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LIVESTOCK PRODUCTION POLICIES AND MEAT PROCESSING MARGINS: THE CASE OF NEW ZEALAND, 1967-1988*

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The New Zealand export meat industry has been through a considerable number of changes in the 1980s. The deregulation of export slaughter facilities, Supplementary Minimum Prices, Producer Board intervention, declining livestock numbers and domestic cost pressures have all affected the performance of the domestically based processing sector. Major changes in market access and demand have influenced off-shore marketing operations, particularly for sheepmeats. Additionally, there has been a change in the type of meat exported with a greater proportion of further processed product shipped in recent years. As an example of the impact of these developments on livestock producers, the producer share of the United Kingdom wholesale market return for a representative prime lamb carcase has fallen from 40 per cent in 1978 to 25 per cent in 1988.

In this article the pattern of intervention in the New Zealand pastoral meat industries from the mid-1960s is detailed, emphasising the different environments of the beef and sheepmeat enterprises. Then the principal factors influencing domestic processing margins for these products are empirically examined. Alternative model specifications and alternative estimation techniques are compared and contrasted. The results of these analyses are discussed in terms of the historical patterns of assistance and structural change, and in terms of current rationalisation pressures on the meat processing sector.

The New Zealand meat industry is a major contributor to foreign exchange earnings with the value of meat and byproducts comprising over 25 per cent of total merchandise export value. The marketing of meat destined for export is usually performed by private companies or

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farmer owned co-operatives under licences approved by the New Zealand Meat Producer's Board. The domestic component of the marketing chain for export meat covers from the farmgate to the port, with the slaughtering/processing sector being the largest segment of this chain. The costs of domestic processing and marketing services at present absorb 60 per cent of the FOB return for lamb and 45 per cent for beef (Zwart and Moore 1990).

Analysis of the farm-FOB margins for meats in New Zealand is important for several reasons. Recent research has shown that changes in domestic margins have had a significant influence on farmgate returns for livestock, along with industry assistance, exchange rates and world prices (Wallace and Reynolds 1990; Reynolds and Moore 1990). It is of interest to understand the determinants of these price transmission effects so as to explain variations in farm returns.

Additionally, there is concern currently about the specific role of processing charges in determining farmgate returns for livestock. In the last ten years the farm share of FOB sheepmeat returns has fallen from 65 to 42 per cent. During the same period, nominal killing charges for lamb have risen by 150 per cent (principally during 1980-1982). As a result of these developments, and changes in the mix of product exported toward more further processed packs, lamb returns at the farmgate have risen by much less than the rise in FOB returns. Finally, there is some question about the consequences of processor rationalisation and declining throughput on processing margins and hence on farmgate returns. If the processing sector decides on a self-rationalisation programme, will New Zealand livestock producers share in the expected benefits? Will the costs of rationalisation outweigh the benefits to these companies in the short to medium term?

The principal aim of this study is to determine and analyse the factors causing variations in processing margins for lamb, mutton and beef in New Zealand. This aim is achieved by the application of econometric analysis to published data and to data available to the Ministry of Agriculture and Fisheries. The following factors are considered to determine their contribution to variations in annual meat processing margins: market returns; throughput; processing costs; byproducts returns; hide and skin returns; extent of further processing; and industry assistance. Model specification is based on previous empirical research by Wohlgenant and Mullen (1987) as modified by knowledge of the market structure of the New Zealand meat processing sector.

The research provides information to those responsible for policy development within the New Zealand meat and livestock industries about the factors determining processing margins for meats, especially the effects of the decreasing throughput in the processing sector. Information is generated for subsequent analyses of the distributional impacts of changing industry structure or changing government policies. These impacts are likely to be seen in the size of processing

and marketing margins, retail prices and farmgate returns, and quantities supplied and demanded.

Intervention in the New Zealand Livestock Industries, 1967-1989[1]

Government policy changes

In 1975 a meat price stabilisation scheme was introduced, with both levy and deficiency payment aspects, and from 1978 the Supplementary Minimum Price scheme was established to provide guaranteed prices for up to two years ahead to assist farmer planning. However, the supplementary minimum prices and the Meat Industry Stabilisation Account price supplements had little effect until 1981/82. At that time the minimum price levels were raised substantially, market returns for lamb and mutton fell sharply and sheepmeat production was still expanding.

For a number of reasons (Griffith and Martin 1988; Zwart and Moore 1990) the Meat Board began purchasing all export sheepmeat from October 1982. During 1983 to 1985 the Board continued to control sheepmeat marketing but the cost to the Board to support producer sheepmeat prices during this period added up to $NZ 1 billion dollars. Producer price assistance and Board control over marketing were both ended in late 1985. The billion dollar debt accumulated in the stabilisation account over 1982-85 was written off in 1986 to 'clear the slate' as a one-off assistance and payment to meat producers and as partial compensation for the removal of supplementary minimum prices.

Changes in levels of sheepmeat and beef assistance and other variables are shown in Tables 1-4. The operation of the two schemes is described in Griffith and Martin (1988). Of particular note in Tables 1, 2 and 3 is the apparent rise in the FOB-farmgate margin for lamb, mutton and beef during the high assistance years. Also of note is the fact that in some years for mutton, the sum of the average pelt and wool schedule price and the value of all supplementary minimum price and stabilisation payments exceeded the average baremeat schedule price, exclusive of subsidies. Thus there was a negative imputed farmgate price equivalent for the meat portion of the mutton carcase.

The removal of these assistance schemes contributed to an initial rise but then a marked reduction in sheep numbers and throughput at processing facilities (see Table 5). Overcapacity problems have again become obvious. In the export meat processing sector prior to 1981, entry was controlled by strong licensing regulations. An 'economic need' criterion was used and this proved to be an effective barrier to entry (Sheppard and Fowler 1984). Export slaughtering/processing costs were estimated to be 50-100 per cent higher than in other countries (Pappas et al. 1985; Zwart and Moore 1990).

[1] The material summarised in this section is developed in more detail in Zwart and Moore (1990), 266-272.

