities derived from utility theory [illegible]ompetitive market. Further work is required to develop an up to date set of annual meat demand elasticities fo[illegible]

on export m[illegible] than the pig and lamb industries, and access to these markets is regulated by licensing [illegible] learly the way in which domestic and export markets are modelled is critical, an issue [illegible] way and illustrated in the results above.

Further [illegible] ts may be sensitive to the way in which different enduses are aggregated into 'homogeneous' products. In the pigmeat industry, for example, there are large fresh and processed enduse components and the difficulty in modelling this feature of the industry may be the cause of the weak evidence against competition in the pigmeat market. Finally, in the sheep industry, meat and wool are produced as joint products. Thus the lamb market is closely linked to the wool market, and in an aggregate sense this may make the lamb industry more responsive to market forces.

In the Introduction several features of the livestock industries in Australia that might lead to the emergence of market power were identified. These included barriers to entry in the form of government regulation. Another issue was the extent of union power. While these results suggest some degreee of monopoly power in the beef industry, it is not clear where this power originates, ie who enjoys the consequent rents? That is, it is not clear which of these features are the binding constraints.

If union power is a binding constraint, then the assumption that the supply of marketing inputs is perfectly elastic is untenable. It is not clear how important the violation of this assumption is because there is little evidence of non-competitive behaviour in the lamb and pig industries. However an area for further work is the derivation of testable hypotheses about competition which do not require the assumption that the supply of marketing inputs is perfectly elastic, and the subsequent testing of these hypotheses.

Finally, as noted already, there is a need to think carefully about how to model the beef export markets, particularly if it can be confirmed that that is where the monopoly power resides. A more theoretically sound and empirically feasible approach than that attempted in this paper is needed to properly handle the trade situation.

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Appendix 1: Byproduct Values and Adjusted Farm Prices

	BBY	PABFAUB	LBY	PALBAUB	PBY
1968	4.50000	48.53928	1.75000	37.70417	5.50000
1969	5.00000	47.84642	1.85000	36.59583	5.95000
1970	5.50000	50.12857	1.95000	34.98750	6.25000
1971	6.19167	50.61845	2.00900	31.26458	6.51583
1972	6.70833	50.14583	2.30550	36.79688	5.90333
1973	8.71333	65.54047	4.03250	60.89896	7.39000
1974	6.77833	43.49584	4.10000	71.98232	10.71333
1975	3.70250	23.68839	3.26850	51.81562	12.39833
1976	4.66583	31.91816	3.55800	53.83749	12.10167
1977	5.15167	37.62559	4.06850	64.49895	11.69750
1978	7.66000	52.69642	5.09900	77.17707	12.52417
1979	16.26917	116.29791	6.88750	98.05104	16.12667
1980	17.41667	114.29880	9.05000	111.52084	14.80000
1981	15.27500	99.64822	8.49167	111.08401	18.40000
1982	16.80833	83.16013	7.82500	89.94791	20.16667
1983	22.56667	109.90237	8.65000	90.42915	18.68333
1984	29.87500	112.82677	9.37500	93.34375	19.74167
1985	27.46667	122.127[illegible]	8.56667	71.25276	19.28333
1986	30.11667	120.52023	8.10833	99.16597	18.20833
1987	34.19167	124.91846	8.54167	112.01318	19.52500
1988	36.26667	138.73808	9.90833	111.43264	22.05000
1989	38.45000	143.98924	10.41000	116.02913	23.05000
1990	40.72000	140.55234	10.88000	114.30831	23.97000
1991	43.07000	129.46423	11.34000	97.01665	24.87000
1992	45.45000	125.17257	11.79000	106.82077	25.75000

	PAPGAUB
1968	52.83332
1969	49.95833
1970	46.43333
1971	52.26527
1972	46.78611
1973	56.10834
1974	79.89444
1975	85.13612
1976	86.03055
1977	86.57916
1978	94.87638
1979	116.22222
1980	117.53333
1981	140.15833
1982	157.53888
1983	130.83612
1984	140.54721
1985	144.66112
1986	151.80280
1987	150.28333
1988	165.59998
1989	184.11662
1990	166.26663
1991	174.02498
1992	149.94162

