Meat - Marketing

Lincoln College

AGRICULTURAL ECONOMICS RESEARCH UNIT

SCIENTIA ET INDUSTRIA CUM PROBITATE

AN ECONOMETRIC MODEL OF THE NEW ZEALAND MEAT MARKET

by

C. A. YANDLE

Technical Paper No. 7

THE AGRICULTURAL ECONOMICS RESEARCH UNIT

The Unit was established in 1962 at Lincoln College with an annual grant from the Department of Scientific and Industrial Research. This general grant has been supplemented by grants from the Wool Research Organisation and other bodies for specific research projects.

The Unit has on hand a long-term programme of research in the fields of agricultural marketing and agricultural production, resource economics, and the relationship between agriculture and the general economy. The results of these research studies will in the future be published as Research Reports as projects are completed. In addition, technical papers, discussion papers, and reprints of papers published or delivered elsewhere will be available on request. For a list of previous publications see inside back cover.

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P R E F A C E

The marketing research programme of the Agricultural Economics Research Unit is naturally heavily concentrated on market relationships in overseas countries where most of our problems lie. However, we have long felt that we should not ignore research or problems concerned with the home market - if only because economic research on New Zealand domestic marketing questions provides an excellent training ground for graduates destined eventually to work on the more pressing overseas marketing problems.

In this spirit we initiated in 1966 a research project on the New Zealand Meat Market and the present paper represents the results of part of the work carried out.

Specifically Mr Yandle gives here the results of using an econometric model to estimate some of the basic economic parameters which are involved in the formation of prices and in the determination of consumption of meat in New Zealand over time.

The research on which the paper is based was partly supported by grants from the Canterbury Frozen Meat Company and the New Zealand Pig Producers' Council whose assistance we gratefully acknowledge.

November 1968 B.P. Philpott

EDITORIAL NOTE

This publication is one of a series based on a thesis by Mr C.A. Yandle entitled "An Econometric Study of the New Zealand Meat Market", written for the Degree of Master of Agricultural Science at Lincoln College.

The papers in this series will be:-

A.E.R.U. Publication No. 43, "Survey of Christchurch Consumer Attitudes to Meat". This is ch.2 of the thesis, available at https://hdl.handle.net/10182/1349

A.E.R.U. Technical Paper No. 3, "The Theory and Estimation of Engel Curves: Some Estimates for Meat in New Zealand". This is Ch.3 of the thesis, available at https://hdl.handle.net/10182/3301

A.E.R.U. Technical Paper No. 7, "An Econometric Model of the New Zealand Meat Market". This paper includes Ch.1, 4,5,6, and 8 of the thesis.

A.E.R.U. Discussion Paper No. 8, "Quarterly Estimates of New Zealand Meat Price, Consumption and Allied Data, 1946-1965". This is Ch.7 of the thesis, available at https://hdl.handle.net/10182/1152

In this series of publications no attempt has been made to alter the original thesis presentation, thus where, in a particular publication, a section of the thesis is not presented, page numbering has not been corrected and foot-note cross references may in some cases refer to page numbers not included in the same publication.

This publication comprising Chapters 1, 4, 5, 6 and 8 of the thesis, is concerned with the aggregate time series model developed to explain the complex relationships which influence meat price formation and consumption in New Zealand. The institutional framework is examined in the first chapter, followed by a development of the model to be used for estimation in Chapters 4 and 5. Alternative estimation techniques are reviewed in Chapter 6, while the final chapter contains the detailed model estimates, and some policy discussion.

Chapters 2 and 3 of the thesis comprise the analysis of data from a survey of Christchurch consumers and form the basis of A.E.R.U. Research Report No. 43 and Technical Paper no. 3.

Chapter 7 of the thesis discusses the data used for the econometric model and is reported in A.E.R.U. Discussion Paper No. 8.

CHAPTER 1

MARKET STRUCTURE OF THE MEAT INDUSTRY IN NEW ZEALAND: THE FATSTOCK MARKETING SYSTEM

Introduction

The marketing system for meat products in New Zealand is, in many respects, unusual. Institutionally, the system is one of private enterprise working under government regulation.

In terms of the marketing problem, the industry must allocate supplies between the export and internal markets. There is therefore a strong price relationship between these markets, even though government licensing forces some physical separation.[1] A description of the system is therefore appropriate before specification of an econometric model can be attempted. The description here will start at the point of sale by the producer, and follow the marketing chain through to the consumer.

Sale by the Producer

The producer has several alternative methods of selling fatstock,[2] he may;

(i) sell on 'schedule' to the export slaughterhouses;

(ii) sell at saleyards to buyers for the internal or external trade;

(iii) sell by private treaty on the farm to a butcher, butcher's buyer, or export buyer;

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1. Export slaughterhouses and local supply abattoirs are licensed separately.
2. In this description only fatstock marketing will be outlined.

(iv) sell on 'owner-account', or through a producer co-operative.

The quantitative importance of the alternative sale methods is difficult to assess due to a lack of statistics. Selling on schedule is however almost certainly the major sale method. Approximately sixty-six per cent of New Zealand's annual meat production is exported.[1] In addition, export meat operators supply substantial quantities of meat for the internal trade. As the meat operators mostly buy on schedule, it is probable therefore that this is the major method of fatstock sale.

The 'schedule' is a price list published weekly by the export meat operators, listing dressed carcase price per pound they are prepared to pay for specific classes and grades of fatstock. Meat operators assess overseas market trends, and on the basis of their expectations of future prices set an f.o.b. price for bare meat in each category. From this they deduct killing charges, and add the expected value of by-products.[2]

For all exported meat there is a deficiency-payment scheme operated by the New Zealand Meat Board.[3] A deficiency payment is made when the f.o.b. price for bare meat falls below the gazetted minimum (published at the beginning of each meat year) for that particular meat type. Because the majority of New Zealand fatstock is sold on schedule, the schedule price plus any deficiency payment will have a strong influence on the level of prices ruling in other fatstock markets. No meat producer will sell stock in other markets if he can obtain a higher price

1. Government of New Zealand, New Zealand Official Yearbook, Wellington, 1966, p. 394.

2. New Zealand Meat Board, Annual Report, Wellington, 1953, p. 22. This report gives an example of the estimation procedure. The schedule calculation has recently been modified, however it remains basically as described.

3. New Zealand Meat Board, Annual Report, Wellington, 1962, p. 26. This report described the mechanism by which the board operates this scheme.

by selling on schedule. In choosing between alternative sale methods the producer must however assess the value of meat on the animal. This is because he is choosing between liveweight and deadweight sale methods. Personal judgement will therefore blurr the certainty of choice.

Owner-account selling gives producers the right (by law) to have their fatstock processed, shipped, and sold overseas using the facilities of the export works and the meat operator's sales organisation. The meat producer who sells by this method accepts all the marketing risks, the meat operator becoming his agent for which he is paid a commission to cover the costs of marketing.

Often there is slight advantage in selling by this method, but if the producer thinks the schedule price is set too low in the light of his expectations of market trends he can sell by this method. This is similar to selling through the producer co-operatives;[1] both these forms of sale give producers for the export market an alternative to forced sale to the large meat operator companies, thus reducing the possibilities of monopsonistic exploitation of the fatstock producer. Monopsonistic exploitation is possible because the method of setting the weekly schedule ensures that there must be aspects of price collusion present. Export operators confer at the end of each week and consider any changes they will make to the price schedule for the coming week. Because an agreed price is always reached, there is no advantage to any one firm in taking the role of 'price leader'. Thus competition between firms for the producer's livestock tends to be in the form of secondary services, and not directly through price.

Undesirable aspects of this price collusion can be minimised

1. 'Primary Producers' Co-operative Society' (P.P.C.S.) in the South Island, and 'Producer Meats' in the North.

within the present institutional structure. Firstly there are alternative methods of sale open to meat producers, including taking the marketing risks himself (owner-operators). This, however, is not a widespread practice among producers. Secondly the New Zealand Meat Board and the Government could advise producers that they think the current schedule is too low in the light of market expectations. This would enable the individual producer to benefit from a larger organization's resources in regard to market information, when deciding on a method of sale. In fact neither the Meat Board nor the Government have ever done this. The producer is therefore less well informed when making his decision. Whether or not the meat operators have exploited the producer is a separate study and no attempt is made to answer that question here.

Other forms of sale open to producers are all on a liveweight basis. The majority of stock sold by these methods are destined for internal consumption, although some export buyers will buy stock on the hoof.

Individual butchers, or a buyer for a group of butchers, will often buy privately from producers, inspecting stock on the farm and paying a negotiated price. There are many variations of this method of sale, but all can be classed as private treaty purchase. Similarly many examples of vertical integration in the marketing chain are possible other than the above. These will not be dealt with separately as they combine individual stages in the marketing process covered separately in this description.

Stock saleyards hold regular auctions of fatstock in association with sale of all classes of store-stock. Individual butchers, group buyers, butcher co-operative association buyers, buyers for firms wholesaling meat within New Zealand, and buyers for exporters all attend these sales. A large part of internal meat requirements are met by the last two methods; a quantitative estimate is not however possible.

To a large extent the schedule prices of the meat operators will set the level of farm-gate prices for fatstock. As previously outlined, it is the major method of sale by producers and moves in response to export stimuli. Producers will not sell on schedule if they are of the opinion that other methods of sale will yield higher returns, and vice-versa.

This generalisation cannot be carried too far when dealing with specific meats (or the associated class of fatstock). Where export demand does not dominate the internal market for a particular type of meat, higher returns by selling for the internal market are quite possible and do occur.

TABLE 1.1

PERCENTAGE OF NEW ZEALAND'S MEAT PRODUCTION CONSUMED WITHIN NEW ZEALAND.

Year ended 30th Sept.	Beef	Veal	Mutton	Lamb	Pigmeat
1960	45.4	28.2	50.8	5.6	88.3
1961	45.8	29.0	50.4	5.5	90.8
1962	42.8	30.8	49.3	6.8	92.2
1963	44.0	31.6	53.1	6.8	89.8
1964	43.5	33.8	50.2	6.9	89.6
1965	48.2	37.7	50.4	6.5	85.9
Six Year Average	45.0	31.9	50.7	6.4	89.4

Source: Monthly Abstracts of Statistics.

Table 1.1 shows the percentage of New Zealand meat production consumed within the country for the six years 1960 to 1965, and the average for those years. These figures suggest that the export price should dominate the local market for all meats except pigmeats, where local market forces should predominate. Three other factors are relevant though.

(a) Seasonal supply factors.

(b) Grades of meat consumed locally, and grade exported.

(c) Whether the supply to the New Zealand market is fresh or frozen.

The New Zealand consumer demands, and for the most part gets, freshly killed chilled meat. This means for a seasonal meat such as lamb there are times of the year when virtually all the lambs coming forward for sale are destined for the internal trade. Even though New Zealand consumes only 6.4 per cent of total lamb production, local market forces will dominate the market with a substantial premium at the beginning of each new season (July, August, and into September). For the remainder of the year market conditions in the United Kingdom will dominate.

The grade of meat consumed internally is of importance with both beef and mutton. Exports of these meats tend to be of the lower quality grades, old ewe mutton and boner beef predominating. Higher quality grades of these meats are mostly consumed within New Zealand, although some higher quality meat is exported. Premiums above schedule can therefore be expected for meat destined for the local trade when there is a separation of the internal and export markets owing to seasonal or quality factors.

At the farm-gate level the New Zealand market is very complex. The New Zealand market for meat is a protected market, but is strongly influenced by overseas prices through exports. How important the overseas market forces are in determining price of meat internally is discussed in more detail later in this study. A priori it may be expected that for beef, veal, mutton and lamb the influence of export price is likely to be strong for the majority of the year. For pigmeats the local market should dominate; there is some evidence for this in that internal wholesale prices of pigmeats have risen substantially above world price in recent years. However marginal supplies exported still have some influence on farm-gate prices in the February to May period.

Processing and Wholesaling

The processing of livestock into products is carried out by several different marketing institutions in New Zealand. Processing for export is carried out at licensed export works, of which there are thirty-nine, plus a few abattoirs which hold export licenses. Rigid hygiene and grading regulations are enforced by New Zealand Government and Meat Board inspectors respectively.

Meat for internal consumption is slaughtered at municipal abattoirs, rural slaughterhouses, export slaughterhouses, with some meat slaughtered on farms for on-farm consumption. Abattoirs are provided by municipal authorities, and will slaughter stock for anyone, charging a fee for the service. Because the prime consideration in providing these slaughter facilities is the provision of fresh, hygienic meat for local residents, the abattoirs often incur a loss. To counter this the local authorities have the right to demand killing charges on all meat sold within their area, regardless of where the stock were slaughtered.[1] There are forty-one abattoirs in New Zealand.

Rural slaughterhouses are provided in areas where abattoir facilities are not warranted. The scale of operations is much smaller, and usually the staff is not permanent. At a typical rural slaughterhouse

1. New Zealand Government Statute 1964/7, 'Meat Act', Section 23, pp. 16-19, Wellington, 1964.

stock will be slaughtered on one or two days each week by local butchers under the supervision of a government appointed veterinary officer.

Because abattoir facilities are available to anyone, there are many alternative ways of selling fatstock destined for local consumption. The major alternatives will be outlined here, but there are numerous variations which can and do occur.

Purchase of stock for slaughter by individual butchers, or a buyer who works for butchers on a commission basis, is frequent. In doing this the butcher is integrating the wholesale and retail marketing functions. Butcher co-operatives are a highly organised form of this type of buying. The co-operative operates as a wholesaler, with the shareholding in the co-operative restricted to the butchers who purchase the co-operative's meat. End of year payment of profit is calculated on the proportion of the co-operative's sales to any one retailer. Often the co-operatives process their own bye-products, including the butcher's waste.

Private wholesaling companies, wholesaling meat in direct competition to the co-operatives, provide a strong element of competition in the market. The strongest competition comes from the meat export companies which sell meat wholesale within New Zealand, generally through subsidary companies. The proportion of meat entering the local trade from meat export works has increased markedly in the post war period.

Of the individual meats shown in Table 1.2, pigmeat is the only one for which the percentage entering the internal trade from meat export works has declined. This has been due to an increase in the percentage of total production now consumed internally, combined with the growth of local market processing and wholesaling companies. The participation of the exporting companies in the local trade shows further the strong influence of overseas realisations from export

TABLE 1.2

SOURCE OF MEAT FOR INTERNAL CONSUMPTION - SHOWN AT POINT OF SLAUGHTER*

Year ended 30th Sept.	Abattoir	Export Meat Works	Rural Slaughterhouse	Killed on Farms
BEEF (thousand tons)				
1947	45.1	31.7	15.8	0.6
1955	56.5	25.6	12.4	0.7
1965	76.2	36.3	5.2	1.3
MUTTON (thousand tons)				
1947	22.4	9.1	6.3	11.9
1955	29.1	20.5	4.9	12.8
1965	39.2	24.3	2.7	19.2
LAMB (thousand tons)				
1947	2.0	2.7	0.3	0.7
1955	2.3	5.3	0.1	1.1
1965	6.5	11.0	0.2	1.8
PIGMEATS (thousand tons)				
1947	8.2	14.8	0.9	0.8
1955	11.8	16.7	0.9	0.7
1965	18.1	18.3	0.7	0.8

Quantity of Meat from Meat Export Works as a Percentage of Total Consumption in New Zealand 1947 and 1965 (Year ended 30th September)

	1947	1965
Beef	18.2	30.5
Mutton	18.3	28.5
Lamb	47.4	57.3
Pigmeat	59.7	48.3
All meat	26.3	34.6

* The quantities of meat entering the internal market from meat exporters may not be identical with 'stock slaughtered at export works for the local market', as is shown in this table. This is because export slaughterhouses will slaughter on contract for outside firms. Such arrangements are however minor, and the general trends shown in the table will not be affected.

Source: New Zealand Department of Agriculture.

meat on the local market. Stock purchased on schedule prices, determined largely by overseas conditions, are competitively marketed in New Zealand on a long-term basis.

Retailing

Retailing meat in New Zealand is largely in the hands of specialised butchers' shops. In recent years there has been an increase in the handling of meat by general food stores, but this form of sale remains but a small proportion of total meat sales.[1] A major function of the retailer is to break up carcass meat into cuts the consumer wants. He must price these cuts in a manner which enables him to dispose of the whole carcass, the total return from the saleable portions covering the wholesale cost of the carcass plus the butcher's margin. While it is possible for the retailer to buy meat in quarters, rather than sides or carcasses, it is less profitable and hence not common.

Butchers also tend to 'level' and 'average' prices. Price levelling occurs when there is (say) an increase in wholesale price and the butcher does not increase his retail prices, expecting wholesale price to decline in the future. This enables the retailer to recover an average expected margin over a period of time. The affect of this is to make consumption changes for a given price change at the wholesale level less elastic than might otherwise have been expected, i.e. lowers the price elasticity of demand at wholesale. Price averaging occurs when the butcher takes a lower margin on one meat than on another, averaging the margin over all meats to place him in a more competitive position.

The meat retailer is subject to laws regarding hygiene, specification of cuts, posting of price information, and in two

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1. See Chapter 2, pp. 29-30.

periods since the war was subject to price control. As meat is a major food item in the New Zealand household there is always some political pressure for the control of meat prices.

The first period of control was an extension of wartime price control, and was continued until May 1950. Up to February 1949 retail prices were fixed, and variation in retail prices was allowed only when prolonged variation in wholesale prices occurred. From February 1949 to May 1950, both wholesale and retail prices were fixed. While the fixing of wholesale prices under present market conditions is unrealistic (they are largely set by external forces), bulk-purchase agreements with the United Kingdom were still operating during the first period of price control, giving steady export prices. Fixing of wholesale prices by price order was therefore possible.

Price control was re-introduced on the 7th March 1960, and lasted until 30th November 1961. During this second period retail prices were pegged to a set margin above wholesale prices. Any change in retail prices in this period was consequently fixed on the basis of a change in wholesale prices. Detailed mechanics of the method used are available from the New Zealand Gazette.[1] Calculation of the per lb. wholesale to retail margin over this period showed that there was a reduction in the margin when compared to the periods preceding and following price control.[2] It was difficult to measure the absolute effect of price control as the margin was subject to constant fluctuation (due to levelling and averaging). An attempt has been made however to estimate the effect of price control, and is reported with the general model results.

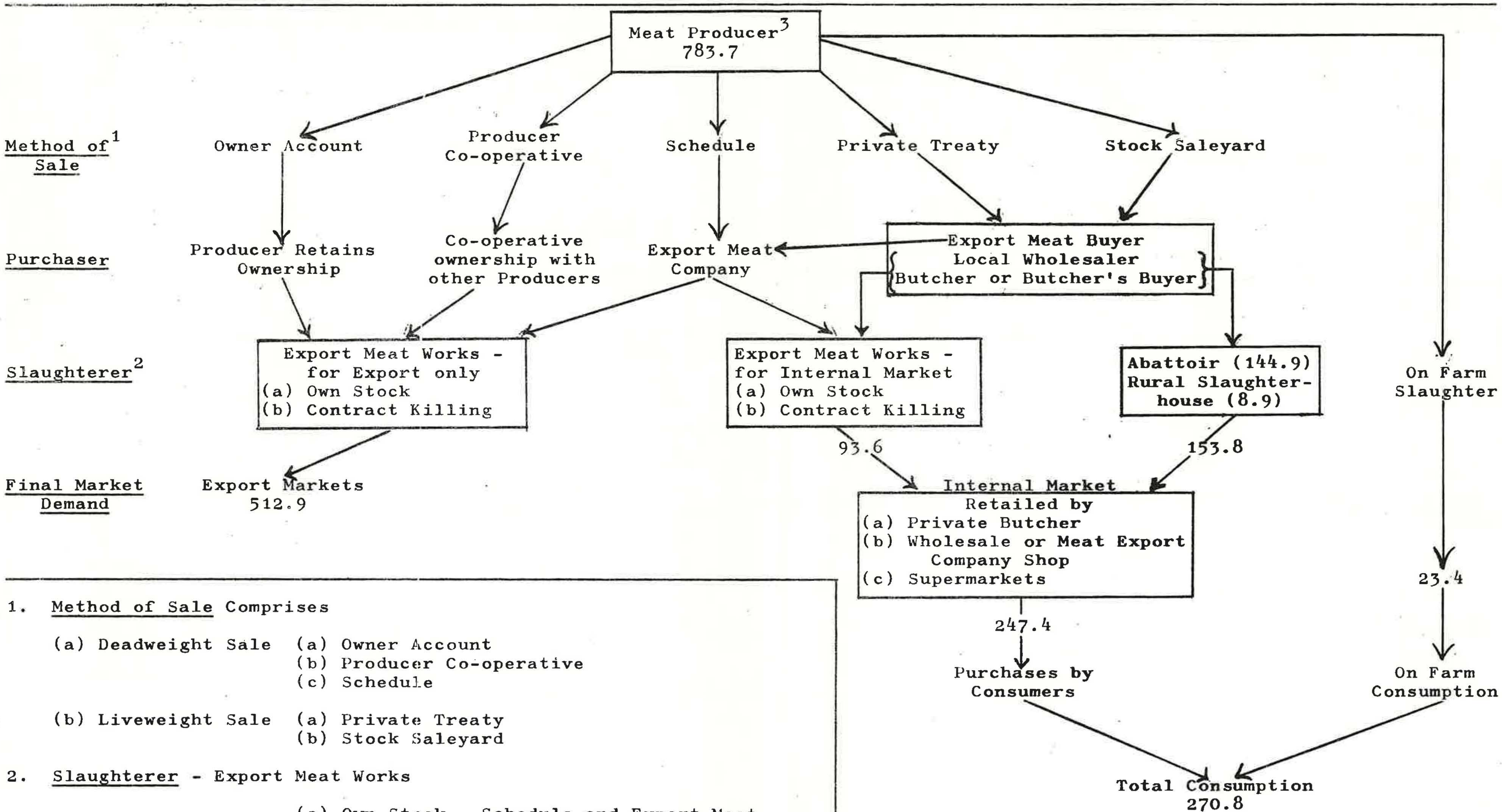
Diagram 1.1 presents a summary of the foregoing description in the

1. Government of New Zealand, New Zealand Gazette, Wellington, 3rd March 1960, No. 15, p. 295.

2. Appendix D, Quarterly Time-Series Data.

DIAGRAM 1.1

FLOW DIAGRAM OF THE MEAT PROCESSING AND MARKETING CHANNELS WITHIN NEW ZEALAND.



1. Method of Sale Comprises

   (a) Deadweight Sale (a) Owner Account
   (b) Producer Co-operative
   (c) Schedule

   (b) Liveweight Sale (a) Private Treaty
   (b) Stock Saleyard

2. Slaughterer - Export Meat Works

   (a) Own Stock - Schedule and Export Meat Buyer Purchase
   (b) Contract Killing for Export - Owner Account and Producer Co-operative
   (c) Contract Killing for Internal Market - Local Wholesaler and Butcher or Butcher's Buyer

3. Note: Figures refer to Carcass Meat Weights (000 tons), Year ended 30th September 1965.

form of a flow diagram. Figures in the diagram show the relevant quantities (in thousand tons) for the 1965 period. It is not possible to quantify all movements of stock or carcass meat. The diagram shows the relationship between the export and internal markets, and the critical role the meat operators buying on schedule play. Being the largest group of fatstock buyers, and able to operate on both internal and export markets, the meat operators price for stock (i.e. schedule price) will set the general market prices for all fatstock.

Special Aspects of the Pigmeat Market

Production Aspects

In the past, pigmeat production has very largely been a complimentary product to butterfat dairying. Pigs have been fed on skimmed milk, with a minimum of supplementary feed which has been either purchased or grown.

Within this general relationship pig numbers have tended to fluctuate inversely to the price of butterfat. It would seem that when the dairy farmer was in a difficult financial position he looked for ways of increasing revenue. With the skimmed milk available, pig farming has in the past been the normal method of achieving this extra revenue. This system of using the dairy bye-products as food for pigs during the butterfat season is now undergoing rapid change.

There has been considerable increase in tanker collection of whole-milk from butterfat farms, instead of just collecting cream. This method of collection is now virtually universal throughout New Zealand. At the same time, the dairy industry has shown increased interest in greater utilisation of the solids-not-fat portion of milk. The result has been to greatly reduce the skimmed or whey milk available for pig food.

There is at present concern in the pigmeat industry as to the direction of future development. Total production of pigmeats has remained almost static since 1950 at around forty thousand tons per annum, while local consumption has risen from seventy-one per cent of production in 1950 to as high as ninety-two per cent in 1962, and falling from this high to eighty-five per cent in 1965. The fall being due to a slight rise in production and slight decline in consumption.[1] The effect on current and future pig production of more efficient collection and utilisation of milk by the dairy industry is shown in Table 1.3.

TABLE 1.3

NUMBERS OF PIGS ON NEW ZEALAND FARMS FOR SELECTED YEARS.

Year	Pig Numbers (000)
1954	628
1958	628
1961	655
1962	686
1963	766
1964	771
1965	716
1966	667
1967*	612

* Estimate

Source: Monthly Abstracts of Statistics, October 1967.

During the 1950's pig numbers fluctuated around the levels shown for 1952 and 1958. Under the influence of rising prices for pigmeats, and lowered prices for dairy products, pig numbers rose until 1964. By 1964 the change to tanker collection of milk reduced the traditional source of pig food (skimmed milk). This combined with the stable prices for butter and cheese resulted in decreased interest in pig production

1. In 1965 there was a case of trichinosis contracted from eating pigmeats. At the time there was widespread publicity of the case; this could have been partly responsible for the decline in consumption in that year.

on the part of dairy farmers. The result has been a rapid decline in pig numbers, with current pig numbers approximately the same as the early 1950's.

If pigmeat production is to continue in New Zealand an alternative source of feed must be found. Many people in the industry think future pig production must come from intensive pig raising units using concentrate feeding methods. It seems reasonably certain that this will occur, especially in the grain producing areas of the South Island. The problem is at what price does this method of producing pigmeat become profitable. Preliminary studies show[1] that profitability of this type of enterprise is very sensitive to the price of meal, number of pigs fattened per sow, and the product price.

Assuming a pig meal price of £29-0-0 per ton, with nine pigs weaned per litter and 2.1 litters per sow per year, then a dead weight price for baconer pigs of 24d/lb. would return six per cent on the capital involved in a commercial piggery, all other factors being paid current rates of return. If the product price were 26.4d/lb., the return on capital becomes 13.25 per cent.

On the same basis, if there were a decline of one pig per litter reared, and the number of litters dropped to two per year, then at 26.4d/lb. for the product, the return on capital declines to 4.7 per cent. As the meal costs comprise very nearly seventy per cent of the total production costs, the profitability of the enterprise is even more sensitive to meal costs than the factors discussed above. Even considering the capital invested in a pig producing enterprise of this nature as a 'sunk cost', it is evident that a relatively high elasticity of

1. O. Kingma (personal communication). Mr Kingma has made some preliminary investigations of intensive pig producing units by linear programming. The results are shown here to indicate a likely range of producer prices, and to illustrate the profitability problems the producer faces.

supply will become a feature of the pig producing industry as it moves further toward intensive production, meal feeding units.

Although this study does not attempt to derive production and supply elasticities, the relevance of their magnitude to projection work is very clear once the consumer's price elasticity of demand is known.

Marketing Aspects

The pig marketing chain is more complex than for other meats because some pigmeats require specialised treatment. Porkers, pigs destined for the pork trade, are marketed in the same way as other stock. Porkers are pigs up to 100 lb. deadweight. Baconers, pigs between 100 lb. and 200 lb. deadweight, require an additional stage of processing, that of curing.

Where baconers are purchased by the export works, the export operator will often act as a storer of pigs for the curers. Thus curers can buy their requirements as frozen whole carcasses, or wiltshire sides (boned and frozen baconer sides) when they are required. If the curer buys live pigs he will often have them killed on a commission basis at the export works, or an abattoir. Few curers have their own slaughter facilities.

Selling methods open to producers are as for the other meats, but the schedule price (based on export realisations) is often below real market price. There is a marked internal premium above schedule of several pence per pound operating for most of the year in New Zealand. This premium is around 3d/lb. for baconers, and 6d/lb. for porkers. Most pigmeat for export is bought in the February - May period at which time the premium is at a minimum level. From May to September there is a higher premium for pork to ensure fresh pork coming forward over the winter. Local demand and supply conditions are therefore the major influence in setting market prices for pigmeats, and the export market is largely for the disposal of small surpluses in production at whatever price can be obtained.