TABLE 1
Lamb Prices, Margins and Assistance (c/kg)

Year	Actual Farmgate Price	Skin Value	Assistance Payments	Farmgate Price Equiv.	Domestic Margin	Export Price
1964/65	44	6	0	38	3	41
1965/66	41	5	0	35	2	38
1966/67	33	5	0	28	8	35
1967/68	40	11	0	29	11	41
1968/69	49	11	0	38	7	44
1969/70	44	7	0	38	11	48
1970/71	42	9	0	34	15	49
1971/72	38	10	3	25	20	45
1972/73	68	21	0	47	17	64
1973/74	70	15	0	55	23	78
1974/75	47	8	8	31	39	70
1975/76	73	17	0	56	27	83
1976/77	98	30	0	68	40	108
1977/78	92	27	0	65	45	110
1978/79	109	33	5	71	59	131
1979/80	118	26	4	88	65	153
1980/81	124	9	4	111	75	186
1981/82	164	19	27	118	60	178
1982/83	168	19	94	54	146	200
1983/84	176	26	118	32	166	198
1984/85	191	54	83	55	170	225
1985/86	108	40	56	12	189	201
1986/87	165	88	7	70	203	273
1987/88	124	70	1	54	175	229
1988/89	146	63	1	82	185	267

Source: see Appendix 1
Export price – domestic margin = farmgate price equivalent
Farmgate price equivalent + skin value + assistance payments = actual farmgate price

TABLE 2
Mutton Prices, Margins and Assistance (c/kg)

Year	Actual Farmgate Price	Skin Value	Assistance Payments	Farmgate Price Equiv.	Domestic Margin	Export Price
1964/65	18	4	0	13	7	20
1965/66	18	3	0	15	3	18
1966/67	16	1	0	15	5	20
1967/68	16	4	0	12	3	16
1968/69	17	8	0	10	9	19
1969/70	23	5	0	18	6	24
1970/71	17	4	0	12	14	26
1971/72	14	5	2	7	16	24
1972/73	53	11	0	43	–3	40
1973/74	41	6	0	35	28	63
1974/75	15	3	0	12	31	43
1975/76	31	14	0	17	25	42
1976/77	53	22	–6	37	27	64
1977/78	44	20	1	23	53	76
1978/79	55	21	2	32	46	79
1979/80	58	25	3	30	81	112
1980/81	63	7	2	55	63	118
1981/82	55	10	9	35	93	128
1982/83	66	15	17	34	50	83
1983/84	76	21	10	45	98	143
1984/85	92	43	80	–31	159	128
1985/86	22	36	29	–43	258	215
1986/87	58	47	2	10	149	159
1987/88	56	56	1	–1	160	159
1988/89	54	46	1	7	157	164

Source: see Appendix 1
Export price – domestic margin = farmgate price equivalent
Farmgate price equivalent + skin value + assistance payments = actual farmgate price

TABLE 3
Beef Prices, Margins and Assistance (c/kg)

Year	Actual Farmgate Price	Skin Value	Assistance Payments	Farmgate Price Equiv.	Domestic Margin	Export Price
1964/65	27	7	0	20	27	47
1965/66	27	7	0	29	25	54
1966/67	33	7	0	27	34	60
1967/68	42	6	0	37	32	69
1968/69	45	6	0	39	43	82
1969/70	59	7	0	52	35	87
1970/71	55	6	0	49	45	94
1971/72	51	7	0	44	57	101
1972/73	73	10	0	64	55	119
1973/74	48	8	0	40	88	128
1974/75	31	7	0	23	61	84
1975/76	54	8	0	47	59	106
1976/77	60	12	0	48	72	120
1977/78	66	12	2	53	86	139
1978/79	119	13	5	101	98	199
1979/80	122	19	−1	103	142	245
1980/81	124	14	7	103	150	253
1981/82	148	15	16	117	148	265
1982/83	162	16	13	132	206	338
1983/84	169	26	3	140	197	336
1984/85	236	41	1	194	214	408
1985/86	165	36	4	126	195	321
1986/87	164	38	2	123	250	372
1987/88	172	47	2	124	233	356
1988/89	222	41	2	179	230	409

Source: see Appendix 1
Export price – domestic margin = farmgate price equivalent
Farmgate price equivalent + skin value + assistance payments = actual farmgate price

TABLE 4
Payments to Farmers Under the SMP Scheme and MISA Account Balances ($M)

Commodity	Season							Total
	1978/79	*1979/80*	*1980/81*	*1981/82*	*1982/83*	*1983/84*	*1984/85*[a]	
Lamb	0	0	0	93.9	146.5	213.2	93.8	547.4
Mutton	0	0	0	8.7	11.6	48.4	37.9	106.6
Wool	1.4	0	0	184.2	176.7	78.8	0.7	441.8
Sheep Industry	1.4	0	0	286.8	334.8	340.4	132.4	1095.8
Beef	0	0	1.9	53.3	17.6	0	0	72.8
Dairy	17.4	0	0	0	0	0	0	17.4
TOTAL	20.2	0	1.9	340.1	352.4	340.4	132.4	1186.0
MISA Account Balance (approx.)	32.0	22.9	(0.9)	(64.6)	(350.6)	(495.6)	(852.2)	(1010.0)

Sources: NZ Meat Producers' Board *Annual Reports* and MAF *Agricultural Statistics* — various issues.
[a] payments from a transitional lump sum grant
Meat season ends 30 September
Wool season ends 30 June
Dairy season ends 31 May

TABLE 5
New Zealand Inspected Livestock Slaughterings ('000 head)