BBY - beef byproduct values

LBY - lamb byproduct values

PBY - pigmeat byproduct values

PABFAUB - beef auction price adjusted for byproduct values

PALBAUB - lamb auction price adjusted for byproduct values

PAPGAUB - pigmeat auction price adjusted for byproduct values

Appendix 2: Raw Cost Component Indices and Aggregate Cost Indices

	WAGEAUI	ELECTI	INTI	COST1	COST2
1968	95.59524	99.05000	98.30500	95.74718	95.89912
1969	105.30476	101.75000	101.69490	103.80781	102.31085
1970	112.28571	107.55000	104.23730	109.80488	107.32404
1971	118.38571	106.55000	110.16950	115.36971	112.35371
1972	129.36665	108.70000	102.54240	122.67635	115.98605
1973	147.88095	112.80000	119.49150	139.51443	131.14792
1974	182.94286	123.25000	150.00000	171.43214	159.92143
1975	220.33334	137.25000	165.25420	203.16313	185.99294
1976	247.48096	149.35001	171.18640	225.62367	203.76640
1977	276.01428	160.85001	167.79660	247.66521	219.31612
1978	293.78094	173.35001	159.32201	260.96902	228.15707
1979	306.15759	186.25000	168.64410	272.93982	239.72203
1980	336.93237	204.45000	197.45760	302.16293	267.39346
1981	374.72382	237.75000	238.13560	339.93820	305.15259
1982	420.90479	299.60001	253.38980	383.04706	345.18933
1983	452.61905	348.60001	239.83051	409.69885	366.77869
1984	483.33810	362.54999	231.35590	432.86197	382.38580
1985	502.76187	373.24649	228.81360	448.11810	393.47430
1986	528.19043	386.65100	230.50850	468.78421	409.37796
1987	550.04761	403.78030	221.18640	485.49170	420.93579
1988	574.87140	423.47040	215.25420	505.18872	435.50604
1989	619.29242	443.92651	222.03391	541.56708	463.84167
1990	661.59521	463.19519	215.25420	574.20404	486.81290
1991	705.67139	480.21561	186.44070	604.64124	503.61102
1992	761.44287	498.50339	154.23730	643.46808	525.49329

WAGEAUI - wage rate index

ELECTI - electricity price index

INTI - interest rate index

COST1 - marketing cost index (75:10:15)

COST2 - marketing cost index (50:20:30)

Appendix 3 (a): SUR Model for Estimating Elasticity Values

Log of Likelihood Function = 207.356
Number of Observations = 25

Parameter	Estimate	Standard Error	t-statistic
B0	1.82109	.419844	4.33754
BB	-1.21226	.046278	-26.1950
BL	.718310	.089382	8.03639
BP	.495513	.116993	4.23541
BC	.394835	.070634	5.58988
BY	.467792	.095428	4.90201
L0	2.17325	.434154	5.00571
LB	.611350	.047856	12.7748
LL	-1.11859	.092429	-12.1022
LP	.208883	.120981	1.72658
LC	.704343	.073041	9.64307
LY	.058549	.098681	.593314
P0	2.60706	.372376	7.00115
PB	.335104	.041046	8.16405
PL	.255613	.079277	3.22432
PP	-1.01458	.103766	-9.77757
PC	-.018229	.062648	-.290977
PY	.189280	.084639	2.23631
C0	-2.73404	1.07034	-2.55437
CB	.934603E-02	.117981	.079216
CL	.590274	.227869	2.59041
CP	-.274430	.298259	-.920107
CC	-.650712	.180072	-3.61362
CY	1.42681	.243283	5.86481

Equation BFEQ: Dependent variable: LDCBFAU

Mean of dependent variable = 3.82921
Std. dev. of dependent var. = .201423
Sum of squared residuals = .016895
Variance of residuals = .675786E-03
Std. error of regression = .025996
R-squared = .982649
Durbin-Watson statistic = 1.95788

Equation LBEQ: Dependent variable: LDCLBAU

Mean of dependent variable = 2.81298
Std. dev. of dependent var. = .172964
Sum of squared residuals = .018066
Variance of residuals = .722638E-03
Std. error of regression = .026882
R-squared = .974839
Durbin-Watson statistic = 1.50638

Equation PGEQ: Dependent variable: LDCPGAU

Mean of dependent variable = 2.72525
Std. dev. of dependent var. = .127832
Sum of squared residuals = .013290
Variance of residuals = .531616E-03
Std. error of regression = .023057
R-squared = .966112
Durbin-Watson statistic = 2.55298

Equation CHEQ: Dependent variable: LDCCHAU

Mean of dependent variable = 2.85128
Std. dev. of dependent var. = .316485
Sum of squared residuals = .109804
Variance of residuals = .439215E-02
Std. error of regression = .066273
R-squared = .954323
Durbin-Watson statistic = 1.12458