Between different pigmeats, the price relationship is more complicated. Whether a producer decides to sell pigs as porkers or baconers will largely depend upon the porker/baconer price ratio. The processing industry therefore has the ability to influence the ratio of baconer to porker pigs coming forward for sale. Other factors will also influence the relative supply of porkers or baconers. If the milk production season has been good, for example, pigs are more likely to be finished as baconers. When intensive pig units become more common, it may be expected that the price ratio will have an increased effect on the relative supply.

In setting the relative prices for porkers and baconers the processing industry must also take into account consumers' reaction to prices in terms of changed demand for pork, and ham and bacon. With the stockpiling of hams for Christmas this becomes a medium term forecast of future demand. There is at present no quantitative estimate of the effect on supply or demand of a change in the porker/baconer price ratio. In this study no direct assessment will be made of the ratio, but demand elasticities for pork, and ham and bacon, should indicate the size of consumer demand reaction.

Bacon and ham prices differ widely at the retail level, but follow the same general price movements.[1] These two products come in fixed proportions from the same carcase (baconer), therefore the baconer price reflects demand levels for both bacon and ham. Differences in retail price for the two products have two causes. Firstly, the processing costs of bacon and ham are not the same. Secondly, as the two products are produced in fixed proportions, the product for which there is a

1. Chapter 7. pp. 174-176.

greater demand will therefore sell at a higher price. The product with a lesser demand may even sell at a price below the purchase price of the pig plus processing costs, simply to clear the market. Profit margins thus being made up on the product which has a relatively greater demand.

Apart from pork, which is marketed in a similar way to other meats, pigmeat marketing is carried out by a different marketing chain. Bacon curers usually manufacture smallgoods and market bacon, ham and smallgoods under their own brand name, performing the functions of wholesale distribution as well as manufacturing. Retail outlets are not restricted to butchers' shops. Grocers, food stores, and dairies all sell bacon, ham, and smallgoods. Competition for retail outlets by wholesalers is intense, but shows as increased services (e.g. daily delivery) rather than decreased wholesale prices. Manufacturers also try to create a brand consciousness through advertising, a practise which is rare in other sections of the meat trade.

The method of production of pigs does create problems for the processing industry. In a good milk season pigs are retained past the porker stage and finished as baconers. According to members of the trade a good milk season can cause a decrease of five per cent in the proportion of total pig production finished as porkers. In addition, in a year of high milk production up to forty per cent of the baconers can be overfat. Processors could institute more rigorous grading of baconer pigs, but resist the temptation to do so because they think this would be likely to push more dairy farmers out of pig production. As intensive pig units become more common, however, tighter grading standards can be expected.

Consumption of Meat in New Zealand

Per capita consumption of meat in New Zealand is one of the highest in the world, but of a different pattern to most other countries. New Zealanders consume relatively more sheepmeats and less pigmeats than other countries, with the exception of Australia. While there are no figures available for poultry consumption in New Zealand, present consumption is slight and probably in the region of 5lb./person/year, but likely to grow rapidly with the introduction of low cost production methods used in the United States and Europe.

TABLE 1.4

CONSUMPTION PER CAPITA (LB/PERSON/YEAR) OF RED MEATS IN VARIOUS COUNTRIES IN 1963*

	Beef and Veal	Lamb and Mutton	Pigmeats	Total
New Zealand	111	96	33	240
Australia	101	88	20	209
United Kingdom	53	23	47	123
Canada	80	4	51	135
U.S.A.	99	5	65	169
Argentine	170	11	14	195
France	69	6	48	123

Table compiled from: Commonwealth Economic Committee, Meat, London, 1964, No. 16.

* Statistics apply to years ending in different months as shown in the above volume, and are presented here for illustrative purposes only.

In the period 1950 to 1965 total per capita meat consumption has remained reasonably static, substitution between meats has not been large; sheepmeats rising slightly and beef falling slightly, probably due to a relative decline in sheepmeat prices compared with beef.[1]

Consumption of sheepmeat in New Zealand is mainly in the form of hogget-mutton. Pigmeat consumption is split almost equally between pork and smallgoods on the one hand, and bacon or ham on the other. New Zealanders tend to regard pigmeats as luxury meats rather than

1. Chapter 7, pp. 171-174.

staple food items, as the consumption figures show.

Pork is mostly consumed fresh, very little frozen pork is consumed in New Zealand. To ensure adequate supplies there is a winter premium for fresh pork, production during the winter period is more expensive as butterfat dairy farms do not produce milk over the winter.

Ham is consumed mainly in the summer months, stockpiling of hams occurs from April right through to the Christmas period, incurring storage costs in the region of $\frac{1}{4}$d/lb/month. Bacon tends to be less of a seasonal food, but its consumption could be associated with the price of its complements (e.g. eggs and tomatoes), the production and price of which varies seasonally.

Discussion

The objective of this chapter has been to describe the operation of meat marketing and processing in New Zealand. Detailed cost analysis of the various stages is not attempted, this is a separate research project in itself. In describing the market operations the foundation is laid for econometric model building, which is described in Chapters 4 and 5.

In using the marketing framework outlined, the interpretation will be primarily on the importance of the many price making forces on the internal market. As Chapter 4 shows, the inter-relationships between the export and internal sector require a different model to that normally used in aggregate time series demand analysis. It can be concluded here that for lamb, mutton, and beef the f.o.b. price for exported meat is the major price determining factor in New Zealand for most of the year. For pigmeats, local market forces predominate. These conclusions have great bearing on the ultimate form of the model.

The institutional background described will also have relevance in other sections of this study. Analysis of econometric results and policy recommendations, are but two of the major areas where a knowledge of the actual marketing framework can be of importance. The special circumstances of pigmeat production requires some far reaching policies if the pig industry is to retain its share of the New Zealand market. Feasible alternatives for pig producers will however require judgement on the basis of the present institutional framework.

Before the description embodied in this chapter is used for model building, consumer preferences and attitudes to different meats will be investigated more fully. This investigation is the subject of the following two chapters.

Pages 24-77 of A.E.R.U. Technical Paper No.7 ("An Econometric Model of the New Zealand Meat Market") appear to be missing but are not. They are Ch. 2 and Ch.3 of the thesis and were published separately.

Chapter 2 of this thesis was published as

A.E.R.U. Publication no. 43, "Survey of Christchurch Consumer Attititudes to Meat"

Available at https://hdl.handle.net/10182/1349

Chapter 3 of this thesis was published as

A.E.R.U. Technical Paper no. 3, "The Theory and Estimation of Engel Curves: Some Estimates for Meat in New Zealand."

Available at https://hdl.handle.net/10182/3301

CHAPTER 4

SPECIFICATION OF THE AGGREGATE NEW ZEALAND TIME - SERIES MODELS - I

Introduction

This and the next chapter will be concerned with specification of appropriate econometric models of the New Zealand retail demand for meat. A brief review of current theory and practice will be presented, partly through examining recent empirical research relevant to the New Zealand problem. The specification of appropriate models will also draw heavily on the description of the New Zealand meat market, the subject of Chapter 1. It will be found that in many respects the New Zealand retail market for meat is of very different structure to that in the United Kingdom, United States, and even Australia.

Specification of any economic relationship must also draw upon economic theory. The theory of consumer behaviour, and the theory of the firm are basic economic ingredients of this section of work. Reference to consumer behaviour theory has already been made,[1] and while that reference could be greatly amplified only specific aspects will be mentioned here. The general theory of consumer behaviour, and the maximisation principles involved in both this theory and the theory of the firm will therefore be largely assumed.

Model specification is also limited by statistical problems involved in parameter estimation, and by the data available for that

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1. Chapter 3, pp. 44-48.

estimation. While these problems are dealt with more fully in later chapters, they were considered at all stages of building the model. Where either problem limits the scope of model specification, attention will be drawn at the appropriate stage.

Some Factors Relevant to Model Specification

Working[1] in his now classical article drew attention to what has become recognised as the 'identification' problem. He showed that only under very limited conditions will a statistical estimate of the relationship;

$$Q_i = f(P_i)$$

where Q_i = quantity of the i^{th} good consumed per unit time

and P_i = price of the i^{th} good in the same time period;

give a true demand curve or supply curve. Where the supply and demand curves are both shifting between successive observations, an estimate of the price quantity relationship will only measure the relative movements between the two variables over time. The 'identification' problem is thus one of separating (or identifying) the demand and supply forces active in the market. In current terminology it is thus a problem of model specification, as well as being the key question in deciding whether single or multi-equation models should be used.

Fox[2] has given a set of criteria for deciding whether a single or multi-equation model is appropriate. The points he makes are of relevance to both the formulation of the hypothesis for testing, and for choosing between single and multi-equation estimation techniques. Fox

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1. E.J. Working, "What do Statistical 'Demand Curves' Show", The Quarterly Journal of Economics, Vol. 41, 1927, pp. 212-235.

2. K.A. Fox, "The Analysis of Demand for Farm Products", United States Department of Agriculture, Technical Bulletin No. 1081, Washington D.C., 1953, pp. 8-14.

shows that if a single structural equation is to be used in estimating the demand parameters of a market then:

(a) Supply must be predetermined.

(b) There must be only one market for the product. If there is more than one market (i.e. export market, demand for stocks, or alternative end use markets) then separate functions are required for each market.

(c) Consumer income must not be related to the product price.

(d) There must be no significant cross relationship between the particular product being investigated and any other products (i.e. no close substitutes or complements), or separate equations are required to explain these relationships.

If any of these conditions are violated, then the model will require more than one equation. These points have relevance in interpreting the way the New Zealand meat market operates and hence the specification of the model. From the description of the market operations of the New Zealand meat industry it will be apparent that a multi-equation model is needed. Most of the assumptions listed above, which are implicit in a simple demand equation, are violated to a greater or less extent in New Zealand. These violations will be more fully discussed when specifying the New Zealand model.

Several aspects of demand theory per se, and the aggregate time-series approach to estimation require discussion. The major problem is in applying a static theory to a dynamic situation, that of consumers (for example) adjusting their purchases to price and income changes over a period of time. The concept of a demand curve loses clarity in a dynamic situation. No longer is the concept of a single demand curve appropriate, because in a dynamic situation there can be many demand curves depending upon the length of time period chosen between successive observations. For most purposes it is the long run demand curve, (i.e. after complete adjustment to a given change has occurred) in which interest is centred. Hence allowance for dynamic adjustment to take place is very desirable.

Broadly there are two major schools of thought as to the most suitable way of specifying a dynamic model. Firstly there is the recursive system of Wold[1] in which long run demand is determined in a cobweb type of system. The alternative to the recursive system is the use of 'distributed lags'. Both systems use lagged variables in the estimating equations, as well as the current value of the same variable. However the stepwise adjustment of price and quantity to one another, implied in the recursive system is of slight application in the New Zealand meat market. For the recursive system to be truly applicable a closed market is necessary with a converging cobweb cycle about fixed or shifting supply and demand curves. The description of the New Zealand meat market in Chapter 1 suggests that a recursive system does not apply to the New Zealand market because supply of meat is not determined by a normal supply function. For this reason the distributed lag formulation is used, rather than the recursive system.

The use of distributed lags has in recent years become associated with Nerlove[2] and his co-workers in the United States Department of Agriculture, although the concept was introduced over forty years

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1. H. Wold and L. Jureen, Demand Analysis, Wiley and Sons, New York, 1953, Parts 1.4 and 3.2, pp. 12-15 and 64-70.

2. Many articles have been written by Nerlove demonstrating the use of distributed lags. See for example:
M. Nerlove, "Distributed Lags and the Estimation of Long-run and Short-run Supply and Demand Elasticities: Theoretical Considerations," Journal of Farm Economics, Vol. 40, 1958, pp. 301-311.
and
M. Nerlove and W. Addison, "Statistical Estimation of Long-run Supply and Demand Elasticities", Journal of Farm Economics, Vol. 40, 1958, pp. 861-881.

ago.[1] It is useful to this discussion to distinguish between two types of lag,[2] the first of which is the institutional lag arising from institutional or personal rigidities preventing immediate adjustment to a new market situation. The general form of Nerlove's adaption model for this cause of dynamic adjustment is:

$$\bar{Q}_t = f(P_t, Z) \qquad \ldots\ldots(1)$$

$$Q_t - Q_{t-1} = \gamma(\bar{Q}_t - Q_{t-1}) \qquad \ldots\ldots(2)$$

where Q_t = Quantity of a good consumed in time period t.

$\bar{Q}_t$ = Equilibrium quantity in the same period.

P_t = Price of the good in time period t.

Z = Other variables shifting the demand curve.

and γ = The adjustment coefficient, the value of which is usually: $0 < \gamma < 1$.

This relationship expresses the actual adjustment to a new market situation (e.g. a price change) as some proportion (γ) of the difference between actual quantity consumed in the previous period, and the equilibrium quantity. The demand function expresses the relationship between equilibrium (long-run) consumption and the explanatory variables. It can be seen from the adjustment equation that the absolute value of the adjustment is assumed to be declining as the initial (price) change recedes in time.

The second type of lag useful in this analysis is the expectations lag. This lag results from uncertainty as to the level of future prices, income, or quantity demanded, and is usually formulated in terms of the Hicksian adjustment equation.

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1. I. Fisher, "Our Unstable Dollar and the So-called Business Cycle", Journal of the American Statistical Association, 1925, pp. 179-202.
2. Other types of lag exist, but are not used in this study.

The expectations model, where uncertainty regarding future price exists, is of the form:

$$Q_t = f'(\overline{P}_t, Z) \quad .....(1)$$

$$\overline{P}_t - \overline{P}_{t-1} = \beta(P_{t-1} - \overline{P}_{t-1}) \quad .....(2)$$

where $\overline{P}_t$ is the price which was expected to rule in period t, at time t-1. Other variables as for the institutional lag model.

Equation one expresses a normal demand function, apart from the price of the particular good being the expected price. Equation two expresses the adjustment path of expected to actual prices. Thus the expected price in period t is the same as in t-1, apart from an adjustment by some proportion (β) of the amount the expected price in t-1 was incorrect. β is usually (although not necessarily) between zero and unity.

The empirical measurement of parameters requires the removal of non-observable variables from the estimating equation. This can be achieved by substituting equation two into equation one in both the institutional and expectation lag models.

Above is a brief description of the Nerlove approach to the dynamic problem. While it is not intended to fully explore the theory behind the Nerlove type of dynamic model, the restrictions implied by the Nerlove assumption will be discussed as they may limit this model's usefulness. There are also statistical problems in the estimation of the parameters of the Nerlove model.

The major restriction implied by the Nerlove model is in the pattern of adjustment over time. With this model the adjustment during the current time period to a change in the market which occurred in the past, is a fixed proportion of the remaining adjustment needed to reach equilbrium. Thus where γ or β are between zero and unity the sum of total adjustment increases at a declining rate, complete adjustment occurring after an infinite period of time. While this restriction on the value of the adjustment coefficient is usually regarded as the more normal case, values greater than unity are not impossible. Where such values do occur the interpretation must be that the market has 'over-reacted' to the changed market force, and will reach equilibrium only after a series of such over-reactions of decreasing amplitude if $1 < \beta$ or $\gamma < 2$. When β or γ is greater than 2, the situation is analagous to that of an exploding cobweb.

Because complete adjustment occurs only after an infinite period of time, full adjustment to a long-run stable position is usually assumed as having occurred once ninety-five per cent adjustment has been reached. Using this assumption it is possible to calculate the number of time periods for adjustment from the relationship;[1]

$$(1 - \gamma)^n \leqslant 0.05$$

where γ = adjustment coefficient

n = time periods

It is, however, not necessary to formulate the specific distribution of adjustment over time in the way the preceding adjustment equations do. In general three approaches to the pattern of adjustment over time may be distinguished.[2] Simplest of the three is to make no assumption about the form of distribution, and fit the distribution empirically.

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1. W.G. Tomek and W.W. Cochrane, "Long-run Demand: A Concept, and Elasticity Estimates for Meats", Journal of Farm Economics, Vol. 44, 1962, pp. 717-730.

2. M. Nerlove, "Distributed Lags and Demand Analysis for Agricultural and Other Commodities", United States Department of Agriculture, Handbook 141, 1958, pp. 4-47.

i.e. $Q_t = a + \sum_{i=0} b_i P_{t-i}$

where Q_t = quantity consumed in period t

P_t = price in period t

a and the set of coefficients b_i are constants.

In practice successive equations are estimated, in the first of which i is restricted to equal zero, in the second zero and unity, and so on. When the additional variable produces no statistically significant improvement in the equation (i.e. no improvement in the coefficient of determination), the previous equation is assumed to be 'best', and the result accepted.

The second alternative is to specify the general form of the distribution, and estimate its specific parameters. Thus the distribution of adjustment may be assumed log-normal or linear using Fisher's distributions, or may take the form of Koyk's distribution, depending on the choice of the assumed distribution. The exact form of the chosen distribution is then estimated, and finally the demand parameters estimated. The Nerlove adjustment model forms the third type of distribution. In this model the economic reason for the occurrence of the lag is used to formulate a specific model, the distribution of the lag is yielded only incidentally.

While this third method may not give the 'best' explanation in a statistical sense, it has the advantage of being defined on economic grounds. This gives the model advantages regarding ease of interpretation, and removes the statistically suspect criterion of the highest coefficient of determination as the single criterion of choice, as used with the first distribution. The Nerlove model is therefore, in economic terms, the most acceptable of the three alternatives. That such a model is appropriate to the New Zealand market for meat there is little doubt, the answers to several of the survey questions clearly indicated that consumers' adjustments to changes in prices or income are by no means immediate.[1]

The assumption of an adjustment distribution over time is however not the only problem when using distributed lag models. Unless complicated procedures are used, the estimating equation of the institutional lag model imposes an equal adjustment period for all variables in that model, and this need not be correct. For example, adjustment to equilibrium demand may occur (say) more rapidly when there is a change in income, than when the price of a competing meat changes. This can be allowed for by an iterative procedure described by Tomek and Cochrane,[2] but the criterion of choice is again the conceptually unsatisfactory method of accepting the equation with the highest coefficient of determination.

One major problem in the use of distributed lag models remains to be discussed. In any estimating procedure it is desired that the resultant estimates of parameters fulfill several criteria. These criteria are;

(a) that the estimate should lack bias

i.e. $E(\theta^*) = \theta$ where θ^* = estimate of the parameter

θ = true value of the parameter,

(b) that the estimate have the property of consistency

i.e. as the number of observation tends to infinity $(n \to \infty)$

then $E(\theta^*) \to \theta$,

(c) that the estimate should be efficient, or have minimum variance compared to the variance of any other estimation method,

and (d) the estimate should be sufficient, or extract the maximum

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1. Chapter 2, pp. 31-34, 36, and 38-39.
2. W.G. Tomek and W.W. Cochrane, op. cit., pp. 717-730.

information from the sample data.

Ordinary least squares, the most usual method of estimating stochastic equations, possesses these properties only when it is a maximum likelihood estimate. For ordinary least squares to be a maximum likelihood estimate the following conditions must be fulfilled:

(i) The expected value of the stochastic term (U_t) must be zero: i.e. $E\ (U_t) = 0$

(ii) U_t must be distributed normally, and have a finite variance $E\ (U_t)^2 = \sigma^2$ where σ^2 = variance of U_t).

(iii) There should be no autocorrelation of the stochastic variable $E\ (U_t U_{t-r}) = 0, \quad r \neq 0.$

Thus successive errors must be entirely random and not defined by the preceding value of the error, a condition often infringed in time-series models due to the presence of trends over time and ommission of variables from the model.

(iv) The stochastic term should not be related to any of the independent variables, i.e. $E\,(U_t X_{it}) = 0$ where X_{it} = the i^{th} independent variable.

(v) The independent variables are a set of fixed numbers, with a greater number of observations than the number of variables.

In addition, for each parameter estimate to be fully trustworthy there should be a minimum of multicollinearity between the independent variables. Thus ideally

$$E\ (X_{it}\ X_{jt}) = 0 \quad i \neq j$$

where X_{it} = the t^{th} observation on the i^{th} independent variable

X_{jt} = the t^{th} observation on the j^{th} independent variable.

If this condition is not fulfilled, then while the estimate of the dependent variable will remain a maximum likelihood estimate, the influence of the individual independent variables may be under- or over-estimated.

A variety of problems occur when these conditions of ordinary least squares are violated,[1] and it is the effect of these possible violations in the use of models with the dependent variable lagged one period which is of major concern here. These problems exist in any model estimated by ordinary least squares, but in some respects they are more acute with the use of distributed lags.

Most time-series data are serially correlated,[2] and unless there is completely accurate model specification then the stochastic term will probably be autocorrelated. Given this fact it is intended to explore the effects of this autocorrelation by way of two assumptions, assuming that data measurement errors are not present. This assumption will later be relaxed.

Consider first the case where the 'true' model does not involve lagged variables (i.e. is a simple model). Several sub-cases can be conceived depending on whether the model for estimation is correctly specified. If a simple model is used and the specification is entirely correct, then the resulting estimate will exhibit all the desirable properties. Estimated coefficients will be unbiased, and standard errors reliable. It an incorrect specification of the simple model occurs through ommitted variables, then the influence of the ommitted variables is contained in the stochastic error variable. The stochastic

1. J. Johnston, Econometric Methods, McGraw-Hill, New York, 1963, Chapters 4, 6, 7 and 8, pp. 106-144 and 148-230.

2. For supporting evidence see: M. Nerlove and W. Addison, op. cit., pp. 861-881
and
W.A. Fuller and J.E. Martin, "The Effects of Autocorrelated Errors on Statistical Estimation of Distributed Lag Models", Journal of Farm Economics, Vol. 43, 1961, pp. 71-82.

variable will thus no longer be purely random, will probably be autocorrelated, and may be correlated with the included explanatory variables. This will lead to biased estimates of coefficients, unreliable standard errors, and an estimate of the dependent variable which cannot be regarded as a maximum likelihood estimate. It is however possible to test for autocorrelation by use of the Durbin-Watson statistic or the von Neumann ratio, and if autocorrelation of the residuals (i.e. the estimates of the stochastic variable) is present to respecify the model.

The third possibility is that a distributed lag model may be specified, if this model is accurate apart from the inclusion of the lagged endogenous variable, the coefficients should be unbiased (with zero value for the lagged variable) and the standard errors reliable. However if, as is common with time-series data, serial correlation of the endogenous variable is present, then the lagged value of the endogenous variable will have undue influence in the estimated equation. All coefficients will be biased, and standard errors untrustworthy because the stochastic variable will probably be autocorrelated. The problem is that the Durbin-Watson statistic (and associated tests for autocorrelation) are insensitive in testing for autocorrelation in autoregressive schemes such as distributed lag models.[1] Thus there is no test available which is able to cast doubt on the validity of the resultant estimate.

It is this problem of errors in model specification, associated with the lack of a suitable test for autocorrelation, which has been at the centre of the controversy over the use of distributed lags in recent

1. J. Durbin and C. Watson, "Tests for Serial Correlation in Least Squares Regression (2), Biometrika, Vol. 38, 1951, pp. 159-177. M. Nerlove and K. Wallis, "Use of the Durbin-Watson Statistic in Inappropriate Situations", Econometrica, Vol. 34, 1966, pp. 235-238. W.A. Fuller and J.E. Martin, op. cit., p. 79.

years. The remaining hypothesis will now be briefly explored.

A second hypothesis is that the true model is a distributed lag model of the Nerlove type, again the effects of an incorrect model specification will be explored. If a simple (non-lagged) model is used, coefficients will be biased because of the specification error, but if the data is not serially correlated the standard errors will be reliable. If the data is serially correlated then the standard errors will now be unreliable as the excluded variable (i.e. the lagged endogenous variable) will be included in the stochastic variable, and the errors will thus be autocorrelated. This may be tested for by using the Durbin-Watson statistic, but other causes of autocorrelation may confuse the issue.

If the true lagged model is estimated, then the coefficients are unbiased and the standard errors reliable. Even if the data are serially correlated this will be true because the true model is estimated and thus the stochastic variable should not be autocorrelated. If an incorrect distributed lag model is estimated (e.g. variables excluded) the usual specification error problems of biased coefficients and unreliable standard errors will occur because of probable autocorrelation in the residuals. As before, it is difficult to test for this autocorrelation, because no test is entirely applicable.

These are the major specification-estimation problems of using distributed lags. Other forms of error (e.g. multicollinearity) have not been specifically mentioned because they are relevant to all models, not specifically distributed lag models. Errors in observations can also present special problems in the use of the distributed lags, as they can cause untestable autocorrelation problems. In a simple model the position is not greatly improved even though it is possible to test for autocorrelation. This is because in any model there can be several distinct causes of autocorrelation, the problem is to determine what the true cause is. However the simple case does retain the advantage of a satisfactory autocorrelation test, hence the researcher can become aware of the existence of autocorrelation problems, whatever the cause.

A strong case can be made that the older 'errors in variables' approach should be used when estimating distributed lag models, rather than the 'errors in equations' approach. The errors in equation approach assumes that the dependent (endogenous) variable contains all the error, i.e.

$$Y_t - U_t = a + b X_t$$

where the true relationship $Y = f(X)$ exists.

U_t = random disturbance variable

t = t^{th} time period.

In a lagged model the approach should be;

$$Y_t - U_t = a + b X_t + c (Y_{t-1} - U_{t-1})$$

as it is not logical to assume the errors exist in Y_t, but not Y_{t-1}. The errors in variables approach is, however, more difficult to estimate although in this respect conceptually superior.

Many authors have shown concern over the use of distributed lag models because of the difficulty of determining whether the results are valid. Brandow[1] analyses this problem in terms of specification error for supply function analysis, demonstrating that excluded variables will often result in biased estimates of long-run elasticities because the adjustment coefficient is especially sensitive to such specification bias Nerlove[2] does not agree that the long run elasticity will be biased,

1. G. Brandow, "Note on the Nerlove Estimate of Supply Elasticities". Journal of Farm Economics, Vol. 40, 1958, pp. 719-721.

2. M. Nerlove, "On the Nerlove Estimate of Supply Elasticities: A Reply" Journal of Farm Economics, Vol. 40, 1958, pp. 721-722.

although he does agree that bias of short run and adjustment coefficients will probably be present.

Unfortunately little can be done about the above problems. Fuller and Martin[1] suggest an iterative method of overcoming autocorrelation. They suggest that the assumption of non-autocorrelated error (U_t) be replaced by the assumption that U_t follow a first order autoregressive scheme, i.e.

$$U_t = \beta U_{t-1} + e_t \qquad \beta = \text{a coefficient of autocorrelation}$$

where it is assumed that e_t is non-autocorrelated and contains all the other desirable properties needed for least squares estimation. By replacing U_t by the above expression in the original lagged equation it is now possible to estimate all the parameters, but only by an iterative procedure. While this assumption is a degree more general than assuming U_t it not autocorrelated, it is still difficult to determine if in fact autocorrelation is still present in the residuals. Thus the advance over the more usual assumption regarding U_t is limited.

Griliches[2] explores more deeply the implication implicit in some of the examples considered here, and especially the application of the above error model to parameter estimation. He concludes that because it is not possible to test when an equation's specification is 'true', if the distributed lag model reduces autocorrelation of the residuals the use of such a model must imply the assumption that the cause of the removed autocorrelation is the distributed lag effect. This in itself is no justification for using a distributed lag model because there may be other reasons for the presence of autocorrelation (e.g. non-lagged ommitted variables). In closing, however, Griliches makes the following

1. W.A. Fuller and J.E. Martin, op. cit., p. 71.

2. Z. Griliches, "A Note on Serial Correlation Bias in Estimates of Distributed Lags", Econometrica, Vol. 29, 1961, pp. 65-73.

general comment:

"..... as long as we have serial correlation of disturbances there is still something systematic in this world our model has not incorporated. It seems ..... much more desirable to find the economic reasons behind this correlation and incorporate them into the model than to pursue complicated estimation techniques designed to deal with this problem. The research strategy should be directed toward eliminating serial correlation by including its causes explicitly within our models rather than devising new methods of living with it". This is a major justification for using distributed lags, their use being motivated on economic theory grounds and adding a powerful tool to economic model building. It must always be remembered though that in some respects statistical methods are not equal to the task. This discussion of distributed lags has shown that when distributed lag formulations are used, caution should be exercised in their interpretation. The specification and estimation problems associated with these models are often greater than in the more simple formulations, thus while care is needed in evaluating all models, special care in the directions indicated above is needed when distributed lag are used.

Two other contributions to demand theory are of special relevance to this study. The first is Friedman's permanent income theory[1] which relates consumption expenditure to normal income. Normal income can, however, be interpreted as expected income, and this the Nerlove expectation model can take account of. Friedman's more rigorous formulation of normal income requires breaking disposable income into two components;

(a) normal income levels, usually calculated by moving averages,

1. M. Friedman, op. cit.
and
M.J. Farrell, "The New Theories of the Consumption Function", Economic Journal, Vol. 69, 1959, pp. 678-696.