Seasons Ended 30 September	Lambs	Adult Sheep	Adult Cattle
1970/71	27,118	9,270	1,814
1971/72	27,842	8,613	1,771
1972/73	26,684	10,328	2,031
1973/74	22,997	8,762	1,790
1974/75	25,428	7,094	2,137
1975/76	25,961	6,592	2,573
1976/77	25,417	6,900	2,287
1977/78	26,392	7,706	2,408
1978/79	26,051	7,378	2,133
1979/80	28,692	7,460	2,015
1980/81	32,306	9,143	2,056
1981/82	32,115	9,021	2,173
1982/83	35,995	9,234	2,156
1983/84	34,711	8,895	1,771
1984/85	39,961	10,740	1,981
1985/86	34,669	6,709	1,882
1986/87	31,627	9,302	2,279
1987/88	30,414	7,927	2,222
1988/89[P]	30,302	9,757	2,289

[P] provisional
Source: NZ Meat Producers' Board *Annual Reports*

In 1980, the economic need criterion of the licensing regulations was removed and this allowed freer entry into the processing sector. However, most of the effects of delicensing were not felt until after the removal of the supplementary minimum prices which was coincident with the relinquishing of sheepmeat trading by the Board. The supplementary payments and Board trading losses served to maintain artificially both levels of throughput and profitability of processing activities (see also Griffith and Grundy 1988). The implementation of the price support policies in the livestock sector substantially delayed necessary adjustments in the meat processing sector. Beef producers received only small supplementary and stabilisation payments, so beef processing and marketing was much less affected than sheepmeats.

There was no direct regulation of processing charges except for the general wage-price freeze in 1982/83 and a lump sum payment made by the government in 1978 in compensation for a mandated wage award. Indirectly, processing charges may have been affected by the government's variable contribution to the funding of meat inspection,

the setting of a 'national' weekly meat schedule by processing firms and the commission-based fees paid by the Board to processors.

Trends in livestock numbers, prices and margins

Trends in prices are provided in Tables 1-3 above. Trends in pastoral sector outputs (processing throughput) are shown in Table 5 and Figure 1. Note the effects of the asymmetrical treatment of sheepmeats under the assistance policies in particular. The Livestock Incentive Scheme from the mid 1970s helped to stimulate an increase in sheep numbers to 1981 and these numbers were kept high by the supplementary minimum prices.

As shown in Table 3 and Figure 2 export beef processing margins in the 1980s have largely followed export returns. The marketing environment has been reasonably stable with relatively little output assistance. On the other hand, lamb margins experienced a dramatic increase from 1983 and only recently has the export price and the farmgate price showed coincident movement.

Prices for representative lamb and beef products during the period 1979-1989 are shown in Figure 2. The margin between market and farmgate returns for beef has only increased slightly in the post-1984 period. For the lamb margin though, the effects of both Board trading activity and price support payments over the 1982-1985 period can be seen clearly. The assistance payments and increasing processing costs have led to a weaker relationship between FOB and farm prices.

Processor adjustments

As a consequence of these disruptions to market signals, adjustments in the processing sector which should have occurred in the early 1980s were delayed, with only 4 chains (2 works) closed during the period of high assistance payments. However some 41 beef and sheep chains closed from 1986 to the end of 1989.

Adjustment in the processing sector which has occurred recently has resulted in average plant size decreasing, but labour productivity of the processing sector has actually increased (Savage 1990). The industry still has overcapacity (estimated in 1989 at 40-45 per cent) but further rationalisations are occurring amongst processors. Another adjustment which has occurred is in labour markets. Wages in the meat processing sector traditionally have been 50 per cent higher than national averages, but since 1985 real wages have fallen and in 1989 wage rates were only 20 per cent higher than the national average. Industry rationalisation had reduced total employment in mid 1989 by 30 per cent while output per employee had risen by 25 per cent (Savage 1990).

FIGURE 1
Sheep / Beef Numbers (millions)

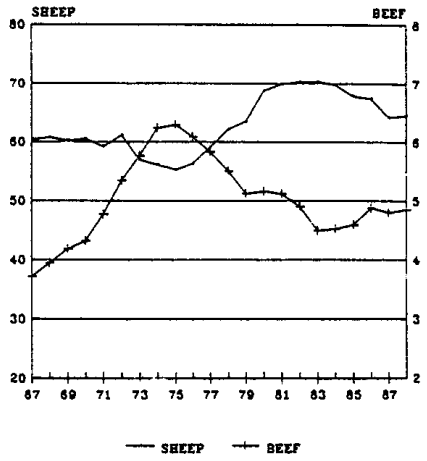
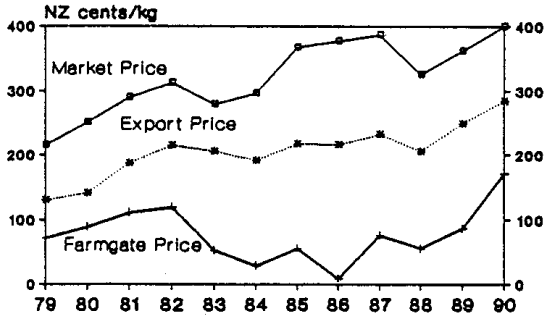


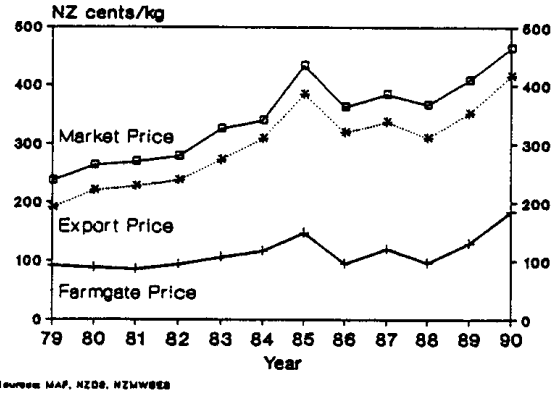
FIGURE 2
Returns to Meat Exports 1979-1989

Lamb to the UK



(NB: Farmgate Prices net of assistance and skin values)

Manufacturing Beef to the USA



Sources: MAF, NZDS, NZMWBSB

Model Specification and Data

The analysis of marketing margins or price spreads has progressed down two paths (see also Digby 1989). The first type of analysis deals with the *short-run behaviour of margins*. Here the emphasis is on disequilibrium behaviour by market participants and the dynamics of price formation and transmission. Typically data of weekly or monthly periodicity, or sometimes quarterly, are used in these models. Hypotheses examined include price levelling and price averaging (Parish 1967; Griffith 1974; Naughtin and Quilkey 1979); the influence of risk in the short-run (Griffith and Duff 1989); asymmetric patterns of behaviour (Heien 1980; Ward 1982; Kinnucan and Forker 1987; Schroeder 1988); the effect of storage behaviour (Wohlgenant 1985); and the influence of short-run variations in throughput (Griffith 1974; Griffith and Duff 1989).

The second type of analysis relates to the *long-run behaviour of margins*. Static equilibrium models are the norm with annual or rarely quarterly data being employed. The focus of these models tends to be on the longer-term effects of throughput and costs (Gardner 1975; Fisher 1981; Wohlgenant and Mullen 1987); risk response (Brorsen et al 1985,1987; Grant et al 1985) or the influence of changes in market structure (Hall, Schmitz and Cothern 1979; Griffith and Gill 1985).

In this study the latter type of analysis is used. The ultimate objective of this research is to provide an empirical framework for the evaluation of the distributional consequences of restructuring proposals and possible changes in Government policy toward the New Zealand meat industries. Since the policy analyses are predominantly concerned with longer-term issues, then the economic framework used to derive the expected outcomes needs to be long-term as well.

Alternative equation specifications for a competitive margin model

The specification of the processing margin model for each meat type and an aggregate of all types, assuming a competitive marketing environment, is taken from previous work by Wohlgenant and Mullen (1987). Based on earlier theoretical developments by Gardner (1975) and Heien (1977), they derive two alternative models and compare them to a standard markup pricing model (see for example George and King 1971):

$$\text{Margin} = f(\text{retail price, costs}).$$

This is equation (1) in the Appendix Tables. Both estimated coefficients in this equation are expected to have positive signs. The first alternative model is the 'relative price' specification:

$$\text{Margin} = f(\text{retail price, (retail price x quantity), costs}).$$

This model is derived from an industry-wide specification of competitive processor behaviour, where the quantity bought by processors

(assumed identical to the quantity sold by processors) will depend on the price of the farm input, the price of other marketing inputs and the price of the retail product. Quantity will also be invariant to proportional changes in input and output prices, so this relationship can be expressed as:

> Quantity = f(ratio of farm to retail price, ratio of marketing costs to retail price).

With farm livestock supply predetermined and retail price effectively determined by demand, farm price is determined by the inverse processor's behavioural relation:

> Ratio of farm to retail price = f(quantity, ratio of marketing costs to retail price).

With prices measured in the same units, the ratio of the margin to retail price is equal to 1 - ratio of the farm to retail price, or:

> Ratio of margin to retail price = f(quantity, ratio of costs to retail price).

Then multiplying both sides by retail price gives:

> Margin = f(retail price, (retail price x quantity), costs)

when the constant term is accounted for. Thus the relationship between the margin and the retail price changes as output and relative marketing input prices change.[2] All coefficients in this equation are expected to be positive. This 'relative price' specification is numbered equations (2) and (3) in the Appendix Tables, where (2) includes a constant term and (3) has the constant omitted.

The second alternative model of Wohlgenant and Mullen (1987) is the 'real price' specification, which is based on the notion of the margin being the price of a collection of marketing services. Firms in a competitive market would be expected to provide these market services to the quantity where the marginal value of these services is equal to their marginal cost of provision:

> Margin = f (quantity, costs)

where f is the marginal cost function of providing the given bundle of marketing services. With f homogeneous of degree one both the margin and input cost variables can be deflated by, say, a general price index.

[2] In the results which follow, the term (retail price x quantity) is denoted as 'revenue'. The emphasis on the 'retail' price comes from the domestic market orientation of the Gardner model and the fact that most previous work related margins to retail price in a simple mark-up model. Of course, since this analysis is concerned not with margins in the domestic retail market but with margins in the export marketing chain, the 'retail' price is actually the price at the upper level of the market sector being analysed — the FOB price.

This is how the 'real price' specification is derived. Both coefficients are expected to be positive. This is equation (4) in the Appendix Tables.

Wohlgenant and Mullen (1987) find the 'relative price' margin specification best explains variations in United States beef margins.

Alternative equation specification for an augmented margin model

In addition to these basic theoretical specifications of the beef, lamb, mutton and aggregate margin equations, variables related to value added, levels of industry assistance and byproduct returns are also considered as potential determinants of New Zealand meat margins. An index of the extent of value added is included because there has been a marked change in the type of meat exported with a greater proportion of further processed product shipped in more recent years (New Zealand Meat Producers' Board 1989). The levels of industry assistance are included for each meat type because of the apparent rise in processing margins during the high assistance period (Tables 1-3), while the addition of byproduct returns reflects the increased recognition given to these co-products as components of the overall return to the producer.

Thus the most general model specification would include retail price, quantity and costs, as well as all these augmenting variables:

> Margin = f(retail price, quantity, costs, value added index, assistance payments, hides/skins price, other byproducts price).

The coefficients on the value added, assistance, and hides and skins price variables are all expected to be positive, while the coefficient on the other byproducts' price is uncertain *a priori*. If these other byproducts are joint products derived in fixed proportions from the live animal, then the expected sign would be positive since, as with hides and skins, a price increase for byproducts means processors could offer a reduced price for the meat portion of the carcase. With no change in the FOB meat price or throughput, the margin would expand. If, however, there is some element of variable proportions at the margin in the supply of these other byproducts (ie, less trimming when the price of meat is relatively high), then a price increase for byproducts means more byproducts produced and less meat. To maintain throughput, processors have to offer more for the meat portion of the carcase. With no change in the price of meat, the margin would contract and the expected sign would be negative. This possibility of variable proportions in the production of byproducts is consistent with a growing awareness of the limitations of a fixed proportions assumption (Wohlgenant and Haidacher 1989) and with some empirical evidence on the supply of meat meal in Australia (Griffith, Henry and Godden 1980). These augmented models are equations (5) and (6) in

the Appendix Tables, where (6) if required is the preferred specification.