(b) the transitory component (being positive or negative).

Both income variables are used in the estimating equation. Normal income levels may thus be expected to have a stronger influence on (say) basic food consumption than the windfall gains or losses, while the reverse may be expected in the case of durable consumer goods. Other approaches to this problem include Modigliani's 'ratchet effect', and the accelerator. All these theories may be grouped together as they formulate a more complex behaviour pattern of the consumer than conventional theory when income changes occur. While recognising the conceptual superiority of these additions to the theory of consumer behaviour, they have not been included in the New Zealand model because of data estimation problems and expected high intercorrelation between more than one income variable to allow fully for the permanent income hypothesis.

Finally, restricted demand model formulations using Engel and Cournot aggregation restrictions and the Symmetry condition will be briefly examined. These economic models are in many respects an improvement over normal unrestricted models. Brandow[1] has estimated demand for farm products in the United States using restrictions, while Court[2] used restrictions with a superior estimating system to determine demand functions for meat in New Zealand. Court's model specification does however possess identification problems. Demand functions may be estimated in isolation when quantity demanded is determined only by demand factors (i.e. is independent of supply factors). When the quantity available for consumption is determined by supply factors, then

1. G.E. Brandow, "Interrelationships Among Demands for Farm Products", Pennsylvania State University, Agricultural Experimental Station, Bulletin 680, 1961.

2. R.H. Court, "The Estimation of Demand Functions Under Restrictions Imposed by the Theory of Consumer Behaviour, with Reference and Application to the Demand for New Zealand Meats", Lincoln College Agricultural Economics Paper, No. 321, 1965, Mimeograph.

a simple demand function is not applicable. In the case of demand for meat in New Zealand it will be demonstrated that for pigmeats this requirement does not hold. Therefore the restricted demand models developed to date including that used by Court, are not applicable and have not been used in this study.

Demand Models Relevant to the Specification of a New Zealand Model

There have been many empirical demand studies carried out by research workers, all of which have contributed to applied economics. It is not the intention here to summarise their findings, but to take a few models of particular relevance to the current problem and isolate those concepts which are applicable here. All the models to be considered analyse the demand for meat.

The first model to be considered is that of Fuller and Ladd.[1] This model estimated long-run demand parameters for beef and pork in the United States, using the Nerlove distributed lag approach. Besides estimating demand parameters, meat inventory equations, farm-gate-to-wholesale margin equations, and wholesale-to-retail margin equations were calculated for both meats. Equations were estimated by ordinary least squares.

In addition to the Nerlove lag, the authors assumed autocorrelated errors in the estimating equations. Their estimation technique followed the form described by Fuller and Martin:[2]

i.e. $U_t = \beta U_{t-1} + e_t$

where U_t = current true stochastic error of the estimating equation

1. W.A. Fuller and G.W. Ladd, "A Dynamic Quarterly Model of the Beef and Pork Economy", Journal of Economics, Vol. 43, 1961, pp. 797-812.

2. W.A. Fuller and J.E. Martin, op. cit., pp. 71-82.

e_t = the remaining non-autocorrelated error

U_{t-1} = stochastic error of the previous period

β = a coefficient of autocorrelation.

Quarterly data were used for estimating the model. To reduce the complexity of the iterative estimation procedure all data was initially regressed against dummy seasonal and time variables to remove seasonal variations and the time trends.[1] While the application of general estimating procedure is of interest it is the specification of the demand functions, and the wholesale-to-retail margin which is of greater interest here.

The stochastic demand function for pork was:[2]

$$E\ C_{p_t} = b_0 + b_1 P_{p_t} + b_2 C_{B_t} + b_3 Y_t \qquad .....(1)$$

Adjustment Lag Equation

$$C_{p_t} - C_{p_{t-1}} = \gamma(E\ C_{p_t} - C_{p_{t-1}}) \qquad .....(2)$$

where Y_t = current deflated per capita disposable income per quarter

C_t = current consumption per capita per quarter

$E\ C_t$ = equilibrium consumption in time period t

P_t = deflated retail price

p = pork

B = beef.

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1. This is equivalent to including the dummy variables specifically in the equation. See G. Tintner, Econometrics, Wiley and Sons, New York, 1952, pp. 301-304. Serious mulicollinearity problems could invalidate this however.

2. The notation used is that of: W.A. Fuller and G.W. Ladd, op. cit., pp. 800-803. To simplify presentation error variables will not be shown in stochastic equations. In all equations where error terms are present, this will be indicated by stating that they are stochastic.

If equations 1 and 2 are combined, the normal Nerlove estimating form is derived. With the additional assumption that supply, and hence consumption, is predetermined the reduced form stochastic estimating equation for pork demand is:

$$P_{p_t} = - \frac{b_0}{b_1} + \frac{1}{b_1} C_{p_t} - \frac{b_2}{b_1} C_{B_t} - \frac{b_3}{b_1} Y_t - \frac{1-\gamma}{b_1} C_{p_{t-1}} \quad \ldots\ldots(3)$$

In this equation price of pork is therefore the endogenous variable, and is expressed as a function of exogenous and predetermined variables.

Equation 1 has the unusual feature of expressing equilibrium pork consumption in terms of actual beef consumption. More normally the beef-pork relationship would be expressed in terms of pork consumption dependent on retail price of beef. The coefficient (b_2) is thus not a cross elasticity of demand, but expresses the change in equilibrium pork consumption with a change in beef consumption.

Fuller and Ladd's specification of the wholesale-to-retail margin equation is also of interest. While many estimates of demand functions in reduced and non-reduced forms have been carried out, empirical estimates of forces determning margins are not common. While it is possible to specify a retailer's demand and supply curves, because meat is perishable and hence demand will normally equal supply, the two functions may be replaced by a single margin equation. The margin equation thus expresses the difference between demand price (wholesale) and supply price (retail). Fuller and Ladd's model for the wholesale-to-retail beef margin is:

$$E\,M_{B_t} = a_0 + a_1 W_t + a_2 P_{B_t} \quad \ldots\ldots(4)$$

$$M_{B_t} - M_{B_{t-1}} = \alpha_0 (E\,M_{B_t} - M_{B_{t-1}}) + \alpha_1 \Delta P_{B_t} + \alpha_2 \Delta P_{p_t} \quad \ldots\ldots(5)$$

where $E\, M_{B_t}$ = equilibrium beef margin in period t

M_{B_t} = deflated beef margin in period t

$M_{B_{t-1}}$ = deflated beef margin in the previous period

P_{B_t} = deflated beef wholesale price in period t

W_t = deflated wage rate of food store employees in period t

$P_{B_t} = P_{B_t} - P_{B_{t-1}}$

The estimating equation from 4 and 5 above is:

$$M_{B_t} = \alpha_0 a_0 + \alpha_0 a_1 W_t + \alpha_0 a_2 P_{B_t} + \alpha_1 \Delta P_{B_t} + \alpha_2 \Delta P_{P_t} + (1-\alpha_0) M_{B_{t-1}}$$

The margin is in many respects the price of the retailer's services, with labour the largest component. From the margin the retailer must meet his direct costs and overheads, and gain a profit margin. The wage cost variable (W_t) was included to allow for movements in retailing costs over time. Ideally this variable should have been a weighted index of all the retailer's direct costs, but data limitations make this impossible. The product's own wholesale price was included as an explanatory variable because a proportionate markup policy based on movements in wholesale price is also a probable major determinant in the level of the margin. Often changes in retail prices lag behind charges in wholesale prices due to price levelling, this was included in the adjustment equation of the beef margin model by the variable P_{B_t}, while price averaging was allowed for by the term P_{P_t}.[1] The Nerlove adjustment lag was included because movement to new equilibrium margins will usually not proceed immediately. This margin model therefore included the direct effect of changes in the costs of retailing, and the effects of retail meat pricing policies which have been observed in the

1. Price levelling and averaging are described in Chapter 1, p. 12.

United States, the United Kingdom and New Zealand.[1]

The remaining two models to be examined in detail both concern the Australian internal market, a market largely subject to similar forces to those which operate in New Zealand. The similarities and the differences between the two markets will be discussed along with the two models.

Taylor[2] was the first researcher to estimate meat demand parameters in Australia, and in discussing his models' specification, states: "Australia regularly exports a considerable proportion of its beef supplies to markets where it constitutes a minor, though significant, proportion of total supplies. The availability of Australian beef would not have a dominating influence on world prices, while on the home market physical supply does not usually set a limit to consumption. With no two-price scheme ...... domestic consumers must bid against the export market to obtain their supplies ...... (thus) ...... wholesale prices of beef are in a large measure determined by overseas prices, or, more precisely the expectation of overseas prices". Taylor therefore considers that the domestic wholesale price of beef is determined by export realisations (or expected export realisations) and hence price is exogenous to the model with consumption endogenous.

Taylor states that it is wholesale price which is exogenously determined, but then uses retail prices in his model, presumably under the assumption that wholesale prices determine the retail price.

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1. W.A. Fuller and G.W. Ladd, op. cit., pp. 802-805.
   For the United Kingdom see:
   Government of the United Kingdom, Committee of Enquiry into Fatstock and Carcass Meat Marketing and Distribution Report, Parliamentary Command Paper, No. 2282, London, 1964, pp. 102-111.

2. G.W. Taylor, "Meat Consumption in Australia", Economic Record, Vol. 39, 1963, pp. 81-87.

Duloy and van der Meulen[1] criticise Taylor on this point, and suggest that a relationship which applies at the wholesale level need not apply at the retail level. These authors found that the correlation coefficient between wholesale and retail price was only 0.58 which for the number of observations, was not significantly different from zero at the five per cent level. With regard to the wholesale price of beef they are of the opinion that it should be endogenous to the model as a function of export price and total supply of beef and other meats. They also suggest that the retail price of beef should be endogenous to the model and influenced by the supply of other meats. Taylor[2] in a later note substantially disagrees with this assumed influence the supply of other meat may have on retail beef price.

Duloy and van der Meulen's point regarding the use of retail prices when the logic behind the model is discussed with respect to the wholesale level is of importance, even though there seems some confusion about the role the supply of other meats play in the price making forces. It would seem that the most logical path through the problem is to make use of the identity; 'retail price equals wholesale price plus the wholesale-to-retail margin'. If equations explaining both terms on the right hand side of the identity are included in the model then retail price is certainly endogenous, though not quite in the manner Duloy and van der Meulen suggest.

With lamb and mutton Taylor argues that export price will not significantly affect the local market. With lamb he holds that this is because lamb killings for export occur in only a few months of the year, while with mutton the exported good is of lower quality than the product

1. J.H. Duloy and J. van der Meulen, "Meat Consumption in Australia - A Comment", Economic Record, Vol. 39, 1963, pp. 366-367.

2. G.W. Taylor, "Meat Consumption in Australia - A Reply", Economic Record, Vol. 40, 1964, p. 127.

consumed internally. Thus for these two meats consumption is considered predetermined (presumably because of production lags) and hence retail price is the endogenous variable.

Taylor's model is therefore:

$$C_B = f' \quad (P_B \quad C_L \quad C_M)$$
$$P_L = f'' \quad (C_L \quad C_M \quad P_B)$$
$$P_M = f''' \quad (C_M \quad C_L \quad P_B)$$

where C = consumption in lbs. per head of each meat
P = deflated price
B = beef
L = lamb
M = mutton

The equations of this model were calculated by ordinary least squares,[1] and were linear in logarithms. Data were annual averages for the years 1949/50 to 1959/60. The estimated parameters were used to calculate demand elasticities. As with the next model to be discussed, the significance of the model lies in the way the link between the export and local markets is specified. This problem, which is critical to the New Zealand model, will be discussed more deeply when specifying that model.

Gruen[2] et. al., develop a more complex model to explain demand for meat in Australia. In discussing Taylor's work, a brief summary is given of Taylor's rationale for the specification of the beef equation, and then it is stated:

" ...... The amount of beef available[3] for consumption in Australia is thus influenced by the export price and by the availability of other

1. The model was formulated in such a way as to make more elaborate estimation procedures unnecessary. Each endogenous variable appearing only on the left hand side of one equation.

2. F. Gruen et. al., "Long Term projections of Agricultural Supply and Demand, Australia 1965 to 1980", Department of Economics Monash University, Clayton, Victoria, Australia, 1967, pp. 4-42 to 4-51.

3. Emphasis added.

eat". This statement is curious in that it is the availability of beef which is said to be influenced by export price and the availability of other meats. However Taylor is specific that it is <u>actual</u> Australian consumption of beef and not 'availability' which is affected by export price (via wholesale price) and actual consumption of other meats. Further, for beef Taylor states that total supply usually does not restrict consumption in any way.[1] Gruen's interpretation is thus surprising and is at variance with what Taylor states, with the model Taylor formulates, and even with the model Gruen himself proceeds to develop from the Taylor model.

An alternative interpretation of Gruen's statement is that the firms in the Australian meat industry 'allocate' fixed quantities of beef to the Australian market according to the level of the beef export price. These quantities thus become the amount of beef 'available' to the internal market. This is not Taylor's view, and from his model formulation it is not Gruen's - the implied relationship above not appearing in this model.

It is therefore unfortunate that Gruen's description should be so expressed, as it implies a relationship which it seems is unintended and contrary to economic logic.[2] Because the relationship between the two markets (internal and export) is so important, the correct economic link between the two is essential. It is held here that in New Zealand's case that link is via the wholesale meat price, and is thus similar to that described by Taylor, and implied indirectly by Gruen's model.

After discussing Taylor's work Gruen develops the following model:

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1. See quotation p. 99.
2. Apart from possibly describing (in a much more refined form) the operations of a discriminating monopoly.

$$P_B = f' \quad (E\,P_B,\ C_M,\ C_L) \qquad \ldots\ldots(1)$$

$$C_B = f'' \quad (P_B,\ P_M,\ P_L,\ Y) \qquad \ldots\ldots(2)$$

$$P_L = f''' \quad (P_B,\ P_M,\ E\,P_L,\ C_L,\ Y) \qquad \ldots\ldots(3)$$

$$P_M = f'''' \quad (P_B,\ P_L,\ C_M,\ C_L,\ Y) \qquad \ldots\ldots(4)$$

where P = deflated price

C = quantity consumed lb./head/year of each meat

Y = deflated disposable income per person per year

L = lamb

B = beef

M = mutton

E = export

These functions were estimated by ordinary least-squares and two-stage least-squares. In the ordinary least-squares estimates disposable income was replaced by total consumer expenditure per capita. Prices other than export are all retail. Equations were estimated in linear form, and linear in logarithms.

The first equation of the model expresses retail price of beef as a function of export price, and <u>actual</u> consumption of mutton and lamb. Duloy and van der Meulen suggested wholesale price should be in terms of export price, and total supplies of other meats.[1] Thus while the papers retain the same approach important divergences are present. It will be shown in the New Zealand model that the choice of a quantity figure to use (actual consumption or total supplies) presents difficulties, because supply effects largely depend on the relative shortage of supplies available for internal consumption. The first equation does not fully express this.

1. J.H. Duloy and J. van der Meulen, <u>op. cit.</u>, pp. 366-367.

Equation 3 expresses the reduced form of a demand function with supply predetermined, apart from the inclusion of export price of lamb. Presumably the export price is included to quantify the shift in local price due to export influence, when a significant proportion of lamb supply is exported. In equation 4 both the price of lamb and the consumption of lamb are used as explanatory variables, price of mutton being the dependent variable. No explanation is available for this rather unusual specification.

Although this model was tested using two-stage least-squares, it was unsatisfactory and single equation estimates of normal structural demand equations proceeded.[1] It is however not with these results that interest in the model is centred here. The manner in which Gruen specifies his model has relevance to the New Zealand model where several meats are in a similar position to beef in Australia with the export market dominant in price setting. The Australian approach will be shown to have some application to the New Zealand problem.

Discussion

In this chapter the more important aspects of specification, as they apply to the New Zealand models, have been discussed. Some models of particular value to the models derived in Chapter 5 were also outlined. This chapter has therefore laid the ground work from an economic point of view, for the discussion in the next chapter.

Many other problems and research models have relevance to this study, but are not discussed here. The implications of these ommissions will be referred to where necessary, but otherwise largely assumed.

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1. F. Gruen et. al., op. cit., pp. 4-47. The equation form was $Q = f(P, Y)$ where Q represents respective quantities, P the set of retail prices, and Y income or total expenditure.

CHAPTER 5

SPECIFICATION OF AGGREGATE NEW ZEALAND TIME-SERIES MODELS - II

Introduction

This chapter will be concerned with the detailed specification of the New Zealand model developed to obtain estimates of meat demand parameters. In specifying this model the discussion and results of all previous chapters will be drawn upon. The problems raised in Chapter 4 will be of particular importance here.

Initially the components of the New Zealand model will be developed in terms of individual meat 'sub-models'. These sub-models will then be combined to produce an overall model of the New Zealand demand for meat. Later in the chapter associated questions of importance, such as the identification properties of the model derived, will be discussed.

Symbol Notation

To simplify the presentation of the New Zealand models the following symbol notation will be used in all references to model variables.

Major Symbols

Q = Quantity

Y = Income

P = Price

M = Wholesale-to-Retail Margin

I = Index of Butchers' Wage Costs

A = A ratio of quarterly New Zealand consumption divided by quarterly fresh supply (production) i.e. the proportion of current supply consumed locally

S_1 = Shift Variable for season one (April - June inclusive)

S_2 = Shift Variable for season two (July - September)

S_3 = Shift Variable for season three (October - December)

Z_1 = Shift Variable for the period of price control in 1959/60

Z_2 = Shift Variable operating in the two quarters possibly affected by the publicity given to a case of trichinosis contracted from eating pigmeats.

Subscripts to Major Symbols

D = New Zealand Demand

S = New Zealand Fresh Supply (production)

B = Beef

L = Lamb

M = Mutton

P = Pork

H = Ham and Bacon

t = Current time period, thus $_{t-1}$ = previous time period

Superscripts to Major Variables (Prices)

^{r} = Retail

^{w} = Wholesale

^{E} = Export

Where appropriate to the text, equilibrium values (as in a Nerlove model) will be denoted by; ($\overline{}$). Thus $\overline{Q_{DB_t}}$ indicates the equilibrium consumption for beef in the current time period. Likewise a star (*) will be used to indicate variables endogenous to the model. Measurement units of the variables will be outlined, along with data sources and data estimation methods in Chapter 7.

In outlining the specification of the New Zealand models the institutional framework discussed in Chapter 1 will be assumed. The marketing of each meat to be investigated will therefore only be discussed in those cases where it is of special importance in explaining the model. Each sub-model will be developed in terms of linear equations, although some equations will later be transformed to be linear in logarithms. The effect of this transformation will be discussed later in the chapter. All models are based on a quarterly time period.

The Beef Sub-model

As will be apparent from Chapter 1, the internal beef market is strongly linked with the export market. The following model explains the demand for beef in New Zealand, incorporating the effect export prices have on New Zealand demand.

(a) The Stochastic Demand and Nerlove adjustment equations.[1]

$$\overline{Q_{DB_t}} = a_0 + a_1 P^r_{B_t} + a_2 P^r_{M_t} + a_3 P^r_{P_t} + a_4 Y_t + a_5 S_1 + a_6 S_2 + a_7 S_3$$

$$Q_{DB_t} - Q_{DB_{t-1}} = \gamma (\overline{Q_{DB_t}} - Q_{DB_{t-1}})$$

(b) The Stochastic Wholesale Price formation equation and Nerlove adjustment equation.

$$\overline{{}^wP_{B_t}} = b_0 + b_1 \, {}^EP_{B_t} + b_2 A_{B_t} + b_3 A_{M_t} + b_4 Q_{SP_t}$$

$${}^wP_{B_t} - {}^wP_{B_{t-1}} = \beta \, (\overline{{}^wP_{B_t}} - {}^wP_{B_{t-1}})$$

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1. All stochastic equations contain an error variable, but to simplify presentation such equations will be referred to as 'stochastic', and the error variable omitted.

(c) The Stochastic Wholesale-to-Retail Margin, and Nerlove adjustment equations

$$\overline{M_{B_t}} = c_0 + c_1 I_t + c_2 {}^wP_{B_t} + c_3 Z_1$$

$$M_{B_t} - M_{B_{t-1}} = \alpha_0(\overline{M_{B_t}} - M_{B_{t-1}}) + \alpha_1 \Delta {}^wP_{B_t} + \alpha_2 \Delta {}^wP_{M_t} + \alpha_3 \Delta {}^wP_{P_t}$$

(d) Identities

$$P^r_{B_t} \equiv {}^wP_{B_t} + M_{B_t}$$

$$A_{B_t} \equiv \frac{Q_{DB_t}}{Q_{SB_t}}$$

$$A_{M_t} \equiv \frac{Q_{DM_t}}{Q_{SM_t}}$$

$\Delta {}^wP_{B_t} \equiv {}^wP_{B_t} - {}^wP_{B_{t-1}}$ similar identities are assumed for the other meats.

Thus by substituting the adjustment equations into the three stochastic equations, three stochastic estimating equations are obtained:

(a) The Demand equation

$$Q_{DB_t} = \gamma a_0 + \gamma a_1 P^r_{B_t} + \gamma a_2 P^r_{M_t} + \gamma a_3 P^r_{P_t} + \gamma a_4 Y_t + \gamma a_5 S_1 + \gamma a_6 S_2 + \gamma a_7 S_3 + (1 - \gamma) Q_{DB_{t-1}}$$

(b) The Wholesale Price formation equation

$${}^wP_{B_t} = \beta b_0 + \beta b_1 {}^EP_{B_t} + \beta b_2 A_{B_t} + \beta b_3 A_{M_t} + \beta b_4 Q_{SP_t} + (1 - \beta) {}^wP_{B_{t-1}}$$

(c) The Margin equation

$$M_{B_t} = \alpha_0 c_0 + \alpha_0 c_1 I_t + \alpha_0 c_2 \, {}^{w}P_{B_t} + \alpha_0 c_3 Z_1 + \alpha_1 \Delta^{w}P_{B_t} + \alpha_2 \Delta^{w}P_{M_t} + \alpha_3 \Delta^{w}P_{P_t} + (1 - \alpha_0) M_{B_{t-1}}$$

Put in functional notation the beef sub-model is:

$$Q_{DB_t} = f' \quad (P^r_{B_t}, P^r_{M_t}, P^r_{P_t}, Y_t, S_1, S_2, S_3, Q_{DB_{t-1}})$$

$${}^{w}P_{B_t} = f'' \quad ({}^{E}P_{B_t}, A_{B_t}, A_{M_t}, Q_{SP_t}, {}^{w}P_{B_{t-1}})$$

$$M_{B_t} = f''' \quad (I_t, {}^{w}P_{B_t}, Z_1, \Delta^{w}P_{B_t}, \Delta^{w}P_{M_t}, \Delta^{w}P_{P_t}, M_{B_{t-1}})$$

The demand equation is a normal structural demand equation including a Nerlove adjustment lag. The adjustment lag has been included to allow consumers' adjustments to price or income changes to take place over greater than one time period (three months). Overseas studies[1] have shown that the time period of adjustment is usually greater than three months, these findings are consistent with those of the consumer survey,[2] which indicated lengthy adjustment period as being probable in New Zealand.

The substitution relationships included above allow only for the major meats, largely because of data limitations.[3] The most important meat excluded is lamb, the consumption of which is slight relative to the included meats (other than pork). Ham and bacon have been excluded here as they are not in close competition with beef, as was shown by the consumer survey.

Seasonal shift variables measuring seasonal deviations from the

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1. See for example: W.A. Fuller and G.W. Ladd, op. cit., 800-805.
2. Chapter 2, pp. 31-34, 36, and 38-39.
3. Chapter 7, pp. 147-152.

first quarter of the year are included. The legitimacy of their use will not be proven here. Initially a trend variable to measure changes in taste was examined for possible inclusion in the model. It was found, however, that the trend was highly correlated with income, and as there was no strong evidence to suggest that important taste changes had occurred for meat in New Zealand over the time period of this analysis, the trend was excluded to reduce multicollinearity problems.[1]

In discussing the wholesale price formation equation for beef, the relationship between the export market and the internal market is implicitly being examined. In Chapter 1 the price formation mechanism at various market levels was discussed. It was argued that for those meats for which there is a large export demand the f.o.b. export value of bare meat is a major determinant of the internal New Zealand wholesale and farm-gate prices. The latter parts of Chapter 4 examined the way in which other studies have specified the relationship between export and internal prices. In specifying the model used here extensive use will be made of both discussions.

Because export operators sell in both markets and largely set farm-gate prices for fatstock through the meat schedule, the reasoning that Taylor[2] used with respect to beef is largely applicable to the New Zealand meat market. Further corrobatory evidence is provided by Sault[2] who found a high correlation between United Kingdom and Australian lamb prices, for those periods in the year in which Australian lamb is exported. To examine this assumption for application to New Zealand, a series of simple correlation coefficients were calculated. Monthly

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1. Chapter 8, pp. 197-210.
2. G.W. Taylor, 1963, op. cit., pp. 81-87.
2. J.L. Sault, "The Relationship Between Prices for Lamb in Australia and the United Kingdom", Quarterly Review of Agricultural Economics, Vol. 18, 1965, pp. 198-206.

observations from May 1955 to December 1964 (116 observations) of United Kingdom and New Zealand wholesale prices were correlated. For beef, lamb, and mutton the correlation coefficients were highly significant at the one per cent level, all values were positive. Pork had a negative and non-significant correlation coefficient. Estimated correlation coefficients were:

Beef	0.328
Lamb	0.567
Mutton	0.452
Pork	-0.175

Estimates of correlation coefficients were also made with each country's prices in turn lagged one and two periods.[1] The estimates were, however, successively smaller the greater the lag. These correlation coefficients do not prove a relationship, but may be regarded as supporting evidence that a relationship between export and internal wholesale prices exists. It is the direction and form of this relationship that is the centre of the specification problem.

Taylor states that Australian supplies are unlikely to dominate the price in overseas markets, and hence the direction of the relationship between export and internal price is one in which Australian wholesale prices for beef is determined by the export price. While this assumption is valid for New Zealand beef, New Zealand sheepmeats do have a large share of the available markets for mutton and lamb and hence do influence export price. The same direction of causation between export and internal wholesale prices for sheepmeats will, however, be assumed here. While the profit function (and its maximisation) of the internal wholesaler and exporter of sheepmeats will not be discussed in detail it will

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1. Corresponding to alternative assumptions regarding the mechanism by which export prices influence local price. There is further discussion of this point on p. 117.

be evident from Chapter 1 that the farm-gate-to-wholesale margin, and farm-gate-to-f.o.b. export margin, will tend to be equalised as wholesale and f.o.b. are equivalent levels in the marketing chain. For the individual exporter/wholesaler the share he has of the export and/or internal markets will, in virtually all cases, be sufficiently small for price to equal marginal revenue. Thus the wholesale/export industry will attempt to equalise prices between markets, rather than internal and export market marginal revenues. Because the industry has a greater degree of control over the internal New Zealand market than those markets overseas, it will therefore always be the internal market that will be adjusted to alignment with overseas conditions. The only alternative to this is if the export market were to be treated as a method of surplus disposal, which is not the case with sheepmeats. There are many reasons why the export market for sheepmeats is not for disposal of surpluses, the most important of which is that the proportion of New Zealand production consumed within the country is small relative to that exported. Taylor's more limiting assumption is therefore a sufficient but not a necessary condition for internal wholesale price to be dependent on export prices.

Factors other than export price of beef may be expected to influence the local wholesale price of beef, Duloy and van der Meulen[1] after discussing Taylor's rationale regarding specification of the beef equation, state;

"Taylor thus argues that the wholesale price of beef is an exogenous variable. We would treat the (wholesale) price of beef as endogenous in a model of the demand for meat; probably as a function of the export price, the total supply of beef and other meats, and a random disturbance".

1. Duloy and van der Meulen, op. cit., p. 366.

Gruen et. al., state;[1]

"We have estimated a model similar to that of Taylor but have included (retail) price of beef as an endogenous variable, determined by the export price of beef and by the quantities of other meat available". 'Other meat available' was in fact actual Australian consumption.[2]

The problem is thus whether total supply or actual internal consumption should be used as an explanatory variable. It is thought here that what is required is a variable explaining the circumstance when, for reasons of seasonal shortage of supply, all or nearly all the meat supply coming forward is destined for local consumption. In this period it may be expected that an internal premium for fresh meat can occur, thus raising the internal wholesale price above the export equivalent. As has been explained in Chapter 1,[3] New Zealand is a fresh meat market, and while stocks of frozen meat may be on hand, they will seldom enter internal trade. Even if they do, a premium for fresh meat will exist.