Both the competitive and augmented models are static with longer term dynamic adjustments not allowed. Even though annual data are used, this assumption may be limiting when adjustments in processing capacity are considered.

Data and methods

Margin calculation procedures: The theoretical basis on which meat margins have been calculated and analysed has been well developed over the past two decades. The original work was done at the United States Department of Agriculture (see for example United States Department of Agriculture 1972) with the procedures modified for local conditions by various staff in NSW Agriculture & Fisheries (for example Griffith et al. 1991). These procedures are now well documented in various publications and are not spelt out in detail here. The one critical check that needs to be made is that the prices at the different levels of the marketing system must be in terms of an equivalent quantity of product. In the analyses which follow, all prices were expressed on a per kg basis in terms of carcase weight.

Data definitions and sources: The definitions of the variables used in the following analyses and their sources are given in Appendix A. Although data on most variables are available over 1965-1989, the analysis was restricted by a few missing observations to 1967-1988. All price and value data were deflated by the wholesale non-tradable price index.

Estimation techniques: Two estimation techniques were employed in the following analyses. In the results reported in Table B1 and Tables B3 to B5, ordinary least squares regressions were run on the specified equations. In the results reported in Table B2, seemingly unrelated regressions were run on the lamb, mutton and beef equations together. This method was used to account for the interrelationships between the margins. Most large works have both beef and sheepmeat chains and, therefore, the possibility exists of cross-subsidisation between the different meats and correlation between the error terms of the individual equations.

Results

The detailed results of the analyses for lamb, mutton, beef and the aggregate form are reported in Appendix B. In each Appendix Table the explanatory variables are listed down the lefthand margin and the specified equation numbers across the top. Under each estimated coefficient are the computed t values and calculated elasticities at the data means for coefficients of statistical interest. The summary statistics reported are the adjusted R^2 and the Durbin-Watson statistic for first-order autocorrelation. Note that the $\overline{R}^2$ from the ordinary least

squares, autocorrelation-corrected regression and seemingly unrelated regression methods are all calculated slightly differently and so are not directly comparable. The preferred seemingly unrelated regression results are collated and reported in Table 6. Formal specification tests are not carried out on these equations beyond testing the significance of individual coefficients and the provision of the summary statistics. As shown below, the augmented models clearly dominate the competitive models in all cases and that is the main point to be made, not discriminating between the various competitive models as done by Wohlgenant and Mullen (1987).

Lamb domestic margin

Equations (1)–(4) in Table B1 represent the three theoretically based specifications. Firstly, the $\bar{R}^2$ of these equations were quite low and there were potential autocorrelation problems with the residuals. However, correcting the equations for autocorrelation gave an insignificant value for the first-order autocorrelation coefficient (RHO). Additionally, in each equation large errors were evident for the 1975 and 1982 observations. Price had a consistent negative sign, although only marginally significant, and cost and throughput were uniformly significant explanatory variables. The large size (>1) of the estimated cost elasticity values suggests that lamb processing in New Zealand may be a cost-plus activity (see also Clemes and Wood 1985). The revenue specification was not significant. It is certainly not evident that the specification favoured by Wohlgenant and Mullen (1987) provides an enhanced explanation with this data set.

Equations (5)–(6) represent the equation specifications with variables added based on knowledge of the structure and operation of the New Zealand meat processing sector. These additional variables include industry assistance payments, byproduct revenues, skin revenues and the extent of value added processing (Moore 1988). With the addition of these variables, cost remained a significant variable but with a reduced elasticity value, and assistance payments, skin value and the extent of value added were also highly significant. Byproduct price was not significant, while FOB price was still negative but not significant, and throughput became negative and non-significant. These non-significant variables were omitted in the preferred specification. Compared with equations (1)–(4), in these augmented equations the $\bar{R}^2$ values were also improved, the residuals were better behaved, and the 1975 and 1982 errors were smaller. Further, these results held for alternative measures of skin values.

Autocorrelation-corrected versions of equations (5) and (6) were run as well, but in each case the t value on the estimated autocorrelation coefficient was insignificant, the $\bar{R}^2$ values fell and there was no appreciable change in coefficient values or their significance levels.

The seemingly unrelated regression results for lamb are reported in Table B2 along with those for mutton and beef. The first equation in

each set is the full specification, while the second is the preferred equation based on that in the individual tables of results. The results for lamb were very close to the ordinary least squares results.

TABLE 6
Preferred Estimates, Farm-FOB Margin, 1967-1988

Explanatory Variables	Lamb	Mutton	Beef	Aggregate
C	–2.626 (–3.88)	2.845 (6.80)	–0.631 (–2.73)	0.585 (1.63)
FOB Price		0.332 (3.74) [0.54]	0.641 (7.30) [1.13]	0.288 (2.64) [0.51]
Throughput		–0.0119 (–5.74) [–3.00]		–0.00091 (–2.48) [–0.70]
Cost	0.838 (2.66) [0.59]		0.667 (4.23) [0.42]	1.089 (3.96) [0.74]
Assistance	0.693 (4.96) [0.14]	1.871 (7.67) [0.15]		0.898 (4.43) [0.06]
Byproducts		–0.302 (–1.23) [–0.15]	–0.951 (–3.03) [–0.21]	–0.902 (–3.98) [–0.27]
Hide/Skins	0.459 (1.95) [0.21]	–1.105 (–3.05) [–0.37]		0.921 (2.85) [0.21]
Value added	2.553 (4.11) [3.00]			
R^2	0.81	0.82	0.83	0.87
DW	2.74	2.49	1.81	2.01

t statistics in (.); elasticity with respect to the margin in [.].
See text for details.