Elements of both total current supply and internal demand are therefore present. As meat stocks (i.e. frozen meat) will not normally enter the market except at a substantial discount, supply for these purposes may be taken as quarterly production. Quantity demanded is, as before, quarterly consumption. While there are several possible alternative ways of quantifying the demand-supply relationship, in this study a ratio of quantity demanded divided by quantity supplied was used. This ratio will henceforth be referred to as the Availability ratio, and designated algebraically as A. The ratio measures the proportion of total supply consumed within New Zealand. When the ratio tends to unity, premiums above the export price may be expected. Alternately, when the

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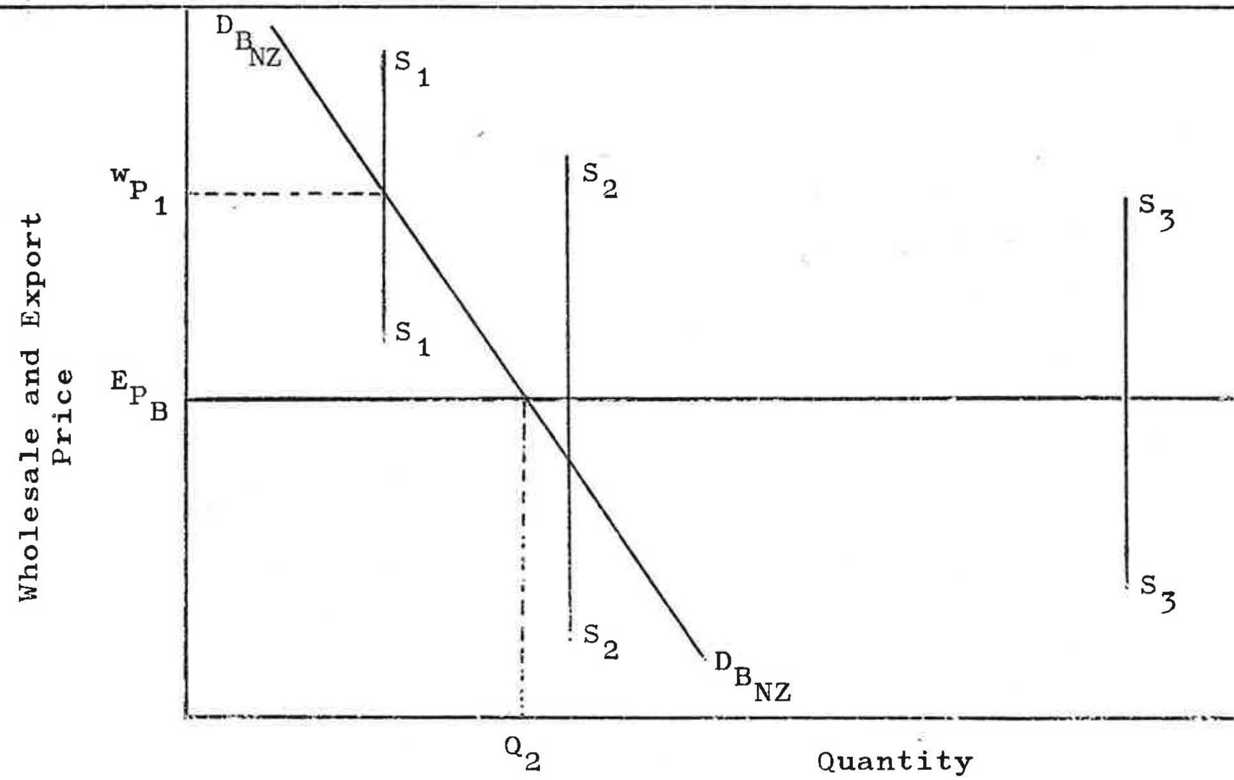
1. Gruen et. al., op. cit., p. 4-46.
2. Chapter 4, pp. 101-102.
3. Chapter 1, pp. 8-9.

ratio tends to zero supply is far in excess of local consumption, and export prices may be expected to be the dominant influence in setting the internal wholesale price. Diagramatically the situation represented is:

DIAGRAM 5.1

THE RELATIONSHIP BETWEEN THE AVAILABILITY RATIO AND WHOLESALE PRICE OF BEEF IN NEW ZEALAND.*



* The diagram depicts the position of the meat industry allocating between alternative markets on the basis of price. While the individual exporter/wholesale will not face the New Zealand demand curve, it will be evident that in aggregate the exporter/wholesalers, each of whom allocates according to price, will face the market condition described.

Diagram 5.1 analyses three different market situations. The same demand curve (at wholesale) for beef within New Zealand (D_BNZ), and the same export price for beef (^EP_B) is common to all three cases. Case one considers the situation where the current level of supply is fixed at

$S_1 - S_1$. Here A_B (the availability ratio for beef) equals unity. All current supply (S_1) will be consumed locally at a wholesale price of ${}^{w}P_1$, well above the export price.

Case two, with supply $S_2 - S_2$, corresponds to the case where $A_B \rightarrow 1.0$. In terms of the diagram, beef consumption will equal Q_2, at a wholesale price equal to the export price ${}^{E}P_B$ (assuming equal costs for internal distribution, and ex-works to f.o.b.). Case three, with supply $S_3 - S_3$, corresponds to the case where $A_B \rightarrow 0$. The internal consumption will again be Q_2 at a wholesale price equivalent to ${}^{E}P_B$.

This would indicate that the ratio A is a relatively insensitive measure of the influence of changes in the proportion of supply sold to the internal market. However several other factors not represented on the diagram enter the market. Exporters must be able to give continuous supplies to overseas markets for long term maximisation of profits. Thus as ratio A tends to unity it can be in their interests to sell less on the internal markets to assure continuous supply overseas. Market imperfections of time and place, and quality of the current production will also increase the influence of the availability ratio. It may therefore be expected that as the value of A_B rises, the influence of the availability ratio on the wholesale price of beef will increase, resulting in premiums above export price on the internal market. Likewise as the value of A_B declines, the level of wholesale price will decline to the level of export price.

One other property of ratio A remains to be discussed, the relationship it implies exists between supply and consumption. The stochastic wholesale price formation equation has been specified as:

$$\overline{{}^{w}P_{B_t}} = b_0 + b_1 \, {}^{E}P_{B_t} + b_2 \, A_{B_t} + b_3 \, A_{M_t} + b_4 \, Q_{SP_t}$$

If this equation is estimated linear in logarithms, then:

$$b_2 \log A_{B_t} = b_2 \log Q_{DB_t} - b_2 \log Q_{SB_t}$$

Thus the supply coefficient is restricted to the negative of the demand coefficient in this equation. This restriction expresses the relationship which could be expected on a priori grounds. The problem of whether consumption or total supply should be included is therefore solved in this model by including both, but restricting the value each can take. As is discussed later, it was expected that the wholesale price relationship would be better estimated linear in logarithms, hence the formulation of A_B as a ratio rather than the difference between supply and demand.

Above are the reasons for including A_B in the wholesale price formation equation. Ratio A_M, the availability ratio for mutton, is included to allow for possible interaction between the availability ratio for mutton and the wholesale price of beef. As the ratio A_M tends to unity, it can be expected that ceteris paribus the wholesale price of beef will rise if there is any elasticity between mutton price and beef consumption. The quantity supplied of pork is also included for similar reasons to the inclusion of A_M. As will be discussed shortly, it is assumed in the model that quantity of pork demanded equals quantity supplied, hence ratio A for pork would always equal unity; thus the absolute quantity is included rather than the ratio A_P.

An adjustment lag was included in the wholesale price formation equation to allow for non-instantaneous adjustment to an equilibrium wholesale price. Because the wholesale price making forces are complex, it was thought this would be a more realistic assumption than either an expectations lead equation based on the expected future value of export price, or assuming a static model with complete adjustment occurring within the one time period.

It is possible that exporters base their internal prices on the price that they expect current meat production to receive overseas, in some future period. Equally these prices could be set on current realisations of meat processed and shipped in the past. Although the available information suggests the latter method as being the more common,[1] even if it were not the three month period of the data gives sufficient time for some meat processed in the current period to be sold on export markets within that period. The additional evidence provided by correlating current United Kingdom wholesale prices and New Zealand wholesale prices lagged one or two (monthly) periods also suggests that it is the current values of export prices which influence current wholesale prices.[2] In addition, the high serial correlation found in the United Kingdom price series would make the choice between alternative expectations assumptions difficult to make. For all these reasons it was decided that an institutional lag model was the more appropriate.

The beef margin equation is basically that described by Fuller and Ladd,[3] and discussed previously.[4] One additional variable has, however, been included. The variable (Z_1) was included to allow for the effect of price control in the 1959/60 period and takes a value of zero for all quarters in which price control was not operative, and unity for those quarters that price control did operate in. As described earlier,[5] price control limited the wholesale-to-retail margin for beef, mutton and pork, hence its inclusion in this equation.

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1. Discussion with exporters indicated that current market realisations were what they base current schedule prices on.
2. Pp. 111-113.
3. W.A. Fuller and G.W. Ladd, op. cit., pp. 802-805.
4. Chapter 4, pp. 97-100.
5. Chapter 1, pp. 12-13.

It was possible to include the effect of price control in either the equilibrium margin equation, or the adjustment equation. It was decided to include this variable in the equilibrium margin equation as price control was an institutional restriction limiting the size of the equilibrium margin during this period.

The Mutton Sub-model

The mutton sub-model is specified the same as the beef sub-model, a description of the market forces which affect mutton demand has been included in the discussion of the beef sub-model. Any differences between the market situation for beef and mutton were discussed in that section with respect to the formulation of the demand, wholesale price formation, and margins equations. The mutton sub-model is, therefore;

(a) The Stochastic Demand and Nerlove adjustment equations[1]

$$\overline{Q_{DM_t}} = a_0 + a_1 P^r_{B_t} + a_2 P^r_{M_t} + a_3 P^r_{P_t} + a_4 Y_t + a_5 S_1 + a_6 S_2 + a_7 S_3$$

$$Q_{DM_t} - Q_{DM_{t-1}} = \gamma (\overline{Q_{DM_t}} - Q_{DM_{t-1}})$$

(b) The Stochastic Wholesale Price Formation equation, and Nerlove adjustment equation

$$\overline{{}^wP_{M_t}} = b_0 + b_1 {}^EP_{M_t} + b_2 A_{B_t} + b_3 A_{M_t} + b_4 Q_{SP_t}$$

$${}^wP_{M_t} - {}^wP_{M_{t-1}} = \beta (\overline{{}^wP_{M_t}} - {}^wP_{M_{t-1}})$$

(c) The Stochastic Wholesale-to-Retail Margin, and Nerlove adjustment equation

$$\overline{M_{M_t}} = c_0 + c_1 I_t + c_2 {}^wP_{M_t} + c_3 Z_1$$

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1. The same symbols for equation constants are used here as in the beef sub-model. This is done for simplicity of presentation.

$$M_{M_t} - M_{M_{t-1}} = \alpha_0 (\overline{M_{M_t}} - M_{M_{t-1}}) + \alpha_1 \Delta {}^wP_{B_t} + \alpha_2 \Delta {}^wP_{M_t} + \alpha_3 \Delta {}^wP_{P_t}$$

Identities

$$P^r_{M_t} \equiv {}^wP_{M_t} + M_{M_t}$$

Other identities are as for the beef sub-model.

Put in functional form the sub-model is;

$$Q_{DM_t} = g' \quad (P^r_{B_t}, P^r_{M_t}, P^r_{P_t}, Y_t, S_1, S_2, S_3, Q_{DM_{t-1}})$$

$${}^wP_{M_t} = g'' \quad ({}^EP_{M_t}, A_{B_t}, A_{M_t}, Q_{SP_t}, {}^wP_{M_{t-1}})$$

$$M_{M_t} = g''' \quad (I_t, {}^wP_{M_t}, Z_1, \Delta^wP_{B_t}, \Delta^wP_{M_t}, \Delta^wP_{P_t}, M_{M_{t-1}})$$

The Pork Sub-model

As was discussed in Chapter 1 the market forces which affect pork demand are different to those for the other major meats. The internal market is by far the major market for pork, and while there are some profitable export markets,[1] most exports are for the disposal of small quantities of 'surplus' production which occur mainly in the February to May period. In most quarters of the year consumption is little different to production.

Demand for pork within New Zealand is confined to fresh pork, very little frozen pork enters the internal market and on the accasions when it does there is a marked discount for the frozen product.[2] Stocks may therefore be neglected in the specification of demand relationships for pork in New Zealand. It will also be assumed here that the quantity of pork demanded equals the quantity supplied. From this discussion and

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1. The Pacific Islands and the Caribbean are the major examples.
2. Wholesalers' weekly price lists show clearly the existence of a large discount.

Chapter 1 it will be seen that this latter assumption does not violate reality as in most quarters consumption is little different to production. In the period when an exportable surplus is produced, once the pork has been frozen it is virtually excluded from the internal market.

The pork sub-model may therefore be expressed as:

(a) Stochastic Demand equation

$$\overline{Q_{DP_t}} = a_0 + a_1 P^r_{B_t} + a_2 P^r_{M_t} + a_3 P^r_{P_t} + a_4 Y_t + a_5 S_1 + a_6 S_2 + a_7 S_3$$

(b) Adjustment equation

$$Q_{DP_t} - Q_{DP_{t-1}} = \gamma (\overline{Q_{DM_t}} - Q_{DM_{t-1}})$$

Thus the stochastic estimating equation is:

$$Q_{DP_t} = \gamma a_0 + \gamma a_1 P^r_{B_t} + \gamma a_2 P^r_{M_t} + \gamma a_3 P^r_{P_t} + \gamma a_4 Y_t + \gamma a_5 S_1 + \gamma a_6 S_2 + \gamma a_7 S_3 + (1 - \gamma) Q_{DP_{t-1}}$$

with the added assumption in the form of an identity i.e.

$$Q_{DP_t} \equiv Q_{SP_t}$$

It is evident that a supply function is required before further progress is possible in specifying the pork sub-model. Many factors affect the supply of pork. In the past these factors have been largely associated with the dairy industry. This is unlikely to continue in the future[1] due to the probable growth of a pigmeat producing industry feeding grain rather than dairy bye-products.

An equation explaining pork supply in the immediate past needs to

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1. Chapter 1, pp. 15-20.

include the following variables:

(i) Farm-gate price of pork in the previous period. The lag of one period being necessary because the production period for porker pigs is greater than three months.

(ii) Price of butterfat in the previous period. As was noted in Chapter 1, dairy farmers have usually produced more pork when returns from dairying were low.

(iii) Quantity of milk production in the previous period. In the past dairy farmers have tended to increase the number of pigs on hand when skimmed milk was freely available.

(iv) Porker/baconer price ratio in the current period. The pig farmer normally has had the option of selling his pigs as porkers or baconers; the decision which to produce being made in the current period. A major deciding factor would be the price ratio, and to some extent current and future milk availability.

The only variables where current values are thought to have affected current supply has been the porker/baconer price ratio, and to a lesser extent the quantity of milk available. These two variables are however unlikely to have changed supply by more than marginal amounts, especially as the porker/baconer price ratio has normally been unchanging. Thus with the production period being greater than three months, pork supply may be considered predetermined. It is therefore assumed that fresh pork supply is a predetermined variable.

With pork supply predetermined, quantity of pork demanded is predetermined because of the supply-demand identity. The dependent variable in the demand equation is, therefore, the retail price of pork. Transforming the stochastic pork demand equation into the direction of dependence gives;

$$P^r_{P_t} = - \frac{a_0}{a_3} - \frac{a_1}{a_3} P^r_{B_t} - \frac{a_2}{a_3} P^r_{M_t} + \frac{1}{\gamma a_3} Q_{DP_t} - \frac{a_4}{a_3} Y_t - \frac{a_5}{a_3} S_1 -$$

$$\frac{a_6}{a_3} S_2 - \frac{a_7}{a_3} S_3 - \frac{(1-\gamma)}{(\gamma a_3)} Q_{DP_{t-1}}$$

or in functional notation the estimating equation becomes:

$$P^r_{P_t} = p' \quad (P^r_{B_t}, P^r_{M_t}, Q_{DP_t}, Y_t, S_1, S_2, S_3, Q_{DP_{t-1}})$$

With retail price of pork determined at the retail level of the market, the identity linking retail and wholesale price becomes:

$$^wP_{P_t} \equiv P^r_{P_t} - M_{P_t}$$

Thus the level of price is set primarily in the retail market. The pork margin equation is the link between retail and wholesale levels, and is expressed in the same terms as the beef and mutton margin equations. In function notation the pork margin equation is therefore:

$$M_{P_t} = p'' \quad (I_t, {}^wP_{P_t}, Z_1, \Delta {}^wP_{B_t}, \Delta {}^wP_{M_t}, \Delta {}^wP_{P_t}, M_{P_{t-1}})$$

With equations explaining the retail price and wholesale-to-retail margin for pork, a wholesale price formation equation for pork is therefore not appropriate.

Ham and bacon have not been included in the New Zealand meat model, their parameters were estimated in a separate model because ham and bacon are not major competitors of the main meats. The results of the consumer survey clearly show this lack of competition, and with annual consumption of ham and bacon being only a few pounds per head, changes in consumption of these products are unlikely to have a significant impact on the consumption of the major meats. Ham consumption is more likely to be a competitor of processed meats, and bacon a complement of eggs, tomatoes, etc. A full discussion of the ham and bacon model is made later, it is sufficient here to briefly outline the reasons for their non-inclusion in the main New Zealand model.

The New Zealand Model

The three meat sub-models may now be integrated into the complete New Zealand model. This will be done in functional notation for clarity of exposition. Variables endogenous to the model are shown by a star (*).

Stochastic equations

$$
\begin{aligned}
\overset{*}{Q}_{DB_t} &= f' \quad (\overset{*}{P}{}^{r}_{B_t},\ \overset{*}{P}{}^{r}_{M_t},\ \overset{*}{P}{}^{r}_{P_t},\ Y_t,\ S_1,\ S_2,\ S_3,\ Q_{DB_{t-1}}) \\
\overset{*}{Q}_{DM_t} &= g' \quad (\overset{*}{P}{}^{r}_{B_t},\ \overset{*}{P}{}^{r}_{M_t},\ \overset{*}{P}{}^{r}_{P_t},\ Y_t,\ S_1,\ S_2,\ S_3,\ Q_{DM_{t-1}}) \\
\overset{*}{P}{}^{r}_{P_t} &= p' \quad (\overset{*}{P}{}^{r}_{B_t},\ \overset{*}{P}{}^{r}_{M_t},\ \overset{*}{Q}_{DP_t},\ Y_t,\ S_1,\ S_2,\ S_3,\ Q_{DP_{t-1}}) \\
{}^{w}\overset{*}{P}_{B_t} &= f'' \quad ({}^{E}P_{B_t},\ \overset{*}{A}_{B_t},\ \overset{*}{A}_{M_t},\ Q_{SP_t},\ {}^{w}P_{B_{t-1}}) \\
{}^{w}\overset{*}{P}_{M_t} &= g'' \quad ({}^{E}P_{M_t},\ \overset{*}{A}_{B_t},\ \overset{*}{A}_{M_t},\ Q_{SP_t},\ {}^{w}P_{M_{t-1}}) \\
\overset{*}{M}_{B_t} &= f''' \quad (I_t,\ {}^{w}\overset{*}{P}_{B_t},\ Z_1,\ \Delta{}^{w}\overset{*}{P}_{B_t},\ \Delta{}^{w}\overset{*}{P}_{M_t},\ \Delta{}^{w}\overset{*}{P}_{P_t},\ M_{B_{t-1}}) \\
\overset{*}{M}_{M_t} &= g''' \quad (I_t,\ {}^{w}\overset{*}{P}_{M_t},\ Z_1,\ \Delta{}^{w}\overset{*}{P}_{B_t},\ \Delta{}^{w}\overset{*}{P}_{M_t},\ \Delta{}^{w}\overset{*}{P}_{P_t},\ M_{M_{t-1}}) \\
\overset{*}{M}_{P_t} &= p'' \quad (I_t,\ {}^{w}\overset{*}{P}_{P_t},\ Z_1,\ \Delta{}^{w}P_{B_t},\ \Delta{}^{w}\overset{*}{P}_{M_t},\ \Delta{}^{w}\overset{*}{P}_{P_t},\ M_{P_{t-1}})
\end{aligned}
$$

Identities

$$\overset{*}{P}{}^{r}_{B_t} \equiv {}^{w}\overset{*}{P}_{B_t} + \overset{*}{M}_{B_t} \qquad \overset{*}{A}_{B_t} \equiv \frac{\overset{*}{Q}_{DB_t}}{Q_{SB_t}}$$

$$\overset{*}{P}{}^{r}_{M_t} \equiv {}^{w}\overset{*}{P}_{M_t} + \overset{*}{M}_{M_t} \qquad \overset{*}{A}_{M_t} \equiv \frac{\overset{*}{Q}_{DM_t}}{Q_{SM_t}}$$

$${}^{w}\overset{*}{P}_{P_t} \equiv \overset{*}{P}{}^{r}_{P_t} - \overset{*}{M}_{P_t} \qquad \overset{*}{Q}_{DP_t} \equiv Q_{SP_t}$$

$$\Delta^{w}\overset{*}{P}_{B_t} \equiv {}^{w}\overset{*}{P}_{B_t} - {}^{w}P_{B_{t-1}}$$

$$\Delta^{w}\overset{*}{P}_{M_t} \equiv {}^{w}\overset{*}{P}_{M_t} - {}^{w}P_{M_{t-1}}$$

$$\Delta^{w}\overset{*}{P}_{P_t} \equiv {}^{w}\overset{*}{P}_{P_t} - {}^{w}P_{P_{t-1}}$$

In this model there are seventeen endogenous variables expressed in terms of eight stochastic equations and nine identities. If the values on the right hand side of the identities are substituted in the stochastic equations for the values on the left hand side, then the model reduces to eight endogenous variables expressed in eight stochastic equations. It is however simpler to retain (for example) the term $P^{r}_{B_t}$, then substitute $({}^{w}P_{B_t} + M_{B_t})$ for it, and hence the above notation will be retained.

The New Zealand Ham and Bacon Model

The reasoning behind the specification of the ham and bacon model is in some respects similar to the reasoning behind the pork sub-model. As was mentioned in discussion of the pork sub-model, the ham and bacon model was estimated separately from the New Zealand model, as available evidence indicated that these meats are not close competitors of the major meats. Consumption of ham occurs mainly in summer months, and processors stockpile hams throughout the year to ensure sufficient summer supplies. Bacon consumption is expected to be related more closely to the price of complementary foods, than to the price of the major meat items.

Ham and bacon have been combined in this model to give single price and quantity variables. This course was followed for several reasons. Firstly bacon and ham are derived from the same carcase, appearing in fixed proportions. Hence it is not unrealistic to combine them into single variables. Because these meats are derived from the same carcase and are processed by similar though not identical methods, there is a close price relationship between them. The correlation coefficient between retail price of ham and retail price of bacon for sixty-one quarterly observations between 1950 and 1965 was 0.925. Similarly, the correlation coefficient between the wholesale prices for forty-eight observations between 1953 and 1964 was 0.780. It therefore seemed desirable to remove this source of intercorrelation, and use a combined price variable, as little additional information would be obtained by using these variables separately. Finally (and perhaps decisively) it was not possible to determine the separate quantities of each meat consumed. Consumption of meat from baconer carcasses (which produces both bacon and ham) could be determined, but a greater break-down of quantity into separate classes could not be achieved with accuracy. Consumption of baconer meat, which will be considered as 'ham and bacon' consumption, is influenced by;

(a) ham consumption, which occurs mostly in the summer months (fourth and first quarters of the calendar year),

and

(b) bacon consumption, which occurs mostly in the winter months (second and third quarters of the calendar year). Seasonal patterns in 'ham and bacon' consumption therefore tend to cancel one another.

Unlike pork, ham and bacon can be stockpiled as they are processed meats and not consumed fresh. The level of stocks are therefore relevant to the specification of a 'ham and bacon' model. With the annual consumption of 'ham and bacon' very close to the quantity produced, and with processors stockpiling hams throughout the year for the summer months, supply can be considered as being managed within a year although not significantly between years. 'Within' year bacon supplies are managed in much the same way as ham supplies are, but with maximum consumption in different seasons. Stock demand and supply equations are, therefore, essential if an accurate representation of the 'ham and bacon' market forces is to be made, however stock figures are not available and another alternative had to be sought.

The assumption which was used was that demand equalled supply. This can be considered as an unsatisfactory, though necessary, approximation to a market situation where processors of baconer pigs marginally adjust seasonal supply through stock changes to maximise annual profit. As with the pork sub-model, supply is considered as being predetermined.

Although the basic assumptions behind this 'ham and bacon' model have been demonstrated as being less than satisfactory, an attempt was made to estimate the model's parameters. The resulting 'ham and bacon' model was similar in specification to the pork sub-model; expressed in functional notation it was:

Stochastic equations

$$\overset{*}{Q}_{DH_t} = d' \quad (\overset{*}{P}{}^{r}_{H_t}, Y_t, S_1, S_2, S_3, Q_{DH_{t-1}})$$

$$\overset{*}{M}_{H_t} = d'' \quad (I_t, {}^{w}\overset{*}{P}_{H_t}, Z_1, \Delta^{w}\overset{*}{P}_{H_t}, M_{H_{t-1}})$$

Identities

$$\overset{*}{Q}_{DH_t} = Q_{SH_t} \qquad\qquad \Delta^{w}\overset{*}{P}_{H_t} = {}^{w}\overset{*}{P}_{H_t} - {}^{w}P_{H_{t-1}}$$

$${}^{w}\overset{*}{P}_{H_t} = \overset{*}{P}{}^{r}_{H_t} - \overset{*}{M}_{H_t}$$

By substituting the identity which formalises the assumption that supply is predetermined the stochastic model for estimation becomes:

$$\overset{*}{P}{}^{r}_{H_t} = h' \quad (Q_{DH_t}, Y_t, S_1, S_2, S_3, Q_{DH_{t-1}})$$

$$\overset{*}{M}_{H_t} = h'' \quad (I_t, {}^{w}\overset{*}{P}_{H_t}, Z_1, \Delta^{w}\overset{*}{P}_{H_t}, M_{H_{t-1}})$$

By replacing the left hand side of the identities with right hand side, the model becomes one of two equation explaining two endogenous variables.

Discussion of the New Zealand Models

In this section the New Zealand model specified will be discussed in general terms, some alternative models will be briefly examined along with the limitations of the present model specification. Further sections in this chapter will consider the appropriate functional form for each equation, the specification of the models to be estimated, and the identification properties of the models to be estimated. A discussion of alternative estimation procedures is left until Chapter 6.

A model other than that specified for the New Zealand demand for meat could perhaps have been useful in examining the internal demand for a commodity which is exported. Demand functions expressing demand for the product in each market could be used in conjunction with the assumption of predetermined supply, a stock demand equation, and an identity linking supply, demand and stocks, i.e.

$$Q_{S_t} = \sum_{i=1}^{n} Q_{D_{it}} + \Delta \text{Stocks} \qquad \text{where there are n markets.}$$

This approach has been rejected because several demand functions would be required for each meat, each function explaining the market situation in the particular market, or group of markets. Inevitably the model would become an expression of world demand for New Zealand meat products. The complexity of such a model, and the data requirements could be overwhelming, even if the computing facilities for such a large multi-equation model were available. It is also doubtful whether such a model would provide 'better' (in an economic sense) estimates of New Zealand demand parameters than the model employed. The causal chain propounded here follows the decision making processes of the meat operators, the influence of all the export sales of meat being included in the export-price variable.

Another alternative is to derive a profit maximising model[1] for meat wholesalers. In this model the wholesalers face the New Zealand demand curve, and an infinitely elastic export demand curve. The model is thus profit maximisation of a discriminating monopoly. The wholesale and export trade is, however, composed of many firms, with each firm probably facing demand curves of infinite elasticity in both markets. Thus marketing is carried out by price equalisation in alternative markets rather than on marginal revenue grounds. A model specified on these lines could not therefore be expected to provide estimates of the aggregate New Zealand market demand parameters. If however the marketing

1. This alternative was suggested by R.J. Townsley and W.A. Fuller, Iowa State University, personal communication.

of New Zealand meat was under the control of a monopoly marketing commission this approach would be of great value.

Although it was not stated formally in the New Zealand meat model, it has been assumed that total supply of beef and mutton is predetermined. This assumption is necessary only when A_B and A_M respectively tend to unity. While the assumption is not always valid, as at times of shortage frozen meat from stocks can enter the market at a discount, the quantities are usually small and the discount large.

Finally, the model assumes that income is independent of meat prices. This may in fact not be true in New Zealand as export prices for meat could be a significant determinant of income, as well as a determinant of internal meat prices. Normally the effect of prices on national income can reasonably be assumed to be negligible. In New Zealand's case this may not be so, the value of meat exports in 1965 was 28.6 per cent of total exports,[1] and if export meat prices were to fall the total value of all exports would decline, as would internal meat prices and hence meat realisations. This would not only affect the meat industry, the major effect of such a decline would be in New Zealand's ability to import goods and raw materials for manufacturing. It is through the dependence of the New Zealand economy on export income that a decline in meat prices would affect national income the greatest. Whether a decline in meat prices would significantly affect national income it is not possible to say, such a decline would certainly be more likely to affect income in New Zealand than in most other countries.

To include the price-income relationship in the New Zealand meat model would require several more equations explaining the determination

1. Government of New Zealand, New Zealand Official Year Book, Wellington, 1967, p. 633. Actual figures were: Meat exports £106.25 million. Total exports £371.1 million.

of national income in terms of export prices of the major exports as well as the more usual income determination variables. As with the alternatives outlined earlier, such a model would become very complex, and in view of the difficulties associated with estimation and data as well as the possibly tenuous link between income and meat prices, income determination equations have not been included. The model therefore assumes that no such relation exists.

Functional Forms

Selection of the appropriate functional form is of great importance in specification of any relationship. While the theoretical implication of this problem will not be discussed here,[1] a brief outline of the alternative functional forms for each equation will be made. A great variety of functional forms are available; however, for the New Zealand models the choice was restricted to two, linear and linear in logarithms.

On theoretical grounds it was expected that the logarithmic form would be more appropriate for the demand and wholesale price formation equations. Similarly it was expected that the margin equations would be better estimated in the linear form. Supporting evidence for the use of the logarithmic demand function is provided by Court,[2] and for the linear margin function by Fuller and Ladd.[3]

The specification of the models has to this point proceeded in terms of linear functions. The transformation of some equations into functions linear in logarithms will not essentially change the relationships in the models, only the form of the relationships. It was,

1. See: Chapter 3, pp. 55-58, where alternative functional forms are discussed with respect to Engel Curve estimation.

2. R.H. Court, *op. cit.*, pp. 24-26.

2. W.A. Fuller and G.W. Ladd, *op. cit.*, pp. 802-804.

however, because the wholesale price formation equation was a priori expected to be more accurately represented by an equation linear in logarithms that availability ratio was expressed as a ratio. Similarly the margin equations were expected to be arithmetic, hence first differences in wholesale prices were used rather than ratios. All equations were estimated in the form a priori expected to be the more appropriate.

New Zealand Meat Models Estimated

Four variants of the New Zealand meat model were estimated with equations in linear or logarithmic form as above. These models were:

(a) The New Zealand retail demand model with adjustment lags. This model was the basic New Zealand meat model outlined in this chapter.

(b) The New Zealand retail demand model with no lags included. This model was as outlined in the chapter, but with the adjustment lags excluded. It was hoped that this model would provide some check on the estimated coefficients and the statistical acceptability of the dynamic model.

(c) A wholesale demand model with adjustment lags. In this model the demand function was specified at the wholesale level (i.e. with wholesale prices). Estimation at this level allowed the inclusion of demand for lamb into the model, which was not possible at the retail level because no retail prices for lamb were available.[1] Expressed in functional notation this model was:

Stochastic equations

$$\overset{*}{Q}_{DB_t} = a' \quad ({}^{w}P^*_{B_t},\ {}^{w}P^*_{L_t},\ {}^{w}P^*_{M_t},\ {}^{w}P^*_{P_t},\ Y_t,\ S_1,\ S_2,\ S_3,\ Q_{DB_{t-1}})$$

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1. Chapter 7, pp. 147-149 and 181-184.

$$\overset{*}{Q}_{DL_t} = a'' \quad ({}^{w}P^*_{B_t},\ {}^{w}P^*_{L_t},\ {}^{w}P^*_{M_t},\ {}^{w}P^*_{P_t},\ Y_t,\ S_1,\ S_2,\ S_3,\ Q_{DL_{t-1}})$$

$$\overset{*}{Q}_{DM_t} = a''' \quad ({}^{w}P^*_{B_t},\ {}^{w}P^*_{L_t},\ {}^{w}P^*_{M_t},\ {}^{w}P^*_{P_t},\ Y_t,\ S_1,\ S_2,\ S_3,\ Q_{DM_{t-1}})$$

$${}^{w}P^*_{P_t} = a'''' \quad ({}^{w}P^*_{B_t},\ {}^{w}P^*_{L_t},\ {}^{w}P^*_{M_t},\ \overset{*}{Q}_{DP_t},\ Y_t,\ S_1,\ S_2,\ S_3,\ Q_{DP_{t-1}})$$

$${}^{w}P^*_{P_t} = b' \quad ({}^{E}P_{B_t},\ \overset{*}{A}_{B_t},\ \overset{*}{A}_{L_t},\ \overset{*}{A}_{M_t},\ Q_{SP_t},\ {}^{w}P_{B_{t-1}})$$

$${}^{w}P^*_{L_t} = b'' \quad ({}^{E}P_{L_t},\ \overset{*}{A}_{B_t},\ \overset{*}{A}_{L_t},\ \overset{*}{A}_{M_t},\ Q_{SP_t},\ {}^{w}P_{L_{t-1}})$$

$${}^{w}P^*_{M_t} = b''' \quad ({}^{E}P_{M_t},\ \overset{*}{A}_{B_t},\ \overset{*}{A}_{L_t},\ \overset{*}{A}_{M_t},\ Q_{SP_t},\ {}^{w}P_{M_{t-1}})$$

Identities

$$\overset{*}{A}_{B_t} \equiv \frac{\overset{*}{Q}_{DB_t}}{Q_{SB_t}}$$

$$\overset{*}{A}_{L_t} \equiv \frac{\overset{*}{Q}_{DL_t}}{Q_{SL_t}}$$

$$\overset{*}{A}_{M_t} \equiv \frac{\overset{*}{Q}_{DM_t}}{Q_{SM_t}}$$

$$\overset{*}{Q}_{DP_t} \equiv Q_{SP_t}$$

As before, if the right hand side of the identities are placed in the stochastic equations, the model becomes one of seven endogenous variables in terms of seven equations. It will be noted that the wholesale to retail margin equations have been excluded from this model. This was done because, with the demand functions estimated at the wholesale level, the margin equations become unnecessary to the model.

(d) A static wholesale demand model which was the same as the dynamic wholesale model, but with the dynamic adjustment terms excluded. The reasons for estimating this model were the same as for the static retail model.

Prior to the development of the New Zealand model a series of simple demand equations of an exploratory nature were estimated. These models, which were estimated without regard to detailed specification, were more in the nature of data exploration, and as such proved useful in later work. The results of these naive models are presented in the first section of Chapter 8.

New Zealand 'Ham and Bacon' Models Estimated

As with the New Zealand model , alternative variants of the 'Ham and bacon' model were estimated, these were:

(a) Dynamic retail model as above.

(b) Static retail model, in which the lagged variables were removed. The reasons for estimating this model are the same as those for estimating static models in the New Zealand meat model. In this model a shift variable for trichinosis (Z_2) was included in the demand equation.

The discussion of the New Zealand model with respect to alternative formulations, the independence of income, and the functional form of the estimating equations is equally relevant to the 'ham and bacon' models but will not be repeated here.

Identification

If the New Zealand models were to be estimated by indirect least squares to obtain structural coefficients, then all the stochastic equations in the model must be just-identified. If under-identification exists, then the model parameters cannot be estimated, and if the model is over-identified, then simultaneous methods other than indirect least squares must be used to obtain the structural coefficients. With such a model as that described for New Zealand meats, ordinary least squares estimates of the structural equations would lead to biased estimates of the equation parameters. It is therefore desirable for the model to be just-identified in all equations, as this allows the use of indirect least squares, the simplest unbiased method of estimating the structural parameters from a multi-equation model. The problem of alternative estimating procedures is discussed more fully in Chapter 6, it is sufficient here to briefly outline the problem and hence demonstrate the importance of structural identification.

Identifiability criteria and their implications have been discussed in several works,[1] the findings of which result in two criteria for identifiability. These criteria are:

(i) the order condition, which is the easier to use, and is a necessary but not sufficient condition for identification;

(ii) the rank condition, which is a necessary and sufficient condition for identification.[2]

In general if the order condition holds, then it is probable that the rank condition will also hold. If the order condition is violated, then identification of structural relationships will not be possible. The order condition may be expressed as follows:

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1. See for example: E.C. Hood and T.C. Koopmans (Editors), Studies in Econometric Methods, Cowles Commission Monograph No. 14, Wiley and Sons, New York, Chapters 2 and 3, pp. 27-74
and
T.C. Koopmans (Editor), Statistical Inference in Dynamic Economic Models, Cowles Commission Monograph No. 10, Wiley and Sons, New York, 1950, Chapter 2, pp. 69-109, and Chapters 3, 4, and 5, pp. 238-265.

2. T.C. Koopmans, op. cit., pp. 78-79.

If the i^{th} equation in a multi-equation model is just-identified, then $H - H' = k - 1$ where:

H = number of variables in the system of equations

H' = number of variables in the i^{th} equation

k = number of equations in the system.

If $H - H' > k - 1$ then the i^{th} equation is over-identified, and if $H - H' < k - 1$ then the i^{th} equation is under-identified.

In all the New Zealand models every equation was over-identified by the order condition. As the order condition is a necessary condition, no useful purpose would have been served by applying the rank condition. The over-identification of the models make it necessary to investigate the possibility of using simultaneous equation solution methods other than indirect least squares to estimate the models' parameters. This investigation is the subject of Chapter 6.

The identification properties of the 'ham and bacon' model are the same as for the New Zealand model. A slight difference in the model does exist though: the first equation has only one endogenous variable present. Ordinary least squares estimation of this equation will therefore give an estimate of the coefficients unbiased by the method of estimation. The second equation, and hence the model, does not retain this property. For an unbiased estimate of the complete model simultaneous estimation procedures are therefore required.

Discussion

In the previous chapter an attempt was made to define some of the main problems involved in specifying a model appropriate to the New Zealand meat market. A few examples relevant to the New Zealand internal market were discussed. In the present chapter the use of this information, and that information relevant from all the previous chapters has been drawn together in the detailed specification of models explaining the internal demand for New Zealand meat. Problems involved in estimation procedures have been raised. These problems are discussed in the next chapter. Some problems regarding data were also brought to light. Data series and the data estimation methods used, along with some discussion are presented in Chapter 7.

CHAPTER 6

ALTERNATIVE ESTIMATION PROCEDURES APPLICABLE TO THE NEW ZEALAND MODELS

Introduction

In the previous chapters economic models for estimating the demand parameters of meat in New Zealand were developed, and the identification properties of these models examined. It will be evident from the property of over-identification common to all the models that unbiased parameter estimates will not be achieved by other than a simultaneous equations solution method.

It is the purpose of this chapter to discuss some of the alternative estimation methods available, and select a suitable estimation procedure on the basis of theory and past performance. Some attention must also be paid to the practical limitation of the available computational facilities. Because the alternative methods are clearly shown in many textbooks a description of computational procedures will not be presented. Attention will be confined to the performance and theoretical limitations of each method.

The Generalised System of Linear Equations

A complete linear equation system in M jointly dependent and R predetermined and exogenous variables may be shown as:

$$\begin{array}{l} a_{11}Y_{1_t} \ldots + a_{1}Y_{M_t} + b_{11}X_{1_t} + \ldots + b_{1R}X_{R_t} = U_{1_t} \\ \vdots \\ a_{M1}Y_{1_t} \ldots + a_{MM}Y_{M_t} + b_{M1}X_{1_t} + \ldots + b_{MR}X_{R_t} = U_{M_t}. \end{array}$$

where;

$Y_1 \ldots Y_M$ are M jointly dependent variables

$X_1 \ldots X_R$ are R predetermined and exogenous variables

$U_1 \ldots U_M$ are M random distubance terms associated with the system of M equations. The a's and b's are equation coefficients. There are T observations (t = 1,2,...T).

In any multi-equation model the relationships will not necessarily be expressed in the above form. Each structural equation may not include all the X's and Y's, thus on a priori grounds restricting the value of the associated coefficients to zero. Similarly the equations will usually be normalised, i.e. the coefficient of one of the Y's will be restricted to equal unity. Thus any one structural equation may be:

$$Y_t = \sum_{i=1}^{m} a_i Y_{it} + \sum_{j=1}^{r} b_j X_j + U_t$$

where there are $m + 1 \leqslant M$ jointly dependent variables
and there are $r \leqslant R$ predetermined and exogenous variables.

While it is not intended to delve into the theory of identification here,[1] it may be noted that whether the model is under-, over-, or just-identified by the order condition depends upon how many restrictions are placed upon coefficients in the model. Thus for each equation if the number of coefficients restricted to a value of zero equals the number of structural equations minus one (M - 1 in the above general model) the equation is just-identified. If more restrictions are placed upon the equation it is over-identified, and if less it is under-identified. Taken over M structural equations, the whole model is just-identified if all the equations are just-identified.

1. See: Chapter 5, pp. 133-135.

For the coefficients of the generalised model to be estimated several assumptions are required.

These assumptions are:

1. The matrix of coefficients from the generalised model is consistent and independent, i.e. the coefficient matrix is non-singular.
2. The predetermined and exogenous variables are independent of one another and non-stochastic for all sample observations.
3. The disturbance variables in the model are random with zero mean, have zero lagged variances (i.e. no auto-correlation) and covariances, and their current variances and covariances are finite and independent of t, i.e.

$$E\,(U_{i_t}\;U_{j_{t'}}) \;=\; 0 \quad \text{if } t \neq t'$$

$$\;=\; \sigma_{ij} \quad \text{if } t = t'$$

where σ_{ij} is independent of t
and i and j refer to equation numbers in the system of M equations, i may or may not equal j.

Thus it is assumed that there is no autocorrelation of random error variables, and that these variables have finite variance and covariance only between current values. These assumptions, additional to those outlined in Chapter 4,[1] are necessary for estimation of the structural coefficients by any of the multi-equation solution methods currently available.

It will be evident from assumption two above, and the relationships expressed in the general model, that ordinary least squares (OLS) estimates of the structural parameters will not be satisfactory. The

1. Chapter 4, pp. 86-88.

presence of jointly dependent variables on the right hand side of the equation(s), each jointly dependent variable with a stochastic component, means that estimates of the parameters by OLS will be biased and inconsistent. Even where the relationships are just-identified this problem exists. Although the structural coefficients may be uniquely calculated from the reduced form coefficients estimated by OLS, the structural coefficients will be biased. The reduced form coefficients will, however, be unbiased estimates, as the reduced form equations are calculated only in terms of predetermined and exogenous variables on the right hand side. These equations may therefore be estimated by least squares without bias or lack of consistency provided the other normal assumption of least squares are fulfilled, but they will only yield unbiased estimates of the reduced form coefficients.

Where over-identification exists there is no single unique solution obtainable for the structural coefficients from the reduced form. Thus if estimates of the structural coefficients are required alternative (and more complex) simultaneous solution methods must be used. Because the specified New Zealand meat model is over-identified in all equations, a brief examination of the performance of alternative estimating procedures is relevant to this study. That estimates of the structural coefficients are necessary, if meaningful use is to be made of the New Zealand model, there can be no doubt.

Alternative Estimation Methods and Their Performance

Several estimation methods are available for simultaneous estimation of parameters in multi-equation models. The methods considered here will be mostly those for which Monte Carlo experiments have been carried out to examine each method's relative performance. As the New Zealand model is over-identified, the methods considered will be those which make use of all restrictions. Indirect least squares does not make use of all restrictions and hence will not be considered.

Monte Carlo experiments are those in which random numbers are used in the generation of the population of observations for the model. True values of parameters are taken and used in conjunction with 'observations' on predetermined and exogenous variables. By using these values in the 'true' equation, along with the randomly generated error, the values of endogenous variables are calculated.

As the true population parameters are known, experiments can be carried out to see how well various estimating techniques perform under a variety of conditions. It is therefore possible to find out what happens when procedure A is used in situation X. It is of importance however that a limitation of this procedure be appreciated. The results will always be specific to the model employed. A great many models need to be experimented with, therefore, before any reliable general conclusions can be drawn. At present insufficient experimental work has been carried out using this approach for firm conclusions to be drawn. However the results achieved to date have been reasonably uniform, and hence some empirical indication of each alternative estimation technique's worth is available.

Four estimating procedures have been widely examined by Monte Carlo experiment.[1] These procedures are:

(a) Limited-information single equation (LISE)

(b) Two-stage least-squares (2SLS)

(c) Ordinary least-squares (OLS)

(d) Full-information maximum-likelihood (FIML).

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1. Several alternative estimating procedures are however available. See for example: A.L. Nagar, "A Monte Carlo Study of Alternative Simultaneous Equation Estimations", Econometrica, Vol. 28, 1960, pp. 573-590.

The first three methods are limited information procedures in that they do not make full use of all the information in the data and model, each method corresponds to a different value of k in Theil's group of k - class estimators.[1] The FIML method does simultaneously estimate all the relationships in the model, thus making full use of all the *a priori* information available.[2]

In Monte Carlo studies of the performance of alternative estimating procedures three criteria are normally used to rate the reliability of parameter estimates. These criteria are bias, variance and mean-square error.

Bias, used in this context, is a measure of the discrepancy between the mean of the estimates' sampling distribution, and the true parameter value. Variance as used here is a measure of the variance of the estimates around their mean. The mean can however be biased from the true parameter value. The mean-square error is the variance of the estimates around the true parameter value, and is equal to the variance plus the square of the bias.[3] Thus an estimate with greater bias may show a smaller mean-square error if it has a sufficiently small variance.

It is not intended to detail each individual experiment, or give detailed results. Several reviews of the experiments are available

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1. For estimation procedures and relationship to k - class estimators see: A.S. Goldberger, *Econometric Theory*, Wiley and Sons, New York, 1964, pp. 329-356.

   also: J. Johnston, *op. cit.*, pp. 236-272.

   and H. Theil, *Economic Forecasts and Policy*, 2nd Edition, North-Holland Publishing Co., Amsterdam, 1961, pp. 225-232 and 334-344.

2. See those references indicated in footnote (1) above for the estimation procedure.

3. J. Johnston, *op. cit.*, pp. 276-277.

which give this analysis.[1] The general conclusions are however important in deciding the estimation procedure to be adopted.

On theoretical grounds estimates of structural parameters by ordinary least-squares will be biased, but have minimum variance about the estimated mean. This estimated mean may not, however, be the true mean. Ordinary least-squares also has more desirable small sample properties. The other methods (i.e. 2SLS, LISE and FIML) should be unbiased and consistent. These conclusions are largely supported by Monte Carlo studies which will now be considered.

Johnston[2] discusses the results achieved from several Monte Carlo studies. Where the correct model specification is used FIML has an advantage over all other methods, followed by 2SLS and LISE with OLS a poor last. However with investigations in a 'real world' context the correct model specification is often not achieved. Experiments where the estimating models were mis-specified showed the sensitivity of FIML to this error. Because FIML estimation makes maximum use of all the restrictions it is more subject to error and performed uniformly the worst. As could be expected OLS performed much better in cases of mis-specification. On balance the ranking of methods where specification error occurred, according to Johnston, was: 2SLS, LISE and OLS, FIML. The difference between the first three methods was, however, slight.

Other errors such as multicollinearity give similar results to mis-specification with little to choose between the first three methods

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1. J. Johnston, ibid., pp. 275-295.
   also:
   C.F. Christ, "Simultaneous Equation Estimation: Any Verdict Yet?", Econometrica, Vol. 28, 1960, pp. 835-845.

   C. Hildreth, "Simultaneous Equations: Any Verdict Yet?", Econometrica, Vol. 28, 1960, pp. 846-854.

   L.R. Klein, "Single Equation versus Equation System Methods of Estimation in Econometrics", Econometrica, Vol. 28, 1960, pp. 866-871.

2. J. Johnston, op. cit., pp. 236-272.

(2SLS, LISE, OLS) and FIML uniformly the worst. As yet no satisfactory investigations have been carried out where serial correlation occurs in the data although indications are that a similar ranking to that under specification error need not be unexpected.

Goldberger[1] concludes that as yet only tentative conclusions can be made as to which method is 'best'. Where cost restricts the choice to single equation estimators Goldberger suggests 2SLS as the most preferable method. If a full information procedure is possible three-stage least-squares[2] (3SLS) is the more acceptable unless <u>a priori</u> information is available about the error variance-covariance matrix. Where such information is available the full-information least-generalised residual variance method, or a linearised version should be chosen. This method is that which has been referred to previously as FIML. Strictly FIML covers a range of full-information estimators which have recently become available. The 3SLS method of estimating an over-identified model simultaneously is simpler than previous full-information methods, and makes use of 2SLS estimates of parameters in calculating the third stage estimates.

One further method of estimating the equations was considered. This method is a modification of ordinary least-squares and has been termed by its authors as three-pass least-squares (3PLS).[3] Essentially this method assumes the form of the autocorrelated error term in the same way as Fuller and Martin,[4] but instead of using an iterative procedure

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1. A.S. Goldberger, <u>op. cit</u>., pp. 360-364.
2. A. Zellner and H. Theil, "Three Stage Least Squares: Simultaneous Estimation of Simultaneous Equations", <u>Econometrica</u>, Vol. 30, 1962, pp. 54-78.
3. L.D. Taylor and T.A. Wilson, "Three Pass Least Squares: A Method for Estimating Models with a Lagged Dependent Variables", <u>The Review of Economics and Statistics</u>, Vol. 46, 1964, pp. 329-346.
4. W.A. Fuller and J.E. Martin, <u>op. cit</u>., pp. 71-82.

estimate the autocorrelation coefficient (λ) in the model;

$$Y_t = aY_{t-1} + \beta X_t + U_t \qquad \ldots\ldots(1)$$

$$U_t = \lambda U_{t-1} + \varepsilon_t \qquad \ldots\ldots(2)$$

where Y and X are variables

a, β and λ are coefficients

U = autocorrelated error

ε = random error

t = time period

the value of λ and hence other coefficients are determined by a series of three regression estimates. In testing the worth of this procedure the authors carried out several Monte Carlo experiments. These experiments demonstrated 3PLS as a superior estimator to OLS under most conditions, both where the autocorrelated error took the form expressed in equation two above, and when it took other forms. The problem of testing to know when autocorrelation is present, and hence 3PLS should be used, is however still present. In an attempt to solve this problem the power of the Durbin-Watson statistic was also tested by Monte Carlo experiment. It is interesting to note that in most cases the Durbin-Watson statistic was between 80 and 100 per cent efficient in detecting the presence of an autocorrelation in auto-regressive models.

A great variety of estimation methods could be used in estimating the parameters of the New Zealand models. On the basis of conclusions which can be drawn from existing Monte Carlo experiments, and on theoretical expectations the following procedure was adopted.

Firstly, all structural equations were estimated by ordinary least-squares. This was done to limit the number of models estimated by more complicated procedures. Those models which appeared the more reasonable on the basis of ordinary least-squares results and _a priori_ information were to be estimated by two-stage least-squares. If the resulting estimated variance-covariance matrix of the equation error variables was not a diagonal matrix[1] three-stage least-squares estimates would then be made. As 3PLS is a variant of ordinary least squares, unless severe autocorrelation problems were encountered it was decided that 3PLS would not be used as it is not a maximum-likelihood solution method for multi-equation models.

Discussion

In this chapter, the performance of the various methods available for estimating structural coefficients in the New Zealand model have been discussed. The actual methods have not been detailed, these are available in texts referred to. The chapter culminated in the selection of the estimation techniques to be used. It is not suggested that the methods above are the only ones applicable. However some limitation had to be placed on the mechanical job of estimation. The models were estimated using the University of Canterbury's I.B.M. 1620 computer with the additional storage unit.[2] This relatively small machine imposed limits upon the size of model which could be estimated by two- and three-stage least-squares. This problem is further discussed in Chapter 8.

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1. If the estimated error covariances tend to zero at the two-stage estimates, then no advantage is gained by proceeding to three-stage least-squares, the two estimates then being the same. See: A. Zellner and H. Thiel, op. cit., p. 58.

2. The programming of the computer for the calculation of two- and three-stage least-squares solutions was carried out by Mrs Mary Woods (neè Matheson) of the Agricultural Economics Research Unit, Lincoln College.

Pages 147-192 of A.E.R.U. Technical Paper No.7 ("An Econometric Model of the New Zealand Meat Market") appear to be missing but are not. That is Chapter 7 of the thesis and was published separately.

Chapter 7 of this thesis was published as

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CHAPTER 8

THE ESTIMATED AGGREGATE TIME - SERIES MODELS

Introduction

In this chapter the estimated parameters of the aggregate time-series models will be presented and discussed. Initially the naive models will be examined. These naive models were simple demand functions estimated by ordinary least-squares in the process of data exploration. Specification of these single equation models is therefore recognisably unsatisfactory.

The second part of this chapter contains the ordinary least-squares estimates of the meat and 'ham and bacon' models. A third section will discuss the two-stage least-squares estimates of the model variants. Finally there will be a general discussion of all the aggregate time-series model estimates.

Estimated coefficients will be shown mostly in tabular form, along with their associated statistics. The correlation coefficient matrices will be shown in separate tables. There were several transformations performed on the data before they were used in the models. These transformations were common to all models. All quantity variables, and income statistics, were expressed in per person terms rather than as New Zealand aggregates. This corresponds to an assumption that the community is composed of 'average' consumers with respect to income and consumption patterns. While this assumption is not fully satisfactory it is an often used approximation.

Price and margin variables were expressed in pence per pound for each meat and deflated by the Government Statistician's retail consumer price index. The income variable was also deflated by the retail consumer price index. The use of the consumer price index as a deflator may be looked at in two ways. Firstly, it assumes that consumers react to changes in real income and real prices rather than changes in money values. Converted into money terms the coefficient associated with the consumer price index is thus restricted to equal the negative sum of the price and income coefficients. If, therefore, consumers' meat buying is in any way dependent upon a 'money illusion' effect, this effect can be determined from the models. Secondly, by using the consumer price index as a deflator a possibly serious intercorrelation problem is removed from the model. Both aspects were important in the decision as to which was the most suitable way to use this index.

The Naive Models

Because of the influence overseas prices have on internal prices it was accepted at an early stage of this work that a series of simple demand functions would not adequately explain the relationships involved in the New Zealand meat market. If, for example, the problem was only the estimation of the demand elasticities, a model similar to that used by Taylor[1] would have been satisfactory. However, a knowledge of how much quantity demanded changes when retail price changes is of small value if a quantitative assessment of the causes of retail price changes is unknown. It was for this reason that the estimation of the more difficult model was attempted.

Within the more complete models, however, the demand functions remain an extremely important component. A set of simple demand

1. G.W. Taylor, 1963, op. cit., pp. 81-87.

functions were therefore estimated and examined at an early stage of this research project. These simple and unsophisticated estimates showed some problems (e.g. multicollinearity) to be present in the data, and this enabled these problems to be countered at an early stage of the study. The resulting estimates of the simple models are included here because of the estimation problems which were shown to be present, as well as for the value which the estimates themselves may have.

There were three groups of simple demand functions estimated, corresponding to different data groups. The first of these groups were the quarterly retail demand functions. Data for this group were for the time period 1950 (fourth quarter) to 1965 (fourth quarter) inclusive. The meats for which these demand functions were estimated were beef, beef and veal, mutton, lamb and mutton, pigmeats, and all meats. The per person consumption of each meat per quarter was regressed against the same set of price, income, and seasonal variables. The stochastic equation estimated for beef (for example) was:

$$\log Q_{DB_t} = \log a_0 + a_1 \log P^r_{B_t} + a_2 \log P^r_{M_t} + a_3 \log P^r_{P_t} + a_4 \log P^r_{h_t} + a_5 \log P^r_{f_t} + a_6 \log Y_t + a_7 S_1 + a_8 S_2 + a_9 S_3$$

where Q = quantity consumed in lbs/person/quarter year

P = quarterly average price

Y = income per person per quarter

S = seasonal shift variable (S_1 = second quarter of the year, S_2 = third quarter, and S_3 = fourth quarter)

T = trend variable, taking the value of unity in the first quarter, with the value increasing by one in each successive quarter.