Mutton domestic margin

Equations (1)–(4) in Table B3 again represent the three theoretically based specifications. The $\overline{R}^2$ of these equations are again low, especially (1), and autocorrelation problems seemed important, although a correction gave an insignificant value for the autocorrelation coefficient. Price, throughput effects and the revenue variable were all significant explanatory variables. Cost was positive and reasonably significant. Additionally, there were large errors in the 1973/74 and 1985/86 periods, including the calculated negative margin in 1973 (see also Table 2). Again the 'revenue' specification favoured by Wohlgenant and Mullen (1987) does not provide an outstanding explanation, although it is probably the best of this set of equations.

Equations (5)–(6) represent the equation specifications with the augmenting variables included. Price remains a significant variable as does throughput and assistance, while cost and skin values were not significant, and byproduct revenues were of only marginal significance. The negative coefficient on byproducts provided some support for the variable proportions argument though. The $\overline{R}^2$ values were substantially improved, the residuals were acceptable and the model predicted the large fall in 1973 and the rapid rise in margins in 1985 and 1986. Again these results held for alternate measures of skin returns and for an aggregate of all byproduct revenues.

The seemingly unrelated regression results for mutton reported in Table B2 are again very close to the ordinary least squares results and in addition the R^2 value is increased. The skin value was highly significant but has the opposite sign to that expected.

Beef domestic margin

The $\overline{R}^2$ values of equations (1)–(4) in Table B4 were generally high (except for (4)) and there were no obvious autocorrelation problems with the residuals. There were, however, large errors in the observations for 1970, 1974 and 1985. Price, throughput effects and cost were all significant explanatory variables. The revenue specification favoured by Wohlgenant and Mullen (1987) did not provide a good explanation with this data set.

Equations (5)–(6) represent the equation specifications with the augmenting variables added. Cost and price remained significant variables although throughput did not, and byproduct values were a significant addition. Hides revenue, value added and assistance levels were not significant. The $\overline{R}^2$ value was marginally improved.

Equation (6) is the preferred equation for this dependent variable, and the similar level of explanatory power of this equation compared with the sheepmeats equations is noted. Large errors remained in the 1970 and 1974 values but they were smaller than in equations (1)–(4) above.

The results of the seemingly unrelated regression estimation of the system of lamb, mutton and beef equations are reported in Table B2.

The results for beef were almost identical to the ordinary least squares results and the equation summary statistics were improved slightly.

Aggregate domestic margin

The $\bar{R}^2$ values of equations (1)–(4) in Table B5 were very low and there were obvious autocorrelation problems with the residuals which had to be corrected. Cost was a highly significant explanatory variable, while price effects were of lower significance levels. Throughput, and the revenue specification favoured by Wohlgenant and Mullen (1987), did not provide a good explanation with this data set.

Equation (5) represents the specification with the augmenting variables added. Cost remained a significant variable, all new variables were significant additions, and the significance levels of price and throughput were substantially improved. Assistance payments in particular were very highly significant explanators of the aggregate farm-FOB margin. The $\bar{R}^2$ values were much higher and the residual structure showed no sign of autocorrelation. Additionally in this equation there were no large errors, whereas in each of the other equations, there were many large misses, particularly in the 1974 and 1983 observations. These were years of rapid increases in the real all-products farm-FOB margin.

Conclusions and Implications

Summary

Econometric analysis of New Zealand meat processing margins has indicated that the price transmission mechanism in the sheepmeat industry has been markedly different from that experienced for beef. In the case of lamb the study found that output price assistance, processing costs and revenues from skins were the main determinants of margins and hence farmgate returns from exports. The amount of further processing was also important in some versions of the lamb equation. For mutton, export prices and throughput were the major determining factors, but assistance payments and byproduct and skin revenues were also significant. Thus sheepmeat processing and marketing firms were able to increase margins during high assistance periods. The important result is that price transmission in the sheepmeat processing sector has been disrupted by government intervention in livestock production.

Beef margins on the other hand were found to be determined principally by export prices, costs and byproduct revenues, suggesting greater efficiency in price transmission and competition than with sheepmeats.

There was a consistent negative and mostly significant coefficient on the byproducts variable. This provides some evidence of substitution between the output of meat and the output of edible byproducts in the New Zealand meat processing industry.

From a methodological point of view it is interesting also that none of the Wohlgenant and Mullen (1987) models worked very well, evidence perhaps for the common perception that the New Zealand meat processing industry does not approximate a competitive market environment. This leads to a possible limitation of the models presented here in that changes in the structure of the industry described earlier have not been incorporated explicitly (Griffith and Gill 1985).

Another limitation of the work is the reliance on a static model of processor adjustment to changes in the economic environment. This assumption may be restrictive when adjustments in long term processing capacity are considered.

Implications

This paper has illustrated how adjustment in the New Zealand meat processing sector was delayed by government and Meat Board price policies for livestock producers, particularly for sheepmeats. Producers and processors had less incentive to adjust livestock production or processing capacity until removal of assistance measures in late 1985. Possible applications of the results obtained here include an analysis of the distribution of the economic impacts across producers, consumers and the processing and marketing sector of the benefits from further cost efficiences in the New Zealand meat processing sector and the possible further rationalisation of the overcapacity problem.

For lamb, beef and the three meats in aggregate, the cost elasticities are positive and highly significant. For mutton the cost elasticity is positive though insignificant. A ten per cent reduction in the costs of processing may be expected to lead to about a seven per cent reduction in the aggregate processing margin. The benefits of this should flow to processors and marketers, to producers and to domestic and foreign consumers. The actual distribution of these benefits can be assessed by applying the Freebairn, Davis and Edwards (1982) and subsequent (Mullen, Alston and Wohlgenant 1989) types of analysis.

However, for mutton and the three meats in aggregate, there is a highly significant negative effect of throughput on domestic processing margins. Thus, as the New Zealand pastoral livestock sector contracts, margins will expand if the current structure remains. Implications arise for the application of the standard benefit distribution models when such a situation occurs, particularly for measuring the benefits to the processing sector.