Subscripts

B = beef

V = veal

M = mutton

L = Lamb

P = pork

h = ham

f = bacon

H = ham and bacon

j = pigmeats

A = all meats

D = demanded

t = time period

Superscripts

r = retail

w = wholesale.[1]

The second group of equations were annual retail demand functions, based on annual average data for the period 1950 to 1963 (year ended 30th September). The dependent variables in these equations were consumption of beef, beef and veal, mutton, lamb and mutton, pork, ham and bacon, pigmeats, and all meats. Each of the above consumption variables were regressed against the same set of variables. The stochastic equation for beef (for example) was:

$$\log Q_{DB_t} = \log b_0 + b_1 \log P^r_{B_t} + b_2 \log P^r_{M_t} + b_3 \log P^r_{P_t} + b_4 \log P^r_{h_t} +$$

1. This notation will be retained for all simple models. In the presentation of the more complex models the notation listed in Chapter 5, pp. 105-106 will be used. The differences between the two are however slight, the simple models having some variables not used in the complex models.

$$b_5 \log P^r_{f_t} + b_6 \log Y_t$$

The third group of equations were estimated on a quarterly basis using wholesale prices. This enabled an estimate of the price elasticity of demand for lamb to be made. The dependent variables in these models were quarterly consumption of beef, beef and veal, lamb, mutton, pigmeats, and all meat. The observations were for the period 1953 (first quarter) to 1964 (fourth quarter). As before, each consumption variable was regressed against a set of price, income, and seasonal variables. The stochastic equation for beef (for example) was:

$$\log Q_{DB_t} = \log C_0 + C_1 \log {}^wP_{B_t} + C_2 \log {}^wP_{L_t} + C_3 \log {}^wP_{M_t} + C_4 \log {}^wP_{P_t} + C_5 \log {}^wP_{h_t} + C_6 \log {}^wP_{f_t} + C_7 \log Y_t + C_8 S_1 + C_9 S_2 + C_{10} S_3$$

A second set of the three model groups above were also estimated. This second set was identical to the above, apart from the inclusion of a trend variable. The trend variable was equal to unity for the first observation , and increased by one for each successive observation, and was included to provide a measure of systematic change in consumers' meat buying over time. Such changes could, for example, be due to evolving tastes or preference changes.

Tables 8.1, 8.2, and 8.3 present the estimated quarterly retail demand equations, and the associated correlation coefficients. The level at which the estimated coefficients, and coefficients of determination, are significantly different from zero is shown by the code used in Chapter 3.[1] The equation coefficients were tested by t-test, the

1. Chapter 3, pp. 64-65.

TABLE 8.1

SIMPLE QUARTERLY RETAIL DEMAND MODELS 1950 (FOURTH QUARTER) - 1964 (FOURTH QUARTER).

Dependent Variables	Constant	$P^r_{B_t}$	$P^r_{M_t}$	$P^r_{P_t}$	$P^r_{h_t}$	$P^r_{f_t}$	Y_t	S_1	S_2	S_3	R^2
Q_{DB_t}	2.413	-0.455^{***} (0.057)	0.425^{***} (0.064)	-0.413^{***} (0.132)	-0.528^{***} (0.143)	1.070^{***} (0.202)	0.148^{**} (0.073)	0.081^{***} (0.013)	0.084^{***} (0.013)	-0.020 (0.013)	0.866^{***}
$Q_{D(B+V)_t}$	2.156	-0.407^{***} (0.057)	0.414^{***} (0.064)	-0.492^{***} (0.031)	-0.477^{***} (0.142)	1.116^{***} (0.202)	0.166^{**} (0.073)	0.083^{***} (0.013)	0.079^{***} (0.013)	-0.028^{**} (0.013)	0.856^{***}
Q_{DM_t}	3.255	0.378^{***} (0.091)	-0.486^{***} (0.101)	-0.214 (0.207)	1.036^{***} (0.224)	-0.957^{***} (0.318)	-0.049 (0.115)	-0.005 (0.020)	-0.020 (0.020)	-0.036^{*} (0.020)	0.692^{***}
$Q_{D(M+L)_t}$	2.710	0.551^{***} (0.088)	-0.608^{***} (0.098)	-0.515^{**} (0.202)	0.856^{***} (0.219)	-0.499 (0.310)	0.084 (0.112)	-0.022 (0.020)	0.053^{**} (0.020)	-0.006 (0.020)	0.806^{***}
Q_{Dj_t}	0.643	0.345^{***} (0.157)	-0.002 (0.175)	-0.763^{**} (0.359)	1.530^{***} (0.389)	-1.636^{**} (0.551)	0.601^{***} (0.198)	-0.124^{***} (0.035)	-0.225^{***} (0.035)	-0.011 (0.035)	0.709^{***}
Q_{DA_t}	3.185	0.060 (0.056)	-0.039 (0.062)	-0.531^{***} (0.128)	0.313 (0.138)	0.108 (0.196)	0.193^{***} (0.070)	0.013 (0.124)	-0.013 (0.125)	-0.017 (0.123)	0.613^{***}

Apart from Seasonal Variables, all variables in logarithmic form.

TABLE 8.2

SIMPLE QUARTERLY RETAIL DEMAND MODELS INCLUDING A TREND VARIABLE 1950 (FOURTH QUARTER) - 1964 (FOURTH QUARTER).

Dependent Variables	Constant	$P^r_{B_t}$	$P^r_{M_t}$	$P^r_{P_t}$	$P^r_{h_t}$	$P^r_{f_t}$	Y_t	S_1	S_2	S_3	T	R^2
Q_{DB_t}	3.708	-0.605***	0.438***	0.228	-0.755***	1.045***	0.043	0.080***	0.077***	-0.021*	0.0019**	0.877***
		(0.090)	(0.062)	(0.154)	(0.174)	(0.195)	(0.086)	(0.012)	(0.013)	(0.012)	(0.0009)	
$Q_{D(B+V)_t}$	3.812	-0.599***	0.430***	-0.255*	-0.767***	1.084***	0.032	0.083***	0.069***	-0.029**	0.0025***	0.876***
		(0.087)	(0.060)	(0.149)	(0.169)	(0.190)	(0.083)	(0.012)	(0.013)	(0.012)	(0.0009)	
Q_{DM_t}	2.507	0.464***	-0.494***	-0.321	1.167***	-0.943***	0.012	-0.005	-0.015	-0.035*	-0.0011	0.695***
		(0.147)	(0.102)	(0.252)	(0.285)	(0.320)	(0.140)	(0.020)	(0.021)	(0.020)	(0.0015)	
$Q_{D(M+L)_t}$	3.837	0.421***	-0.597***	-0.354	0.658**	-0.521*	-0.008	-0.022	-0.060***	-0.007	0.0017	0.811***
		(0.142)	(0.098)	(0.244)	(0.276)	(0.310)	(0.136)	(0.020)	(0.021)	(0.019)	(0.0014)	
Q_{Dj_t}	3.247	0.037	0.024	0.383	1.065**	-1.688***	0.386	-0.124***	-0.241***	-0.013	0.0040	0.722***
		(0.249)	(0.173)	(0.429)	(0.485)	(0.545)	(0.239)	(0.034)	(0.036)	(0.034)	(0.0025)	
Q_{DA_t}	4.723	-0.118	-0.024	-0.311**	0.044	0.078	0.068	0.013	-0.022*	-0.018	0.0023***	0.662***
		(0.085)	(0.059)	(0.146)	(0.165)	(0.185)	(0.081)	(0.012)	(0.012)	(0.012)	(0.0008)	

Apart from Seasonal and Trend Variables, all variables in logarithmic form.

TABLE 8.3

SIMPLE CORRELATION COEFFICIENTS OF THE QUARTERLY RETAIL DEMAND MODELS 1950 (FOURTH QUARTER) - 1964 (FOURTH QUARTER).

		Log of:-						Shift Variables:-			
		$P^r_{B_t}$	$P^r_{M_t}$	$P^r_{P_t}$	$P^r_{h_t}$	$P^r_{f_t}$	Y_t	S_1	S_2	S_3	T
Log of:-	$P^r_{B_t}$	1.000									
	$P^r_{M_t}$	0.132	1.000								
	$P^r_{P_t}$	0.654	0.327	1.000							
	$P^r_{h_t}$	0.762	0.164	0.812	1.000						
	$P^r_{f_t}$	0.683	0.074	0.841	0.925	1.000					
	Y_t	0.347	-0.073	0.158	0.404	0.412	1.000				
Shift Variables:-	S_1	-0.045	-0.106	-0.088	0.015	0.036	0.016	1.000			
	S_2	0.001	0.060	0.059	-0.041	-0.040	-0.017	-0.326	1.000		
	S_3	0.030	0.120	0.051	0.007	-0.009	0.010	-0.341	-0.341	1.000	
	T	0.841	0.021	0.501	0.815	0.721	0.623	0.000	0.032	0.000	1.000
Log of:-	Q_{DB_t}	-0.630	0.092	-0.381	-0.442	-0.314	-0.049	0.345	0.309	-0.413	-0.425
	$Q_{D(B+V)_t}$	-0.561	0.075	-0.351	-0.365	-0.240	0.019	0.400	0.292	-0.465	-0.326
	$Q_{D(M+L)_t}$	0.638	-0.377	0.196	0.543	0.443	0.404	0.045	-0.238	0.058	0.724
	Q_{DM_t}	0.582	-0.311	0.213	[illegible]	0.375	0.259	0.095	-0.077	-0.144	0.611
	Q_{DA_t}	0.219	-0.270	-0.150	0.268	0.211	0.522	0.299	-0.192	-0.188	0.531
	Q_{Dj_t}	0.300	-0.012	-0.071	0.233	0.072	0.373	-0.111	-0.519	0.304	0.413

coefficients of determination by F-test.[1]

Table 8.3, the matrix of correlation coefficients, indicates the presence of intercorrelation problems between some pairs of 'independent' variables. The retail prices of pork, ham, and bacon were all highly correlated with one another. Ham and bacon prices were indicated as having an especially close relationship, as was expected.[2] Each of these three prices also had a strong positive correlation with the retail price of beef. This relationship was not expected from the examination of the structure of the New Zealand meat industry. All four prices have high correlation coefficients with the trend variable.

While the correlation coefficient matrix is useful in finding sources of intercorrelation between two variables, it is of limited use in that a linear combination of variables which explains one other variable is not disclosed. It need not be expected, therefore, that the elimination of direct correlation between variables assumed by the model to be independent, will remove all intercorrelation problems. This point will be referred to when the models estimated by two-stage least-squares are discussed.

Correlation coefficients between the independent and dependent variables also have some special features. Firstly, the correlations between consumption of pigmeats, and the retail price of pork and bacon are lower than was expected. The correlation of the consumption of beef, and 'beef and veal', with income was also lower than expected.

Tables 8.1 and 8.2 show in tabular form the estimated demand equations, with each coefficient's standard error. Table 8.1 contains those models in which the trend variable was not included, Table 8.2 contains the models estimated with the trend variable included. With

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1. Chapter 3, p. 65.

2. See Chapter 7, pp. 174-176 and Graph 7.4.

the intercorrelation problems previously mentioned present, these equations will not be of great value as the equation coefficients are likely to be distorted.[1] The larger number of coefficients of different size and sign to that expected a priori could be attributable to the intercorrelation problems. In particular, the three pigmeat prices have coefficients which are unacceptable. The addition of the trend variable (Table 8.3) gives estimates which are even less acceptable. Income coefficients are, for example, drastically altered. A reasonably strong correlation between the trend and income exists.

Tables 8.4, 8.5, and 8.6 present the same summary information for the annual retail models. In these equations pork, and 'bacon and ham' demand equations were estimated as well as a total pigmeat demand equation. In general the size of each estimated coefficient is slightly changed, compared with the quarterly retail model estimates. Significance levels of coefficients in these models are much less satisfactory, as might be expected with the reduced number of degrees of freedom. In four equations the coefficient of determination was not significant at even the ten per cent level.

The annual retail models have the same intercorrelation problems as the quarterly models. The reliability of the estimated coefficients is therefore suspect.

The wholesale price series, the results of which are shown in Tables 8.7, 8.8 and 8.9, suffer much less from direct intercorrelation problems. Only three correlations are greater than 0.6 in the first

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1. The effect of intercorrelation is to make the values of the estimated parameters untrustworthy, as it is possible for the estimation procedure to mis-judge the true effect of each variable. This is not, however, bias in its econometric sense as the parameter estimates may tend to the true value in the probability limit. In this sense, therefore, it is perhaps more correct to use the term 'distort' rather than bias when referring to the value of a parameter estimated from a sample.

TABLE 8.4

SIMPLE ANNUAL RETAIL DEMAND MODELS 1950 - 1963.

Dependent Variables	Constant	$P^r_{B_t}$	$P^r_{M_t}$	$P^r_{P_t}$	$P^r_{h_t}$	$P^r_{f_t}$	Y_t	R^2
Q_{DB_t}	3.294	-0.389**	0.535***	-0.652*	-0.603*	1.366**	0.116	0.907***
		(0.131)	(0.148)	(0.335)	(0.296)	(0.459)	(0.182)	
$Q_{D(B+V)_t}$	3.081	-0.359**	0.525***	-0.754*	-0.534	1.428**	0.122	0.899***
		(0.126)	(0.143)	(0.323)	(0.286)	(0.443)	(0.175)	
$Q_{D(M+L)_t}$	2.777	0.630***	-0.442**	-0.864**	0.562*	0.240	0.098	0.958***
		(0.129)	(0.146)	(0.331)	(0.293)	(0.453)	(0.179)	
Q_{DM_t}	3.137	0.487**	-0.341*	-0.375	0.675*	-0.376	0.066	0.924***
		(0.140)	(0.158)	(0.357)	(0.316)	(0.490)	(0.194)	
Q_{Dj_t}	-0.377	0.448	0.246	-1.429	1.293	-0.787	0.690	0.741
		(0.346)	(0.391)	(0.884)	(0.782)	(1.212)	(0.480)	
Q_{DP_t}	0.384	-0.213	0.346	-1.236	1.021	-0.269	0.538	0.669
		(0.359)	(0.406)	(0.916)	(0.812)	(1.256)	(0.497)	
Q_{DH_t}	-2.826	1.359**	0.207	-1.944	1.537	-1.052	0.761	0.842**
		(0.430)	(0.486)	(1.098)	(0.973)	(1.505)	(0.596)	
Q_{DA_t}	3.575	0.121	0.101	-0.873***	0.148	0.643*	0.188	0.833**
		(0.096)	(0.109)	(0.246)	(0.218)	(0.337)	(0.133)	

All variables in logarithmic form.

TABLE 8.5

SIMPLE ANNUAL RETAIL DEMAND MODELS INCLUDING A TREND VARIABLE 1950 - 1963.

Dependent Variables	Constant	$P^r_{B_t}$	$P^r_{M_t}$	$P^r_{P_t}$	$P^r_{h_t}$	$P^r_{f_t}$	Y_t	T	R^2
Q_{DB_t}	5.539	-0.635**	0.571***	-0.131	-1.189**	1.252**	0.024	0.0161	0.937***
		(0.188)	(0.134)	(0.432)	(0.440)	(0.415)	(0.171)	(0.0097)	
$Q_{D(B+V)_t}$	5.642	-0.640***	0.566***	-0.161	-1.203***	1.298***	0.017	0.0183*	0.943***
		(0.164)	(0.117)	(0.377)	(0.384)	(0.362)	(0.150)	(0.0084)	
Q_{DM_t}	3.164	0.484*	-0.340*	-0.369	0.668	-0.378	0.065	0.0002	0.924***
		(0.243)	(0.173)	(0.558)	(0.568)	(0.536)	(0.221)	(0.0125)	
$Q_{D(M+L)_t}$	3.897	0.507*	-0.424**	-0.604	0.269	0.184	0.053	0.0080	0.961***
		(0.216)	(0.154)	(0.496)	(0.505)	(0.476)	(0.196)	(0.0111)	
Q_{Dj_t}	3.913	-0.226	0.316	-0.434	0.173	-1.005	0.515	0.0307	0.784
		(0.550)	(0.392)	(1.262)	(1.285)	(1.212)	(0.500)	(0.0282)	
Q_{DP_t}	3.117	-0.512	0.391	-0.602	0.307	-0.408	0.426	0.0196	0.690
		(0.604)	(0.430)	(1.387)	(1.412)	(1.332)	(0.549)	(0.0310)	
Q_{DH_t}	3.509	0.665	0.310	-0.474	-0.117	-1.374	0.501	0.0454	0.879**
		(0.654)	(0.465)	(1.502)	(1.529)	(1.443)	(0.595)	(0.0335)	
Q_{DA_t}	5.633	-0.105	0.135	-0.395	-0.389	0.539*	0.103	0.0147*	0.915***
		(0.119)	(0.085)	(0.274)	(0.279)	(0.263)	(0.108)	(0.0061)	

Apart from the Trend variable, all variables in logarithmic form.

TABLE 8.6

SIMPLE CORRELATION COEFFICIENTS OF THE ANNUAL RETAIL DEMAND MODELS 1950 - 1963.

		Log of:-						Shift Variable T
		$P^r_{B_t}$	$P^r_{M_t}$	$P^r_{P_t}$	$P^r_{h_t}$	$P^r_{f_t}$	Y_t	
Log of:-	$P^r_{B_t}$	1.000						
	$P^r_{M_t}$	0.259	1.000					
	$P^r_{P_t}$	0.812	0.467	1.000				
	$P^r_{h_t}$	0.857	0.314	0.897	1.000			
	$P^r_{f_t}$	0.800	0.241	0.930	0.948	1.000		
	Y_t	0.008	-0.309	-0.027	0.211	0.183	1.000	
Shift Variable T		0.842	0.038	0.639	0.882	0.782	0.367	1.000
Log of:-	Q_{DB_t}	-0.821	0.079	-0.542	-0.623	-0.519	0.028	-0.669
	$Q_{D(B+V)_t}$	-0.790	0.069	-0.518	-0.569	-0.466	0.087	-0.596
	Q_{DM_t}	0.811	-0.175	0.482	0.720	0.613	0.294	0.890
	$Q_{D(M+L)_t}$	0.746	-0.322	0.399	0.664	0.591	0.369	0.887
	Q_{Dj_t}	0.161	-0.135	0.197	0.149	-0.052	0.508	0.475
	Q_{DP_t}	-0.431	-0.163	-0.549	-0.290	-0.416	0.448	-0.062
	Q_{DH_t}	0.586	-0.515	0.156	0.458	0.268	0.370	0.754
	Q_{DA_t}	0.162	-0.352	-0.115	0.253	0.183	0.650	0.589

series (i.e. excluding the time trend). These were; wholesale prices of mutton and lamb, wholesale prices of ham and bacon, and the wholesale price of ham correlated with income.

The significance levels at which the estimated coefficients were significantly different from zero were in general less acceptable in the wholesale models. As was expected, the estimated price and cross-price elasticities were of lower absolute value than the retail estimates. A more inelastic demand at the wholesale level of the market was expected because the meat retailer practises price averaging and levelling; making consumers' demand less sensitive to wholesale price changes. In addition the margin between wholesale and retail price is in part a fixed margin. This will always tend to reduce the price elasticity of demand at a 'lower' level of the market.

In the repeat models in which the trend variable was included the problem of intercorrelation was evident, the trend variable being quite highly correlated with several other 'independent' variables. The major reason for estimating wholesale demand functions was to obtain an estimate of the demand relationships for lamb. No retail price information was available for lamb, hence its demand parameters could not be estimated in a retail model. The estimated price and income elasticities for lamb were of expected size and sign. However some of the cross-price elasticities were of opposite sign to that expected. This problem occurred in all demand equations for sheepmeats in both wholesale and retail price models, and is further discussed later in this chapter.

Only a brief résumé of the simple demand function estimates has been made above. There can be little worthwhile discussion of the estimated coefficients as they are untrustworthy because of high intercorrelation. The major importance of these estimates was however in

TABLE 8.7

SIMPLE QUARTERLY DEMAND MODELS WITH WHOLESALE PRICES 1953 (FIRST QUARTER) - 1964 (FOURTH QUARTER).

Dependent Variables	Constant	${}^wP_{B_t}$	${}^wP_{L_t}$	${}^wP_{M_t}$	${}^wP_{P_t}$	${}^wP_{h_t}$	${}^wP_{f_t}$	Y_t	S_1	S_2	S_3	R^2
Q_{DB_t}	2.969	-0.247***	-0.110	0.258***	-0.078	-0.328	0.339*	0.168	0.074***	0.076***	-0.020	0.759***
		(0.062)	(0.093)	(0.083)	(0.125)	(0.265)	(0.188)	(0.177)	(0.018)	(0.022)	(0.021)	
$Q_{D(B+V)_t}$	2.873	-0.238***	-0.132	0.266***	-0.130	-0.225	0.314*	0.183	0.079***	0.075***	-0.024	0.761***
		(0.061)	(0.091)	(0.081)	(0.123)	(0.259)	(0.184)	(0.173)	(0.018)	(0.021)	(0.021)	
Q_{DL_t}	-4.029	0.378**	-0.845***	-0.105	-1.189***	1.262	0.324	1.086**	-0.067	-0.177***	0.314***	0.903***
		(0.185)	(0.278)	(0.246)	(0.374)	(0.789)	(0.561)	(0.526)	(0.055)	(0.064)	(0.063)	
Q_{DM_t}	2.705	0.039	0.097	-0.304**	-0.210	0.577	-0.428	0.157	-0.003	0.002	0.021	0.617***
		(0.086)	(0.129)	(0.114)	(0.174)	(0.368)	(0.261)	(0.245)	(0.025)	(0.030)	(0.029)	
Q_{Dj_t}	1.532	-0.139	0.222	0.226	-0.423	1.492**	-1.667***	0.637	-0.125***	-0.199***	0.045	0.734***
		(0.136)	(0.203)	(0.180)	(0.274)	(0.580)	(0.412)	(0.386)	(0.040)	(0.047)	(0.046)	
Q_{DA_t}	3.380	-0.099**	-0.056	-0.004	-0.240***	0.338*	-0.193	0.295**	0.014	0.001	0.006	0.760***
		(0.040)	(0.059)	(0.053)	(0.080)	(0.169)	(0.120)	(0.113)	(0.012)	(0.014)	(0.013)	

Apart from seasonal variables, all variables in logarithimic form.

TABLE 8.8

SIMPLE QUARTERLY DEMAND MODELS WITH WHOLESALE PRICES, INCLUDING A TREND VARIABLE, 1953 (FIRST QUARTER) - 1964 (FOURTH QUARTER).

Dependent Variables	Constant	${}^{w}P_{B_t}$	${}^{w}P_{L_t}$	${}^{w}P_{M_t}$	${}^{w}P_{P_t}$	${}^{w}P_{h_t}$	${}^{w}P_{f_t}$	Y_t	S_1	S_2	S_3	T	R^2
Q_{DB_t}	2.360	-0.230***	-0.163	0.265***	-0.181	0.040	0.121	0.287	0.076***	0.091***	-0.006	-0.0020	0.770***
		(0.063)	(0.101)	(0.082)	(0.147)	(0.384)	(0.250)	(0.199)	(0.018)	(0.024)	(0.024)	(0.0015)	
$Q_{D(B+V)_t}$	2.435	-0.226***	-0.170*	-0.271***	-0.204	0.040	0.157	0.268	0.081***	0.085***	-0.013	-0.0015	0.767***
		(0.062)	(0.100)	(0.081)	(0.145)	(0.380)	(0.247)	(0.195)	(0.018)	(0.024)	(0.023)	(0.0015)	
Q_{DL_t}	-1.481	0.307	-0.622**	-0.134	-0.758*	-0.278	1.236*	0.591	-0.075	-0.238***	0.252***	0.0086*	0.912***
		(0.183)	(0.294)	(0.239)	(0.428)	(1.119)	(0.727)	(0.573)	(0.053)	(0.070)	(0.069)	(0.0045)	
Q_{DM_t}	3.678	0.011	0.183	-0.315***	-0.046	-0.011	-0.080	-0.032	-0.006	-0.021	-0.044	0.0033	0.640***
		(0.087)	(0.139)	(0.113)	(0.202)	(0.529)	(0.344)	(0.271)	(0.025)	(0.033)	(0.033)	(0.0021)	
Q_{Dj_t}	3.775	-0.201	0.419*	-0.251	-0.044	0.137	-0.864	0.202	-0.132***	-0.253***	-0.009	0.0075***	0.768***
		(0.131)	(0.210)	(0.171)	(0.307)	(0.803)	(0.522)	(0.411)	(0.038)	(0.050)	(0.049)	(0.0030)	
Q_{DA_t}	3.927	-0.115***	-0.008	-0.010	-0.146	0.007	0.002	0.188	0.012	-0.012	-0.007	0.0018*	0.781***
		(0.039)	(0.062)	(0.051)	(0.092)	(0.240)	(0.156)	(0.123)	(0.011)	(0.015)	(0.015)	(0.0010)	

Apart from seasonal and trend variables, all variables in logarithmic form.

TABLE 8.9

SIMPLE CORRELATION COEFFICIENTS OF THE QUARTERLY WHOLESALE PRICE DEMAND MODELS 1953 (FIRST QUARTER)-1964 (FOURTH QUARTER).

		Log of:-							Shift Variables:-			
		${}^{w}P_{B_t}$	${}^{w}P_{L_t}$	${}^{w}P_{M_t}$	${}^{w}P_{P_t}$	${}^{w}P_{h_t}$	${}^{w}P_{f_t}$	Y_t	S_1	S_2	S_3	T
Log of:-	${}^{w}P_{B_t}$	1.000										
	${}^{w}P_{L_t}$	-0.140	1.000									
	${}^{w}P_{M_t}$	-0.223	0.879	1.000								
	${}^{w}P_{P_t}$	-0.264	0.395	0.500	1.000							
	${}^{w}P_{h_t}$	-0.023	-0.416	-0.291	0.247	1.000						
	${}^{w}P_{f_t}$	0.004	-0.201	-0.151	0.315	0.780	1.000					
	Y_t	0.385	-0.292	-0.204	-0.232	0.600	0.398	1.000				
Shift Variables:-	S_1	-0.195	-0.159	-0.119	-0.173	-0.001	0.003	0.024	1.000			
	S_2	0.102	0.086	0.193	0.276	-0.070	-0.100	0.005	-0.333	1.000		
	S_3	0.223	0.249	0.106	0.120	0.079	0.083	0.006	-0.333	-0.333	1.000	
	T	0.259	-0.665	-0.576	-0.407	0.593	0.185	0.699	-0.021	0.021	0.063	1.000
Log of:-	Q_{DB_t}	-0.507	0.273	0.468	0.240	-0.102	-0.014	0.044	0.361	0.345	-0.472	-0.299
	$Q_{D(B+V)_t}$	-0.494	0.176	0.386	0.166	-0.037	0.018	0.121	0.417	0.317	-0.514	-0.196
	Q_{DL_t}	0.349	-0.636	-0.672	-0.496	0.483	0.314	0.512	-0.028	-0.433	0.365	0.743
	Q_{DM_t}	0.209	-0.638	-0.711	-0.523	0.268	0.034	0.355	0.094	-0.116	-0.132	0.645
	Q_{Dj_t}	0.018	-0.207	-0.313	-0.437	0.169	-0.112	0.338	-0.130	-0.535	0.371	0.488
	Q_{DA_t}	-0.096	-0.573	-0.513	-0.540	0.401	0.117	0.646	0.264	-0.221	-0.134	0.723

bringing to light this intercorrelation. As far as possible these problems were taken account of when specifying the New Zealand models, as was discussed in Chapter 5. The trend variable for example was excluded from the models altogether. This variable introduced severe intercorrelation, while at the same time adding very little to the explanation of the dependent variable in each equation.

It was also decided to combine the bacon and the ham price variables into a single price variable. This was done because the high intercorrelation between the variables meant that while little information would be lost, and a considerable statistical difficulty removed. In addition, ham and bacon consumption data were only available for the two meats combined, the two meats being derived from the same carcase and hence are joint products.

Although autocorrelation was not tested for in the simple models, there is some evidence that autocorrelation was present. Intercorrelation normally increases the size of standard errors, yet in the above equations the standard errors were generally satisfactory. Autocorrelation however biases the standard errors downward, making the results appear more acceptable. Tests for autocorrelation were included in the estimation of later models.

Lastly, it was noted that in equations where the dependent variable was the consumption of several meats combined (e.g. Q_{DA_t}), the explanation of the dependent variable was relatively poor and equation coefficients were mostly not significantly different from zero. It was therefore decided not to attempt further estimates of such functions.