A possible explanation for this is that livestock and other inputs into processing are used in variable, not fixed, proportions (as assumed implicitly here). Wohlgenant and Haidacher (1989, p.8) have recently shown that 'substitution possibilities between the farm product and marketing inputs provides a theoretical justification for this observed margin behaviour.' In the United States food industry such substitution possibilities were found to exist and to be quite high. Work is proceeding to attempt to test this explanation with these data.

APPENDIX A
Data Definitions and Sources

Variable Name	Definition (all $/kg except where noted, 1967-1988 June year)	Source
1. Domestic beef margin data		
Farm-FOB margin	Farm-FOB margin = FOB price–schedule price	calculated
FOB price	Average FOB price for all beef exported	NZMWBES (1989)
Cost	Total costs for processing, storage, transport and overheads (including profits) of a representative 160kg cow	NZMPB Survey
Schedule price	Average baremeat schedule price for manufacturing and prime beef, exclusive of subsidies	MAF database
Throughput	Total beef production, bone-in, local and export slaughter (000 tonnes)	MAF database
Hide price	Value of 'hide credit' to producer	NZMPB (1989) (Note 1)
Assistance	Value of supplementary minimum prices and stabilisation payments to beef	MAF (1987) Griffith and Martin (1988)
Value added	Ratio of price/kg shipped weight to price/kg carcase equivalent (index base 1.0)	MAF database
2. Domestic lamb margin data		
Farm-FOB margin	Farm-FOB margin = FOB price–schedule price	calculated
FOB price	Average FOB price for all lamb exports	NZMWBES (1989)
Cost	Total costs for processing, storage, transport and overheads (including profits) of a representative 14.2kg lamb	NZMPB Survey
Schedule price	Average baremeat schedule price for all lamb grades, exclusive of subsidies	MAF database
Throughput	Total lamb production, bone-in, local and export slaughter (000 tonnes)	MAF database
Skin price	Average schedule price for pelt and wool for all lamb grades	MAF database
Assistance	Value of supplementary minimum prices and stabilisation payments to lamb	MAF (1987) Griffith and Martin (1988)
Value added	Ratio of price/kg shipped weight to price/kg carcase equivalent (index base 1.0)	MAF database
3. Domestic mutton margin data		
Farm-FOB margin	Farm-FOB margin = FOB price–schedule price	calculated

FOB price	Average FOB price for all mutton exports	NZMWBES (1989)
Cost	Total cost for processing, storage, transport and overheads (including profits) of a representative 20kg ewe	NZMPB Survey
Schedule price	Average baremeat schedule price for all mutton grades, exclusive of subsidies	MAF database
Throughput	Total mutton production, bone-in, local and export slaughter (000 tonnes)	MAF database
Skin price	Average pelt and wool schedule price for all mutton grades	MAF database
Assistance	Value of supplementary minimum prices and stabilisation payments to mutton	MAF (1987) Griffith and Martin (1988)
4. Domestic aggregate margin data		
Farm-FOB margin	Farm-FOB margin = FOB price – schedule price	calculated
FOB price	Average FOB prices of lamb, mutton and beef weighted by production volumes	NZMWBES (1989)
Cost	Total costs for processing, storage, transport and overheads (including profits)	NZMPB Survey (Note 2)
Schedule price	Average baremeat schedule price for lamb, mutton and beef, weighted by production volumes, exclusive of subsidies	MAF database
Throughput	Total lamb, mutton and beef production, bone-in, local and export slaughter (000 t)	MAF database
Byproducts	Byproduct revenue received by processing companies for sale of all byproducts except skins and hides	MIA NZ Dept Stats
Assistance	Average of supplementary minimum price payments and stabilisation payments weighted by production volumes	MAF (1987) Griffith and Martin (1988)
5. Other data		
	NZ wholesale non-tradeables price index, base 1982 = 100. To 1976, wholesale price index of service industry outputs; from 1976 producer price index of outputs	NZ Dept Stats

Note 1:
This is normally offset against processing charges but is treated as a separate variable here (available 1976 onwards).

Note 2:
1967-1974: NZ Department of Statistics, Statistics of Industrial Production; 1974-1987: MIA, Surveys; 1988-1989: Interpolated using previous relativities between MIA data and average of individual product costings from NZMPB. The MIA survey changed the measurement of throughput starting in 1984. These new 'kill units' were not able to be reconciled with previous production figures. Unit cost figures were interpolated using the relativities between total production and previous survey figures for 1984-1987.

APPENDIX B
Detailed Regression Results

TABLE B1
Lamb Farm-FOB Margin, 1967-1988

Explanatory Variables	Equation Number					
	1	2	3	4	5	6
	competitive models				augmented models	
C	0.145 (0.42)	0.073 (0.19)		–0.931 (–2.45)	–1.857 (–1.29)	–2.618 (–3.54)
FOB Price	–0.286 (–1.89) [–0.64]	–0.355 (–1.73) [–0.80]	–0.345 (–1.79) [–0.77]		–0.105 (–0.50)	
Throughput				0.0023 (2.09) [0.99]	–0.00036 (–0.22)	
Revenue		0.00045 (0.52)	0.00051 (0.65)			
Cost	2.064 (5.36) [1.48]	1.858 (3.32) [1.33]	1.865 (3.43) [1.34]	1.455 (3.45) [1.04]	1.066 (2.08) [0.76]	0.921 (2.78) [0.66]
Assistance					0.674 (3.08) [0.14]	0.703 (4.48) [0.14]
Byproducts					–0.161 (–0.39)	
Hides/Skins					0.634 (2.11) [0.28]	0.530 (2.11) [0.24]
Value Added					1.992 (1.93) [2.36]	2.443 (3.53) [2.90]
$\overline{R}^2$	0.56	0.55	0.57	0.58	0.75	0.78
DW	1.41	1.34	1.32	1.34	2.50	2.41

t statistics in (.); elasticity with respect to the margin in [.].
See text for details.

TABLE B2
Lamb, Mutton and Beef Farm-FOB Margins, 1967-1988

Explanatory Variables	Beef		Lamb		Mutton	
	1	2	1	2	1	2
C	–0.837 (–1.06)	–0.631 (–2.73)	–1.899 (–1.53)	–2.626 (–3.88)	3.238 (7.64)	2.845 (6.80)
FOB Price	0.639 (6.19) [1.13]	0.641 (7.30) [1.13]	–0.136 (–0.78)		0.460 (5.00) [0.75]	0.332 (3.74) [0.54]
Throughput	–0.00021 (–0.28)		–0.00042 (–0.29)		–0.0122 (–6.25) [–3.01]	–0.0119 (–5.74) [–3.00]
Cost	0.587 (2.73) [0.37]	0.667 (4.23) [0.42]	1.079 (2.59) [0.76]	0.838 (2.66) [0.59]	–0.632 (–2.36) [–0.50]	
Assistance	0.688 (0.48)		0.668 (3.73) [0.14]	0.692 (4.96) [0.14]	1.884 (8.19) [0.15]	1.871 (7.67) [0.15]
Byproducts	–1.223 (–3.44) [–0.27]	–0.951 (–3.03) [–0.21]	–0.093 (–0.28)		–0.529 (–2.24) [–0.27]	–0.302 (–1.23) [–0.15]
Hides/Skins	1.295 (0.94)		0.580 (2.29) [0.26]	0.459 (1.95) [0.21]	–1.257 (–3.84) [–0.42]	–1.105 (–3.05) [–0.37]
Value added	0.101 (0.33)		2.100 (2.50) [2.49]	2.533 (4.11) [3.00]		
$\bar{R}^2$	0.84	0.83	0.82	0.81	0.90	0.82
DW	1.97	1.81	2.55	2.42	2.74	2.49

t statistics in (.); elasticity with respect to the margin in [.].
See text for details.

TABLE B3
Mutton Farm-FOB Margin, 1967-1988

Explanatory Variables	Equation Number					
	1	2	3	4	5	6
	competitive models				augmented models	
C	–0.225 (–0.63)	–0.077 (–0.24)		1.714 (2.20)	2.364 (3.80)	2.232 (3.79)
FOB Price	0.255 (1.09) [0.42]	1.523 (2.92) [2.49]	1.520 (2.99) [2.49]		0.505 (3.38) [0.83]	0.445 (3.57) [0.73]
Throughput				–0.0085 (–2.46) [–2.08]	–0.0094 (–3.03) [–2.32]	–0.0095 (–3.09) [–2.33]
Revenue		–0.0068 (–2.68) [–2.04]	–0.0069 (–2.84) [–2.04]			
Cost	1.112 (1.93) [0.87]	0.806 (1.55) [0.63]	0.729 (1.80) [0.57]	1.028 (2.10) [0.81]	–0.289 (–0.75)	
Assistance					1.582 (4.21) [0.12]	1.540 (4.20) [0.12]
Byproducts					–0.709 (–1.88) [–0.37]	–0.595 (–1.75) [–0.31]
Hide/Skins					–0.552 (–1.20) [–0.18]	–0.541 (–1.19) [–0.17]
$\overline{R}^2$	0.22	0.41	0.44	0.38	0.78	0.76
DW	1.31	1.28	1.30	1.44	1.78	1.91

t statistics in (.); elasticity with respect to the margin in [.].
See text for details.

TABLE B4
Beef Farm-FOB Margin, 1967-1988

Explanatory Variables	Equation Number					
	1	2	3	4	5	6
	competitive models				augmented models	
C	–0.269 (–0.91)	–0.263 (–0.87)		1.510 (3.17)	–0.435 (–0.45)	–0.066 (–0.16)
FOB Price	0.423 (5.69) [0.75]	0.470 (4.34) [0.83]	0.435 (4.35) [0.77]		0.613 (4.97) [1.09]	0.619 (5.90) [1.09]
Throughput				–0.0025 (–2.52) [–0.65]	–0.00074 (–0.90)	–0.00092 (–1.23) [–0.24]
Revenue		–0.00018 (–0.60)	–0.00019 (–0.64)			
Cost	0.638 (2.88) [0.40]	0.733 (2.68) [0.46]	0.617 (2.60) [0.38]	1.306 (3.99) [0.81]	0.703 (2.70) [0.44]	0.688 (3.05) [0.43]
Assistance					–0.039 (–0.02)	
Byproducts					–1.322 (–3.02) [–0.29]	–1.171 (–3.04) [–0.25]
Hide/Skins					1.185 (0.70)	
Value Added					0.028 (0.07)	
$\overline{R}^2$	0.71	0.70	0.72	0.42	0.77	0.79
DW	2.20	2.17	2.16	2.23	1.95	1.65

t statistics in (.); elasticity with respect to the margin in [.].
See text for details.

TABLE B5
All Products Farm-FOB Margin, 1967-1988

Explanatory Variables	Equation Number				
	1	2	3	4	5
	competitive models				augmented model
C	–0.194 (–0.58)	–0.267 (–0.74)		0.127 (0.25)	–0.585 (–1.63)
FOB Price	0.200 (1.61) [0.36]	0.402 (1.87) [0.72]	0.339 (1.65) [0.61]		0.288 (2.64) [0.51]
Throughput				–0.00020 (–0.42)	–0.00091 (–2.48) [–0.70]
Revenue		–0.00019 (–0.96) [–0.37]	–0.00016 (–0.80) [–0.37]		
Cost	1.154 (2.79) [0.79]	1.210 (2.72) [0.82]	1.007 (3.08) [0.68]	1.545 (4.31) [1.05]	1.089 (3.96) [0.74]
Assistance					0.898 (4.43) [0.06]
Byproduct					–0.902 (–3.98) [–0.27]
Hides/Skins					0.921 (2.85) [0.21]
$\overline{R}^2$	0.39	0.40	0.40	0.35	0.87
DW	2.07	2.16	2.10	1.97	2.01
RHO	0.52 (2.82)	0.64 (3.80)	0.61 (3.51)	0.42 (2.09)	

t statistics in (.); elasticity with respect to the margin in [.].
See text for details.

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