Ordinary Least-Squares Estimates of the New Zealand Meat Model

This section of the results will be concerned with variants of the New Zealand meat model estimated by ordinary least-squares (OLS).

As was discussed in Chapter 6, the OLS estimates were made prior to attempting two-stage least-squares (2SLS) estimates of the structural parameters. The specification of the New Zealand model variants estimated was detailed in Chapters 4 and 5. While it is not intended to repeat the analysis of the above chapters, brief reference will be made to their broad conclusions during this analysis of the parameter estimates. Use will also be made of the empirical findings from the naive models already discussed.

At the conclusion of Chapter 5 several variants were outlined of the basic economic model to be estimated by OLS. The presentation of the estimates follows the sequence below. Firstly, the estimated model considered best in both an economic and statistical sense will be presented and discussed in detail. Following this discussion, OLS estimates of the variants of this model will be reviewed. This review will be concerned mostly with the differences between these other estimates and that chosen as best.

The variants estimated by OLS were as outlined in Chapter 5. These variants of the basic New Zealand meat model are briefly listed below:

(a) a retail demand model with adjustment lags included

(b) a retail demand model with no adjustment lags

(c) a wholesale demand model with adjustment lags included

(d) a wholesale demand model with no adjustment lags.

The most satisfactory model estimated from both the economic and statistical points of view was the retail demand model with the Nerlove adjustment equations included in its specification. This model is the basic New Zealand model built up in Chapter 5. Table 8.10 lists the equations estimated by OLS (i.e. the estimating equations) which enable all the model parameters to be determined.

This section of analysis will consider the results shown in Tables

8.10 to 8.13, and will be mostly concerned with the statistical properties of the OLS equations in Table 8.10. Discussion of the economic relationships expressed in the estimated model will follow.

In general, the overall estimates achieved in the model shown in Table 8.10 were good. Coefficients of most variables included were significantly different from zero at the five per cent level, and only two equations had coefficients of determination less than 0.8. The test used to detect the presence of autocorrelation was based upon the von Neumann ratio, the calculation of which is very similar to the method for calculating the Durbin-Watson d-statistic.[1] With the von Neumann ratio test, the null-hypothesis is that autocorrelation is not present. The code used to indicate significance levels is therefore:

residuals significantly autocorrelated at the five per cent level ..

residuals significantly autocorrelated at the one per cent level ...

Only two equations in Table 8.10 indicate the presence of autocorrelation at either the five or one per cent levels. In both cases positive autocorrelation is indicated.

Equations of the static variant of this model exhibit strong autocorrelation problems. The inclusion of the lagged dependent variable on the right hand side of the equations appears therefore to markedly improve each equation's autocorrelation properties. Of the two equations shown in Table 8.10 as having autocorrelation present, one (the wholesale beef price equation) was just outside the one per cent

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1. M. Ezekiel and K.A. Fox, Methods of Correlation and Regression Analysis, Wiley and Sons, New York, third edition, 1959, pp. 335-341.

TABLE 8.10

ORDINARY LEAST-SQUARES ESTIMATES OF THE ESTIMATING EQUATIONS FOR THE NEW ZEALAND DYNAMIC RETAIL MEAT MODEL.

$$\log Q_{DB_t} = 0.855 - \underset{(0.082)}{0.318^{***}}\log P^r_{B_t} + \underset{(0.082)}{0.148^{*}}\log P^r_{M_t} + \underset{(0.125)}{0.117}\log P^r_{P_t} + \underset{(0.097)}{0.245^{**}}\log Y_t + \underset{(0.015)}{0.074^{***}}S_1 + \underset{(0.020)}{0.035^{*}}S_2 - \underset{(0.020)}{0.082^{***}}S_3 + \underset{(0.127)}{0.429^{***}}\log Q_{DB_{t-1}}$$

$$R^2 = 0.842^{***} \qquad K = 1.9831$$

$$\log Q_{DM_t} = 5.004 + \underset{(0.112)}{0.246^{**}}\log P^r_{B_t} - \underset{(0.136)}{0.459^{***}}\log P^r_{M_t} - \underset{(0.229)}{0.713^{***}}\log P^r_{P_t} + \underset{(0.154)}{0.108}\log Y_t - \underset{(0.023)}{0.031}S_1 - \underset{(0.023)}{0.042^{*}}S_2 - \underset{(0.024)}{0.036}S_3 + \underset{(0.154)}{0.154}\log Q_{DM_{t-1}}$$

$$R^2 = 0.642^{***} \qquad K = 2.1429$$

$$\log P^r_{P_t} = 2.515 + \underset{(0.077)}{0.140^{*}}\log P^r_{B_t} - \underset{(0.061)}{0.086}\log P^r_{M_t} - \underset{(0.036)}{0.110^{***}}\log Q_{DP_t} + \underset{(0.084)}{0.212^{**}}\log Y_t - \underset{(0.017)}{0.043^{**}}S_1 - \underset{(0.018)}{0.037^{**}}S_2 + \underset{(0.029)}{0.021}S_3 - \underset{(0.035)}{0.067^{*}}\log Q_{DP_{t-1}}$$

$$R^2 = 0.451^{***} \qquad K = 0.6722^{\circ\circ\circ}$$

$$\log {}^{w}P_{B_t} = 0.213 + \underset{(0.073)}{0.197^{***}}\log {}^{E}P_{B_t} + \underset{(0.031)}{0.058^{*}}\log A_{B_t} + \underset{(0.019)}{0.057^{***}}\log A_{M_t} - \underset{(0.030)}{0.003}\log Q_{SP_t} + \underset{(0.091)}{0.738^{***}}\log {}^{w}P_{B_{t-1}}$$

$$R^2 = 0.833^{***} \qquad K = 1.3350^{\circ\circ\circ}$$

$$\log {}^{w}P_{M_t} = 0.276 + \underset{(0.076)}{0.301^{***}}\log {}^{E}P_{M_t} + \underset{(0.040)}{0.061}\log A_{B_t} + \underset{(0.023)}{0.098^{***}}\log A_{M_t} - \underset{(0.035)}{0.148^{***}}\log Q_{SP_t} + \underset{(0.057)}{0.722^{***}}\log {}^{w}P_{M_{t-1}}$$

$$R^2 = 0.874^{***} \qquad K = 1.6612$$

$$M_{B_t} = -5.680 + \underset{(0.026)}{0.055^{**}}I_t + \underset{(0.031)}{0.065^{**}}\,{}^{w}P_{B_t} - \underset{(0.145)}{0.400^{***}}Z_1 - \underset{(0.056)}{0.580^{***}}\Delta {}^{w}P_{B_t} - \underset{(0.046)}{0.007}\Delta {}^{w}P_{M_t} - \underset{(0.035)}{0.057}\Delta {}^{w}P_{P_t} + \underset{(0.057)}{0.860^{***}}M_{B_{t-1}}$$

$$R^2 = 0.926^{***} \qquad K = 2.0546$$

$$M_{M_t} = -1.689 + \underset{(0.023)}{0.049^{**}}I_t - \underset{(0.043)}{0.117^{***}}\,{}^{w}P_{M_t} - \underset{(0.168)}{0.466^{***}}Z_1 + \underset{(0.057)}{0.110^{*}}\Delta {}^{w}P_{B_t} - \underset{(0.055)}{0.707^{***}}\Delta {}^{w}P_{M_t} + \underset{(0.037)}{0.031}\Delta {}^{w}P_{P_t} + \underset{(0.066)}{0.654^{***}}M_{M_{t-1}}$$

$$R^2 = 0.949^{***} \qquad K = 1.8280$$

$$M_{P_t} = -3.721 + \underset{(0.042)}{0.081^{*}}I_t - \underset{(0.081)}{0.105}\,{}^{w}P_{P_t} + \underset{(0.267)}{0.061}Z_1 + \underset{(0.100)}{0.108}\Delta {}^{w}P_{B_t} + \underset{(0.086)}{0.019}\Delta {}^{w}P_{M_t} - \underset{(0.079)}{0.633^{***}}\Delta {}^{w}P_{P_t} + \underset{(0.099)}{0.681^{***}}M_{P_{t-1}}$$

$$R^2 = 0.898^{***} \qquad K = 1.8163$$

limit, and the other (pork demand reduced form equation) did not have the lagged dependent variable of the equation included on the right hand side.

As has been previously discussed, the use of a Nerlove distributed lag model, with its inclusion of the lagged dependent variable in the estimating equation, theoretically reduces the sensitivity of auto-correlation tests.[1] The significance levels of K would therefore appear suspect. However the Monte Carlo experiments carried out on three-pass least-squares, which specifically examined the ability of auto-correlation tests to detect the presence of autocorrelation in lagged models, suggested that in practice the tests for autocorrelation are not insensitive.[2] As the von Neumann ratio for those equations which have no evidence of autocorrelation are well within acceptable limits, it is accepted here that these equations are not autocorrelated. The inclusion of the distributed lag assumption therefore appears to have explained the cause of the systematic disturbance which occurred in the static variant of this model.

Tables 8.11, 8.12, and 8.13 list the simple correlation coefficients relevant to this retail demand model. Table 8.11 details in matrix form the correlations associated with variables in the first three equations (the demand functions). Table 8.12 contains the correlations for the fourth and fifth equations (wholesale price formation), and Table 8.13 refers to the remaining equations of the model (wholesale-to-retail margins). In all three tables the independent variables of the equation are shown in the triangular section of the matrix; correlations with the dependent variables are shown below.

Table 8.11 indicates that direct intercorrelation problems in the

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1. Chapter 4, pp. 88-92.
2. Chapter 6, pp. 144-145.

TABLE 8.11

SIMPLE CORRELATION COEFFICIENTS FOR ALL VARIABLES USED IN THE RETAIL DEMAND EQUATIONS OF THE NEW ZEALAND MEAT MODELS.

	$\log P^r_{B_t}$	$\log P^r_{M_t}$	$\log P^r_{P_t}$ [1]	$\log Y_t$	S_1	S_2	S_3	$\log Q_{DB_{t-1}}$	$\log Q_{DM_{t-1}}$	$\log Q_{DP_{t-1}}$	$\log Q_{DP_t}$
$\log P^r_{B_t}$	1.000										
$\log P^r_{M_t}$	-0.163	1.000									
$\log P^r_{P_t}$	-0.021	-0.003	1.000								
$\log Y_t$	0.470	-0.098	0.161	1.000							
S_1	-0.080	-0.114	-0.200	0.023	1.000						
S_2	-0.032	0.027	0.032	0.007	-0.333	1.000					
S_3	0.164	0.160	0.184	0.012	-0.333	-0.333	1.000				
$\log Q_{DB_{t-1}}$	-0.289	0.555	0.206	0.041	-0.264	0.366	0.368	1.000			
$\log Q_{DM_{t-1}}$	0.424	-0.600	-0.307	0.364	0.181	0.077	-0.117	*	1.000		
$\log Q_{DP_{t-1}}$	0.412	-0.238	*	0.283	-0.072	-0.195	-0.348	*	*	1.000	
$\log Q_{DP_t}$	0.351	-0.090	*	0.258	-0.214	-0.365	0.671	*	*	0.253	1.000
$\log Q_{PB_t}$	-0.507	0.309	0.032	0.051	0.371	0.372	-0.494	0.427	*	*	*
$\log Q_{DM_t}$	0.417	-0.585	-0.390	0.232	0.102	-0.116	-0.167	*	0.627	*	*
$\log P^r_{P_t}$ [1]	-0.021	-0.003	*	0.161	-0.200	0.032	0.184	*	*	-0.337	-0.195

1. With ($\log P^r_{P_t}$) two distinct entries are shown. They are (a) as an 'independent' variable - in the diagonal matrix
(b) as a 'dependent' variable - in the rectangular matrix
Combinations of other variables with ($\log P^r_{P_t}$) are shown in all correlation matrices according to the pork price Variable's function.

* This combination of Variables was not used in the Models.

TABLE 8.12

SIMPLE CORRELATION COEFFICIENTS FOR ALL VARIABLES USED IN THE WHOLESALE PRICE FORMATION EQUATIONS OF THE NEW ZEALAND MEAT MODELS

	$\log {}^{E}P_{B_t}$	$\log {}^{E}P_{L_t}$	$\log {}^{E}P_{M_t}$	$\log A_{B_t}$	$\log A_{L_t}$	$\log A_{M_t}$	$\log Q_{SP_t}$	$\log {}^{W}P_{B_{t-1}}$	$\log {}^{W}P_{L_{t-1}}$	$\log {}^{W}P_{M_{t-1}}$
$\log {}^{E}P_{B_t}$	1.000									
$\log {}^{E}P_{L_t}$	*	1.000								
$\log {}^{E}P_{M_t}$	*	*	1.000							
$\log A_{B_t}$	-0.018	0.081	-0.173	1.000						
$\log A_{L_t}$	0.100	-0.071	-0.178	0.609	1.000					
$\log A_{M_t}$	-0.016	-0.027	-0.215	0.528	0.758	1.000				
$\log Q_{SP_t}$	0.136	-0.188	-0.108	0.049	-0.255	0.072	1.000			
$\log {}^{W}P_{B_{t-1}}$	0.633	*	*	0.043	-0.172	-0.198	0.372	1.000		
$\log {}^{W}P_{L_{t-1}}$	*	0.690	*	0.078	-0.276	-0.215	-0.217	*	1.000	
$\log {}^{W}P_{M_{t-1}}$	*	*	0.308	0.136	-0.169	-0.023	-0.162	*	*	1.000
$\log {}^{W}P_{B_t}$	0.673	*	*	0.310	0.137	0.175	0.319	0.824	*	*
$\log {}^{W}P_{L_t}$	*	0.823	*	0.310	0.025	0.195	-0.183	*	0.789	*
$\log {}^{W}P_{M_t}$	*	*	0.398	0.308	0.138	0.250	-0.340	*	*	0.839

* This Combination of Variables was not used in the Models.

TABLE 8.13

SIMPLE CORRELATION COEFFICIENTS FOR ALL VARIABLES USED IN THE MARGIN EQUATIONS OF THE NEW ZEALAND MEAT MODELS

	I_t	${}^wP_{B_t}$	${}^wP_{M_t}$	${}^wP_{P_t}$	Z_1	$\Delta {}^wP_{B_t}$	$\Delta {}^wP_{M_t}$	$\Delta {}^wP_{P_t}$	$M_{B_{t-1}}$	$M_{M_{t-1}}$	$M_{P_{t-1}}$
I_t	1.000										
${}^wP_{B_t}$	-0.022	1.000									
${}^wP_{M_t}$	0.090	*	1.000								
${}^wP_{P_t}$	0.037	*	*	1.000							
Z_1	0.184	0.242	-0.218	0.193	1.000						
$\Delta {}^wP_{B_t}$	0.043	0.329	0.284	0.354	-0.038	1.000					
$\Delta {}^wP_{M_t}$	0.095	-0.003	0.274	0.296	0.149	0.505	1.000				
$\Delta {}^wP_{P_t}$	0.005	-0.095	0.090	0.374	0.123	0.309	0.550	1.000			
$M_{B_{t-1}}$	0.551	-0.219	*	*	0.023	0.178	0.191	0.362	1.000		
$M_{M_{t-1}}$	-0.132	*	-0.754	*	0.070	-0.056	0.098	0.233	*	1.000	
$M_{P_{t-1}}$	0.164	*	*	-0.725	-0.061	-0.219	0.008	0.133	*	*	1.000
M_{B_t}	0.539	-0.298	*	*	-0.047	-0.399	-0.185	0.021	0.768	*	*
M_{M_t}	-0.106	*	-0.794	*	-0.100	-0.314	-0.575	-0.170	*	0.712	*
M_{P_t}	0.212	*	*	-0.819	-0.111	-0.308	-0.309	-0.532	*	*	0.694

* This Combination of Variables was not used in the Models.

demand equations of the model are relatively small. Only two off-diagonal correlations exceed 0.6, and only seven are 0.4 or greater. Distortion of parameter values due to direct intercorrelation in the demand equations is therefore likely to be small. Table 8.12 presents a similar situation for the wholesale price formation equations. Only two of the correlation coefficients shown are relatively large; between export beef price and lagged wholesale beef price, and between the beef and mutton availability ratios. High correlation coefficients are also shown for some lamb equation variables; these variables were, however, not used in the retail model.

Table 8.13 indicates that intercorrelation problems are likely to be comparatively greater in the margin equations. Several correlation coefficients are high, although of these a maximum of two of the associated variable combinations occur in any one equation. For all the equations in the model it appears that the direct intercorrelation problems will not be great; however this does not preclude intercorrelation due to linear combinations of 'independent' variables explaining one other 'independent' variable. Regarding this possibility little can be said as there is no conclusive evidence on which to base judgement.

The above is a brief description of some overall features of the model. The statistical properties of the individual equations in Table 8.10 may now be looked at in greater detail. The beef demand equation reflects the large share of meat demand in New Zealand which beef holds. The coefficient significance levels indicate that beef demand is strongly related to its own price, and to a lesser extent to mutton price; its major competitor. Pork price has a coefficient standard error larger than the coefficient itself, reflecting the fact that movements in the price of pork, a meat with an average consumption of about one-seventh that of beef, are unlikely to significantly affect beef consumption when expressed on a proportional basis (i.e. in terms of elasticities). A significant income effect, and strong seasonal shifts are also indicated by this equation. The coefficient associated with lagged quantity of beef demanded is highly significant, and in the absence of high simple correlation coefficients between lagged quantity and the other independent variables of this equation suggestive of an important adjustment relationship. The coefficient of determination indicates eight-four per cent of the variation in the dependent variable has been explained, which is a satisfactory level. The von Neumann ratio (K) indicates that there is no problem of autocorrelation among the residuals.

Strong price relationships between quantity of mutton demanded and all three meat prices is the main feature of the mutton demand equation. This associated with non-significant income effects, is indicative of a commodity which could be an inferior good. Seasonal effects are largely not significant, apart perhaps, from the winter quarter. The coefficient of lagged quantity is not significant, and of smaller magnitude than was expected, although the economic interpretation will be discussed later, this could be characteristic of a meat largely regarded as inferior.

The coefficient of determination of the mutton demand equation is significant, although of lower value than expected. With the number of observations (fifty-two), explanation of sixty-four per cent of the variation is satisfactory, a higher level would, however, have been desirable. In this equation the von Neumann ratio is again close to 2.0, however it was noted that in the static variant of the model, the mutton demand equation had a von Neumann ratio of 1.8, making it the only equation of that model free of significant autocorrelation. This again suggests that the lagged dependent variable does not add significantly to this equation.

The reduced-form pork demand equation was the least satisfactory of the OLS equations in this model. The coefficient of determination, although significantly different from zero, does not allow great confidence in the use of the equation to explain future equilibrium demand levels. A large proportion of variation in the dependent variable has not been satisfactorily explained. In addition the von Neumann ratio indicates serious positive autocorrelation.

An alternative specification of the pork demand equation was not feasible, however, because of the data limitation previously discussed. Attention is also drawn to the method of estimating pork consumption which may not have been satisfactory, although it was the best method available.[1] The imperfections in these data could have adversely affected the estimated equation.

Most of the variables in the reduced-form pork demand equation have associated coefficients significantly different from zero. Only the mutton price variable, and one seasonal shift variable are shown as not significantly affecting the dependent variable. While the coefficients are therefore satisfactory overall, caution must be used in their interpretation as coefficient bias and some unreliability in the standard errors is possible.

The wholesale price formation equations may be considered together as regards their statistical properties. Both equations have high coefficients of determination, but with the beef equation the von Nuemann ratio shows significant autocorrelation at the one per cent level. This value for K is just outside the null-hypothesis acceptance limits, indicating that autocorrelation of the residuals is possibly present, although bias in the coefficients may not be serious.

1. Chapter 7, pp. 163-166.

Both equations have highly significant coefficients associated with export price, in a statistical sense. This demonstrates the important relationship between export and wholesale prices.

The equations also indicate that the mutton availability ratio and the lagged wholesale price both significantly affect wholesale price. The beef availability ratio coefficient was significant only in the beef wholesale price equation, and then only at the ten per cent level. This probably occurred because the beef availability ratio did not tend to unity in any observations, hence the influence of this variables was likely to be minor. Pork supply is shown as significant only in the mutton wholesale price equation. This was expected following an appraisal of the estimated demand relationships.

As with the wholesale price formation equations, the margins equations will be considered as a group. All three equations have high coefficients of determination, and satisfactory von Neumann ratios. On overall statistical measures the equations are therefore quite acceptable. In the beef and mutton margin equations the change in wholesale price of pork, and in the beef margin equation the change in the wholesale price of mutton, are the only variables which do not have a coefficient significantly different from zero.

The pork margin equation has four variables for which the associated coefficient is not significantly different from zero at the ten per cent level or better. Of these four coefficients only that associated with the wholesale price of pork was expected to be significant on economic grounds. The interpretation of this result is discussed in more detail later.

The above discussion has been concerned with the statistical properties of the OLS estimate of the most satisfactory New Zealand model variant. Overall the model has explained the variation in the dependent variables reasonably well. The absence of serious statistical problems from most equations, and the reasonably high coefficients of determination (considering the probable data measurement errors present) are quite satisfactory. Bias in the results due to the estimation procedure has been previously discussed,[1] the further comments specific to this model will be made later in this chapter.

The economic interpretation of this model will now be considered in terms of the structural model and the estimated structural coefficients. The structural coefficients were derived from the estimating equations in Table 8.10 by substitution of the estimated coefficients into the model outlined in Chapter 5. The structural coefficients were determined, therefore, by algebraic manipulation.

Table 8.14 details the complete dynamic structural retail demand model. This table, and Tables 8.15-8.26, present in detail the economic model results which form the basis of this discussion. The estimated coefficients of the structural model in Table 8.14 are shown without their associated standard errors. Standard errors for all coefficients could have been determined by the method used for the income-expenditure elasticities,[2] however computational problems in their determination would have been large. Not only would separate estimating equations have been required for each different algebraic transformation used to calculate the structural coefficients, but the basic relationship discussed in Chapter 3 would have required expansion to cover cases where more than two variables were involved in the basic transformation. While this in itself would provide no problem, the resulting standard error estimating equation would expand in size very rapidly. Standard errors of the structural coefficients so calculated would provide a measure of the distribution around the stated value of

1. Chapter 6, pp. 137-140.
2. Chapter 3, pp. 61-62.

TABLE 8.14

ORDINARY LEAST-SQUARES ESTIMATE OF THE NEW ZEALAND DYNAMIC RETAIL MEAT MODEL IN STRUCTURAL FORM.

$$\log \overline{Q_{DB_t}} = 1.497 - 0.557 \log P^r_{B_t} + 0.259 \log P^r_{M_t} + 0.205 \log P^r_{P_t} + 0.429 \log Y_t + 0.130 S_1 + 0.061 S_2 - 0.144 S_3$$

$$\log Q_{DB_t} - \log Q_{DB_{t-1}} = 0.571(\log \overline{Q_{DB_t}} - \log Q_{DB_{t-1}})$$

$$\log \overline{Q_{DM_t}} = 5.915 + 0.291 \log P^r_{B_t} - 0.543 \log P^r_{M_t} - 0.843 \log P^r_{P_t} + 0.128 \log Y_t - 0.037 S_1 - 0.050 S_2 - 0.043 S_3$$

$$\log Q_{DM_t} - \log Q_{DM_{t-1}} = 0.846(\log \overline{Q_{DM_t}} - \log Q_{DM_{t-1}})$$

$$\log \overline{Q_{DP_t}} = 14.266 + 0.791 \log P^r_{B_t} - 0.486 \log P^r_{M_t} - 5.650 \log P^r_{P_t} + 1.198 \log Y_t - 0.243 S_1 - 0.209 S_2 + 0.119 S_3$$

$$\log Q_{DP_t} - \log Q_{DP_{t-1}} = 1.609(\log \overline{Q_{DP_t}} - \log Q_{DP_{t-1}})$$

$$\log \overline{{}^wP_{B_t}} = 0.814 + 0.752 \log {}^EP_{B_t} + 0.221 \log A_{B_t} + 0.218 \log A_{M_t} - 0.011 \log Q_{SP_t}$$

$$\log {}^wP_{B_t} - \log {}^wP_{B_{t-1}} = 0.262(\log \overline{{}^wP_{B_t}} - \log {}^wP_{B_{t-1}})$$

$$\log \overline{{}^wP_{M_t}} = 0.993 + 1.083 \log {}^EP_{M_t} + 0.219 \log A_{B_t} + 0.353 \log A_{M_t} - 0.532 \log Q_{SP_t}$$

$$\log {}^wP_{M_t} - \log {}^wP_{M_{t-1}} = 0.278(\log \overline{{}^wP_{M_t}} - \log {}^wP_{M_{t-1}})$$

$$\overline{M_{B_t}} = -40.571 + 0.393 I_t + 0.464\,{}^wP_{B_t} - 2.857 Z_1$$

$$M_{B_t} - M_{B_{t-1}} = 0.140(\overline{M_{B_t}} - M_{B_{t-1}}) - 0.580 \Delta {}^wP_{B_t} - 0.007 \Delta {}^wP_{M_t} - 0.057 \Delta {}^wP_{P_t}$$

$$\overline{M_{M_t}} = 4.882 + 0.142 I_t - 0.338\,{}^wP_{M_t} - 1.347 Z_1$$

$$M_{M_t} - M_{M_{t-1}} = 0.346(\overline{M_{M_t}} - M_{M_{t-1}}) + 0.110 \Delta {}^wP_{B_t} - 0.707 \Delta {}^wP_{M_t} + 0.031 \Delta {}^wP_{P_t}$$

$$\overline{M_{P_t}} = -11.665 + 0.254 I_t - 0.329\,{}^wP_{P_t} + 0.191 Z_1$$

$$M_{P_t} - M_{P_{t-1}} = 0.319(\overline{M_{P_t}} - M_{P_{t-1}}) + 0.108 \Delta {}^wP_{B_t} + 0.019 \Delta {}^wP_{M_t} - 0.633 \Delta {}^wP_{P_t}$$

the coefficient that the coefficient could take at varying levels of probability. While this measure would be useful, it would not be of equal power to the estimating equation standard errors. These estimating equation standard errors, in addition to providing an estimate of the distribution of each coefficient, enables the contribution which an independent variable has made to the determination of the dependent variable to be measured. On the basis of the above considerations it was decided not to measure each structural coefficient's standard error.

It could be thought that a coefficient of determination should be estimated for each structural equation. This however is not appropriate, as each equation in the structural model explains a long term relationship; i.e. after complete adjustment in the dependent variable has occurred following a change in its determining forces. The dependent variable is thus an equilibrium or long-run value. As the long-run values cannot be measured in the market, it is therefore not possible to estimate the coefficients of determination.

The use of the long-run coefficients for projection or other policy purposes must also be framed in equilibrium terms. If, for example, the demand for beef were estimated from the structural equation with a given price and income regime, it would be the equilibrium quantity demanded which would be determined. A comparison with actual consumption at the stated price and income regime would therefore only be relevant if sufficient time for complete adjustment had elapsed during which no further change in market forces had occurred. An estimate of consumption for a period of time shorter than that needed for complete adjustment is, however, still possible. This would require the use of the Nerlove adjustment equation as part of that estimation.

With the above perspective the model coefficients may now be discussed. While Table 8.14 presents the complete structural model, Tables 8.15 to 8.26 give the basic results in small groups. Each of these small groups will be discussed separately, and fitted into the overall model.

Table 8.15 contains the long-run price and income elasticities of this model. All elasticities in this table are of the expected sign apart from the mutton-pork, and pork-mutton cross elasticities. These negative cross-elasticities, implying a complementary rather than a competitive relationship, have also been found for the same two meats in other demand studies.[1]

Whether this unusual relationship is due to a technical relationship or an economic one cannot be stated with any certainty. A technical effect, due to the similarity of the meats as regards colour and texture for example, could influence the way in which the two meats are used. The economic relationship could result from the low and possibly negative income elasticity of mutton. Thus a decline in price of mutton could have the effect of raising real income, resulting in increased consumption of mutton (the price effect) and increased consumption of pork (the income effect). Pork has a relatively high income elasticity of demand. Although there is insufficient evidence to determine exactly the nature of the mutton-pork relationship it has occurred too frequently in recent studies to be dismissed as having occurred by chance. Meat retailers too have observed this phenomenon,

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1. B.P. Philpott and M.J. Matheson, An Analysis of the Retail Demand for Meat in the United Kingdom, Agricultural Economics Research Unit Publication No. 23, Lincoln College, Canterbury University, 1965. also J.M. Chetwin, An Econometric Study of Wholesale Meat Prices in the United Kingdom, Unpublished thesis, Lincoln College, Canterbury University, 1968. and J.A.C. Brown, "Seasonality and Elasticity of the Demand for Food in Great Britain Since Derationing", Journal of Agricultural Economics, Vol. 13, 1959, pp. 228-240.

TABLE 8.15

DYNAMIC RETAIL MEAT MODEL

LONG-RUN DEMAND ELASTICITIES.

Demand for:-	$P^r_{B_t}$	$P^r_{M_t}$	$P^r_{P_t}$	Y_t
Beef	-0.557	0.259	0.205	0.429
Mutton	0.291	-0.543	-0.843	0.128
Pork	0.791	-0.486	-5.650	1.198

TABLE 8.16

DYNAMIC RETAIL MEAT MODEL

SHORT-RUN DEMAND ELASTICITIES (QUARTERLY).

Demand for:-	$P^r_{B_t}$	$P^r_{M_t}$	$P^r_{P_t}$	Y_t
Beef	-0.318	0.148	0.117	0.245
Mutton	0.246	-0.459	-0.713	0.108
Pork	1.273	-0.782	-9.091	1.928

but are unable to advance any explanation for its occurrence.[1]

The beef demand elasticities are all of expected size and sign. The coefficient in the estimating equation from which the pork elasticity was derived was not significantly different from zero. The true value of this elasticity could therefore be zero, on the basis of the probability tests. Thus while the value for this coefficient has been shown in Table 8.15 as 0.205, retail price of pork probably has no noticeable effect on beef consumption. As this discussion proceeds, structural coefficients which also are probably not significantly different from zero, will be mentioned. The interpretation to be placed on these coefficients will be similar to the above case. The reason for the probable zero effect of pork price on beef is, as was discussed earlier, most likely due to the small share of the internal market which pork fills. Beef, however, is the major meat consumed in New Zealand. On a proportional basis therefore a change in the price of a minor, but relatively highly priced competitor, would have little effect on the consumption of the major meat consumed. On a similar basis beef's own price, and income, could be expected to have a quite large and noticeablce influence on consumption. The price of beef's major competitor (mutton) could also be expected to have a significant, although smaller, influence as is shown by the size of the respective coefficients.

The mutton demand elasticities are similar to the above, a price elasticity of demand of 0.54 with a cross-elasticity with beef price of 0.29. The sign of the cross-elasticity with pork price has already been discussed, the size of this elasticity is larger than was expected, suggesting a sensitive pork price - mutton quantity relationship. In absolute terms however a one per cent change in pork price would be

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1. This observation on the part of meat retailers was made at their 1968 national meeting.

large compared with a one per cent change in mutton price. This could explain the relatively large size of the cross-elasticity.

Of the mutton elasticities only the income-elasticity had a coefficient in the estimating equation which was not significantly different from zero. This suggests that income has no noticeable influence on mutton consumption, a conclusion which is supported by the Engel curve estimates discussed in Chapter 3.[1] Although probably not significantly different from zero, the mutton income-elasticity is however of positive sign in the retail model, while the Engel curve estimate, also not significantly different from zero, was of negative sign. These elasticity estimates therefore provide no conclusive evidence for classifying mutton as either an inferior good or as a necessity. This meat has however some inferior good characteristics,[2] and can at best be considered as having an income-elasticity of zero, and probably an income-elasticity of less than zero.

The pork long-run elasticities have several striking features. The negative value of the cross-elasticity with mutton price has already been discussed, and is probably not statistically significant as the corresponding coefficient in the estimating equation was not significantly different from zero. Pork demand is shown as being extremely sensitive to changes in its own price and income, and to a lesser extent retail price of beef. While these coefficients should be accepted with some caution, the high long-run price-elasticity of demand of -5.65 is probably due to the portion of the pork demand curve which was estimated by this equation. The average price of pork over the time span of the data was high relative to the price of other meats. At the same time the average quantity of pork demanded was low. The portion of the

1. Chapter 3, pp. 65-70.
2. Chapter 2, pp. 28-43.

demand curve estimated was therefore the 'top-end' of the demand curve. Thus a one per cent change in price would in absolute terms be large compared with a one per cent change in price of other meats, and the effect this would have on the quantity of pork demanded would in percentage terms be large, although in absolute terms quite small. On this basis, a large price-elasticity of demand could therefore be expected.[1]

The above discussion makes comment on the use of a constant elasticity (logarithmic) estimating function necessary. In using this function, it is the closest possible approximation to a portion of the true demand curve which is being sought. The portion of the demand curve being estimated is defined by the numeric values of the observations. The true demand curve may in fact be of constant or non-constant elasticity over its entire range, there is unfortunately no way of knowing. Over a portion of the curve the constant elasticity estimate can, however, still be a close approximation, even if over the entire range of the true demand curve the price-quantity relationship is one of non-constant elasticity. As an approximation a constant elasticity function is thus quite applicable, provided the spread of the observations does not extend too far. Thus although the estimated demand curve for pork is of constant elasticity it is quite acceptable that at a low price and high demand for pork the elasticity could (and *a priori* probably would) be considerably lower.

Using the same reasoning, the relatively high income-elasticity of demand, and the moderate cross-elasticity of demand with beef price, can also be explained. This is of particular relevance to the income-elasticity. The income-consumption relationship, as was discussed in

1. This does not mean that the estimated price elasticity is completely trustworthy though. Inaccuracies inherent in the method of estimating the quantity of pork demanded could, in fact, be responsible for the high price elasticity. See Chapter 7, pp. 163-166.

Chapter 3, is not expected a priori to be of constant elasticity as income changes. The estimated income-elasticity applies therefore only over a narrow range of income, and is a constant elasticity approximation of a portion of the true income-consumption curve.

Table 8.16 presents in table form the short-run (in this case quarterly) demand elasticities. These elasticities are taken direct from the estimating equations, apart from the pork short-run elasticities which required an initial transformation. The short-run elasticities show the average change in consumption during the first quarter following a change in the value of the associated independent variable. Thus a one per cent increase in retail beef price would decrease beef consumption 0.318 per cent in the first quarter, but after complete adjustment to a new equilibrium, beef consumption would have declined by 0.557 per cent. The assessment made of the long-run elasticities largely applies to the short-run (quarterly) elasticities, the one being linked to the other by the adjustment coefficient. The discussion of the short-run elasticities will therefore essentially be a discussion of the adjustment coefficients and their importance.

In the estimating equations the significance of each lagged variable's coefficient from zero was determined. For all estimating equations in the model, apart from the pork demand estimating equation, the lagged variable's coefficient equalled $(1-\gamma)$ in terms of the structural coefficients, γ being the adjustment elasticity (or coefficient). A consequence of this relationship is that if $(1-\gamma)$ is significantly different from zero, then γ is significantly different from unity. If γ is not significantly different from unity, then by the logic of the model, there is no significant difference between the short- and long-run elasticities, i.e. complete adjustment to the new market situation occurs within one time period.

Of all the equations in the model only the mutton demand estimating equation had a $(1-\gamma)$ coefficient which was not significantly different from zero at the ten per cent level or better. Adjustment to equilibrium demand for mutton in response to changed market forces can therefore be assumed to occur within one time period. The value of γ in the mutton demand equation was 0.846, indicating that eighty-four per cent of adjustment occurs within the first time period. As was stated above, this was not significantly different from 1.0. A static mutton demand equation would therefore have been equally as appropriate as the dynamic equation model. It is of interest that in the static model (which is yet to be discussed) the mutton demand equation was the only equation not significantly autocorrelated, and with a coefficient of determination only slightly less than that of the lagged model. The comparatively rapid adjustment of consumers to changed market forces when buying mutton is perhaps to be expected for a good which is definitely inferior, or close to being inferior.

The beef demand adjustment coefficient was significantly different from unity, and as is shown in Table 8.14 had a value of 0.571. This is the normal case of an adjustment coefficient being between zero and unity, indicating that each time period fifty-seven per cent of the remaining adjustment to equilibrium occurs.

The pork demand adjustment coefficient was however greater than unity, taking a value of 1.609. This adjustment coefficient was calculated differently to the other equations because of the specification necessary for pork demand, however it is probable that this coefficient too is significantly different from unity. A special interpretation must be placed on adjustment coefficients greater than unity and less than two.[1] Essentially the interpretation must be that consumers have

1. This was discussed in: Chapter 4, pp. 83-84.

'over-reacted' to the change in market forces, during the first time period moving the quantity demanded past the equilibrium point by (in the above case) 60.9 per cent of the original shift needed to reach equilibrium. In the second time period movement in demand will be in the opposite direction, exceeding the new difference between actual and equilbrium by 60.9 per cent. Thus after a series of over-reactions of decreasing amplitude, equilibrium quantity will be approached. It must, however, be remembered when interpreting the adjustment coefficient for pork demand that the model has assumed quantity demanded predetermined, with the price of pork the dependent variable.

By comparing each quarterly demand elasticity, and its respective long-run demand elasticity, the importance of the time period required for complete adjustment can be determined. For beef, the long-run elasticities are quite noticeably larger. Beef had a significant and normal ($0<\gamma<1$) adjustment elasticity (γ). With mutton the quarterly and long-run elasticities are very similar, and are probably not significantly different from each other. Mutton had an adjustment elasticity not significantly different from unity. Pork however has quarterly elasticities noticeably larger than the long-run elasticities. This is a reflection of the abnormal adjustment coefficient ($1<\gamma<2$). Equilibrium demand for pork can however still be reached (if sufficient time with the values of independent variables remaining unchanged occurs) because the adjustment elasticity value is less than 2.0.

Table 8.17 shows the long-run influence of seasons. Taking the base season's consumption (January-March) as equal to 1.0, the table expresses that proportion of the base season's consumption would be consumed in each of the remaining three quarters of the year <u>ceteris paribus</u>. These proportionalities were derived as follows:

Consider the demand equation;

$$\log Q = a + b\log P + cS_i$$

where Q = quantity of a good consumed

P = price of the good

S_i = a shift variable for the i^{th} season allowing quantity of the good consumed to shift between seasons without any change in price occurring

a = a constant

b = price elasticity of demand

c = the coefficient associated with the shift variable season S_i.

The seasonal shift variable (S_i) can thus be considered as measuring the movement in Q through time. The equation can therefore be differentiated with respect to seasons (i.e. time). Denoting the derivative $\frac{\partial Q}{\partial S}$ by $\mathring{Q}$, then;

$$\frac{\mathring{Q}}{Q} = b\,\frac{\mathring{P}}{P} + c \qquad \text{where } \frac{\mathring{P}}{P} = \frac{1}{P}\frac{\partial P}{\partial S}$$

i.e. the relative rate of change in demand (Q) as the seasons pass is equal to b times the rate of change in price, plus a shift parameter c which measures the rate of change in demand relative to the level of demand in the base season.

If however price does not change between seasons (i.e. the ceteris paribus assumption holds) the relative change in quantity demanded is the shift parameter c. Expressed mathematically, if price is constant between seasons;

$$\frac{\mathring{P}}{P} = \frac{1}{P}\frac{\partial P}{\partial S} = 0$$

then the relative rate of change in quantity $\frac{(\mathring{Q})}{(Q)}$ is c.

Thus Q_{t+i} (the consumption in season i) is;

$Q_t + cQ_t$ where $_t$ denotes the base season.

Expressed alternatively, as

$$\frac{\dot{Q}}{Q} = c$$

then $\dot{Q} = cQ$.

i.e. $\dot{Q}_t = cQ_t$

therefore $$Q_{t+i} = Q_t + cQ_t$$

$$= Q_t\ (1.0 + c)$$

Expressing the base season's consumption as equal to 1.0, then consumption in the i^{th} season is;

$$1.0 + c$$

In this way the proportion of the base season's consumption which is consumed in each of the remaining seasons during the year can be determined by adding 1.0 to the coefficient associated with each season's shift variable.

The long-run seasonal shifts in consumption shown in Table 8.17 give a measure of the seasonal pattern of consumption based upon the January-March quarter. With beef the estimating equation coefficients indicate that the differences are all significant at the ten per cent level or better, with the first and third seasons significant at the one per cent level. As was expected the winter months are shown as being the seasons in which proportionately more beef is consumed, with the April-June period the quarter in which beef consumption is greatest.

Mutton consumption is shown as being influenced very little by seasonal conditions. The base quarter is shown as being highest, with consumption significantly lower only in the second season(July-September), and then consumption is lower by only five per cent. Mutton supplies are generally lower in this quarter with the availability ratio either equal

TABLE 8.17

DYNAMIC RETAIL MEAT MODEL
LONG-RUN SEASONAL CONSUMPTION VARIATIONS
(EACH SEASON'S CONSUMPTION EXPRESSED AS A PROPORTION OF THE BASE SEASON CONSUMPTION).

Consumption of:-	S_1 (April - June)	S_2 (July - September)	S_3 (October - December)
Beef	1.130	1.061	0.856
Mutton	0.963	0.950	0.957
Pork	0.757	0.791	1.119

TABLE 8.18

DYNAMIC RETAIL MEAT MODEL
SHORT-RUN SEASONAL CONSUMPTION VARIATIONS
(EACH SEASON'S CONSUMPTION EXPRESSED AS A PROPORTION OF THE BASE SEASON CONSUMPTION).

Consumption of:-	S_1 (April - June)	S_2 (July - September)	S_3 (October - December)
Beef	1.074	1.035	0.918
Mutton	0.969	0.958	0.964
Pork	0.957	0.963	1.021

to or approaching unity.

Pork consumption is indicated as being markedly lower in the first two seasons (April-September), with consumption higher in the October-December period, although the estimating equation coefficient was not significantly different from zero for this quarter, indicating that there is not a significant difference between October-December consumption and January-March consumption.

Two points are relevant to this seasonal pattern for pork. Firstly the seasonal pattern for pork is determined by supply, thus the estimated pattern therefore follows the pork production pattern and is very much as expected. Secondly this pattern could be a reflection of the manner in which pork consumption data were estimated as was described in Chapter 7.

Table 8.18 expresses the short-run seasonal adjustments on the same basis as Table 8.17. As could be expected from the adjustment elasticities the short-run effects are smaller for beef and mutton, and larger for pork. The comments made on the difference between the short-run and long-run demand elasticities can equally be applied to the difference between Tables 8.17 and 8.18. A special interpretation of the differences in seasonal adjustment is however relevant. The long-run seasonal adjustments indicate what the equilibrium movement in demand for each meat would be if the season were long enough for complete adjustment to occur. The short-run seasonal adjustments indicate the actual adjustment which on average occurred with this sample of data. In some respects therefore the short-run adjustments are the more applicable.

Table 8.19 indicates the number of time periods (quarters) required for ninety-five per cent of the adjustment to equilibrium demand conditions to be completed. The time periods have also been converted into the number of weeks for easier interpretation. Ninety-five per cent adjustment has been chosen because complete adjustment occurs only after an infinite time period.[1]

The adjustment period for beef is shown as a little under one year, a similar result to that found for the United States.[2] Mutton is shown as requiring twenty-one weeks, this however would not be significantly different to thirteen weeks (one quarter) as the adjustment elasticity was not significantly different from unity. Pork demand is shown as taking a year and a half for adjustment to equilibrium after a change in a market force. These adjustment periods indicate that if a static model is to be used for estimating New Zealand meat demand parameters annual time periods for data are essential, and probably a larger time span for observations very desirable, otherwise long-run elasticities would not be estimated.

Table 8.20 shows in tabular form the estimated long-run elasticities of the wholesale price determining variables. Only equations for beef and mutton were calculated, a wholesale price formation equation for pork was not applicable.[3] Most of the long-run coefficients are probably significantly different from zero. The variables for which the associated coefficients were not significantly different from zero at the one per cent level in the estimating equations were the availability ratio for beef in both equations, and the supply of pork in the beef wholesale price formation equation. The beef availability ratio was significant in the beef wholesale price formation estimating equation at the ten per cent level. In assessing the coefficients for the beef wholesale price equation it must be borne in mind that significant autocorrelation was present in that estimating equation.

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1. For the formula for estimating the time required for ninety-five per cent adjustment see: Chapter 4, p. 84.
2. W.A. Fuller and G.W. Ladd, op. cit., pp. 802-805.
3. Chapter 5, pp. 119-123.

TABLE 8.19

TIME PERIODS REQUIRED FOR NINETY-FIVE PER CENT ADJUSTMENT TO EQUILIBRIUM (DYNAMIC RETAIL MEAT MODEL, DEMAND EQUATIONS).

Demand Equation for.-	Number of Time Periods (Quarters)	Number of Weeks
Beef	3.54	46
Mutton	1.60	21
Pork	6.04	79

TABLE 8.20

DYNAMIC RETAIL MEAT MODEL LONG-RUN WHOLESALE PRICE FORMATION ELASTICITIES (OLS ESTIMATES).

Wholesale Price of:-	EP_{B_t}	EP_{M_t}	A_{B_t}	A_{M_t}	Q_{SP_t}
Beef	0.752	-	0.221	0.218	-0.011
Mutton	-	1.083	0.219	0.353	-0.532

TABLE 8.21

DYNAMIC RETAIL MEAT MODEL SHORT-RUN WHOLESALE PRICE FORMATION ELASTICITIES (OLS ESTIMATES).

Wholesale Price of:-	EP_{B_t}	EP_{M_t}	A_{B_t}	A_{M_t}	Q_{SP_t}
Beef	0.197	-	0.058	0.057	-0.003
Mutton	-	0.301	0.061	0.098	-0.148

The importance of the export price of each meat in determining wholesale price is quite striking. For beef a one per cent shift in export price gives an 0.75 per cent movement in the equilibrium local wholesale price; for mutton a one per cent movement in export price gives a 1.08 per cent increase. The lesser effect on local wholesale price of beef could reflect data problems. Export price data for beef were not entirely representative of New Zealand export price, thus the effect of true export price could have been underestimated.[1]

Although the use of the availability ratios was discussed in Chapter 5, the interpretation of the estimated coefficients is of great importance, and will be briefly repeated. The availability ratio long-run elasticity for mutton in the mutton wholesale price equation indicates the following:

(a) a one per cent increase in demand for mutton, *ceteris paribus*, will result in an 0.353 per cent increase in the equilibrium wholesale price of mutton;

similarly

(b) a one per cent increase in the total quarterly supply of mutton, *ceteris paribus*, will result in an 0.353 per cent decrease in the equilibrium wholesale price of mutton.

The direction of this result is as was expected, while the size of the change in equilibrium wholesale price is quite reasonable. In the beef wholesale price equation a change in the availability of mutton (i.e. in the total supply of, or the demand for mutton) is shown as having a significant though lesser effect on the wholesale price of beef. As before the direction is as was expected.

The beef availability ratio coefficient is shown in Table 8.10 as

1. Chapter 7, pp. 159-161.

being only significantly different from zero at the ten per cent level in the beef wholesale price equation, and not significant in the mutton wholesale price equation. This was probably due to the fact that beef availability was not limiting over the time period from which the data were drawn for this study (i.e. A_{B_t} did not tend to 1.0 in any observation). The highest value of A_{B_t} in this study was 0.76. In contrast, mutton availability frequently approached or took a value of 1.0 in the winter quarter. Similarly beef availability was never far in excess of internal requirements (i.e. tend to zero), whereas mutton availability often tended to zero in the summer months. The influence of the availability of mutton was therefore more pronounced.

Pork supply is shown as having no noticeable effect on equilibrium wholesale beef prices, and a marked influence on wholesale mutton price. This position could have been expected on the basis of the estimated demand equations where pork was shown as having no influence on beef demand, due probably to its small share of the internal meat market. The direction of the change is however as expected in both equations.

Table 8.21 presents the short-run (quarterly) wholesale price formation elasticities. These elasticities should be interpreted in the same way as the short-run demand elasticities. A comparison between the short- and long-run wholesale price formation elasticities suggest that the adjustment elasticities are low, as in fact they are. Both adjustment elasticities are below 0.3, and both are significantly different from 1.0 at the one per cent level. Adjustment to a new equilibrium after a change in the wholesale market forces therefore takes considerable time, indicating that operators in the wholesale market have a much less than perfect knowledge of the market in which they operate. The time period taken for a complete (ninety-five per cent) adjustment (Table 8.22) is between two and quarter, and two and half years, an extraordinarily long period for a market of traders to adjust to a new situation.

The remaining three equations of the dynamic retail model will now be considered. These are the wholesale-to-retail margin equations, which will henceforth be referred to as the margin equations.

All the margin equations for this model were calculated on data in arithmetic form. The coefficients are therefore not elasticities but express the absolute change in the margin, in pence, for each one unit increase in the determining variable. Table 8.23 shows the long-run equilibrium coefficients. All variables, apart from the final two in the pork margin equation, are probably important in the determination of the respective margins as their associated estimating equation coefficients were significantly different from zero.

The index of butchers' wage costs was significant in all three equations, although in the pork margin equation only at the ten per cent level. The coefficients indicate the change in the margin with a one unit increase in wage costs. Taken at the base period for the index, the effect of wage costs can be expressed in percentage terms. A one per cent increase in the index from the base period gives an 0.39 pence per pound increase in the margin for beef, for example. At the base period the butchers' average wage rate was 120 shillings per week.

A relative measure of the services the meat retailer provides with each meat type can be inferred from the wage cost coefficients. Beef has the largest coefficient, indicating that more time must be put into processing a carcase of beef than a carcase of the other meats. Pork is the second most time consuming meat, with mutton the least costly with respect to time. In terms of fixed and proportional components of the margin, wage costs may be considered as representative of the fixed components.

TABLE 8.22

TIME PERIODS REQUIRED FOR NINETY-FIVE PER CENT ADJUSTMENT TO EQUILIBRIUM (DYNAMIC RETAIL MEAT MODEL, WHOLESALE PRICE FORMATION EQUATIONS).

Wholesale Price of:-	Number of Time Periods (Quarters)	Number of Weeks
Beef	9.86	128
Mutton	9.19	119

TABLE 8.23

DYNAMIC RETAIL MEAT MODEL, LONG-RUN WHOLESALE-TO-RETAIL MARGIN COEFFICIENTS (OLS ESTIMATES).

Wholesale-to-Retail Margin for:-	I_t	${}^wP_{B_t}$	${}^wP_{M_t}$	${}^wP_{P_t}$	Z_1
Beef	0.393	0.464	-	-	-2.857
Mutton	0.142	-	-0.338	-	-1.347
Pork	0.254	-	-	-0.329	0.191

TABLE 8.24

DYNAMIC RETAIL MEAT MODEL,

SHORT-RUN WHOLESALE-TO-RETAIL MARGIN COEFFICIENTS (OLS ESTIMATES).

Wholesale-to-Retail Margin for:-	I_t	${}^wP_{B_t}$	${}^wP_{M_t}$	${}^wP_{P_t}$	Z_1
Beef	0.055	0.065	-	-	-0.400
Mutton	0.049	-	-0.117	-	-0.466
Pork	0.081	-	-	-0.105	0.061

The wholesale price coefficients indicate that there are differences in the method of margin formation for each meat. For beef the coefficient is positive, while for the other meats the coefficients are negative. An increase of one penny per pound in the respective wholesale prices increases the equilibrium beef margin by 0.464 pence per pound, decreases the equilibrium mutton margin by 0.338 pence per pound, and for pork the decrease is 0.329 pence per pound, although this is probably not significantly different from zero.

With beef therefore the whole increase in wholesale price is passed on to the consumer, plus an extra 0.464 pence for each 1.0 pence increase in wholesale price once complete adjustment to equilibrium has occurred. Thus for marginal changes in the wholesale price the equilibrium mark-up is quite severe, indicating that as beef is the major meat sold, meat retailers do not attempt to compete on the product which determines the basic profitability of their enterprise. Mutton and pork are however in a very different position. With both meats, retailers absorb some of the increase in wholesale price (approximately 33.8 and 32.9 per cent respectively) in an attempt to put them in a more competitive position. Retailers therefore compete for custom on their minor rather than their major products for sale when wholesale prices increase. The probable significant difference of this coefficient from zero for mutton, and non-significance for pork, suggests that this competition is more pronounced with mutton (a low income elastic and possibly inferior good) than with pork (a luxury meat).

It must be remembered however that a decrease in wholesale price gives the opposite effect. Thus with decreases in wholesale prices, meat retailers tend to pass the benefit on to consumers with the major meat item (beef) but attempt to regain some of their margin with the other two meats. Again this result could be anticipated, it is quite reasonable that in a small business no chances will be taken with the major source of revenue, while competition for customers will occur mostly in the less important lines.

The last variable in Table 8.23 is a shift variable included for the most recent period of price control.[1] In the estimating equations the coefficients associated with this variable were significantly different from zero for beef and mutton, but not for pork. It would appear therefore that price control affected only beef and mutton of these three meats. The long-run coefficients in Table 8.23 indicate that the equilibrium margin was reduced by 2.857 pence per pound for beef, and 1.347 pence per pound for mutton. It is important here to distinguish between the equilibrium and the short-run margin. Only if the market forces had remained constant for a sufficient period of time for the equilibrium to be reached would the margin have been decreased by this amount. In fact market forces did not remain constant for a sufficient period of time. If an evaluation of the true effect of price control on the meat market is desired, then it is the short-run coefficients which must be considered.

The coefficient for the shift variable in the pork equation is of some interest. Although probably not significantly different from zero, the coefficient is positive. This suggests that the price control authorities inaccurately assessed the pork margin prior to price control, and actually specified an increased pork margin in the price control schedules. Equally, the meat retailers faced with reduced margin on the major meats took full advantage of the increased margin allowed for pork to regain some of their lost revenue.

In Table 8.24 the short-run (quarterly) margin coefficients are shown. The relationship these coefficients have to the long-run

1. For discussion see Chapter 5, pp. 117-118 and Chapter 1, pp. 12-13.

coefficients is, as was discussed earlier, through the adjustment coefficient. Initially the price control shift variable short-run coefficients will be discussed, completing the analysis of the effects of price control.

As is shown in the Table 8.24 the short-run effect of price control was to decrease the beef margin (and hence retail price) by 0.4 pence per pound; and the mutton margin by 0.466 pence per pound. This was the average short-run effect over the whole period of price control. As was discussed above it is the short term coefficients which are required for an evaluation of the true effects of price control. The very smallness of the per pound effect could be anticipated, as price control during this period effectively only controlled the wholesale-to-retail margin. Because the margin is but a small proportion of the retail price,[1] the scope for substantial reductions in the retail price was therefore not available. Against the savings shown above must be debited the costs of operating the scheme, as well as the quality substitution which inevitably would occur with a commodity such as meat in which each grade includes a range of qualities.

It would appear probable that in fact retailers would have substituted lower quality meat within the same broad grade of meat, thereby ensuring that they continued to regain their desired margin. A value of one half-penny per pound could easily be accounted for by quality substitution. At the same time the community was required to pay for operating the price control scheme. It is possible therefore that the community in general lost both ways during the period of price control of meat.

Other coefficients in Table 8.24 will not be discussed in detail.

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1. See: Appendix D, Part A, Quarterly Data. For estimates of the respective retail prices and margins.

When compared with the long-run coefficients in Table 8.23 it becomes clear that immediate adjustments are small to any change in the market forces. An increase in either butchers' wage costs or wholesale prices is slow in affecting the margin, suggesting that the meat retailer prefers to adjust slowly to the new market situation, perhaps so his customers will not notice. The consumer is in general antagonistic toward the meat retailer in New Zealand.[1]

Table 8.25 shows the coefficients for the adjustment equation, these coefficients do not change between short- and long-run periods. The adjustment coefficients were all significantly different from unity, their size indicating a long adjustment period is required to reach equilibrium. As was discussed above this could be deliberate policy on the part of the meat retailer. The remaining coefficients in the table give an estimate of how much retailers average and level retail prices (and hence their margins). In the beef adjustment equation only the change in beef's own wholesale price has a coefficient significantly different from zero. This suggests that retailers level beef prices, but do not average their margin on beef with the margin recovered from other meats. The coefficient of -0.580 indicates that a one penny per pound increase in the change in wholesale price each quarter results in a 0.58 pence per lb. decrease in the change of the margin each quarter.

In the mutton equation both the change in beef wholesale price and the change in mutton wholesale price affects the change in the margin. The beef wholesale price coefficient is however only significantly different from zero at the ten per cent level. This suggests that price levelling also occurs with mutton, but in addition when beef wholesale price increases, some margin averaging occurs, increasing the mutton margin (to regain some of the retailers' loss on beef). With pork,

1. This was shown by the Consumer Survey.

TABLE 8.25

DYNAMIC RETAIL MEAT MODEL,

WHOLESALE-TO-RETAIL MARGIN ADJUSTMENT COEFFICIENTS (OLS ESTIMATES).

Change in the Margin for:-	Nerlove Adjustment Coefficient $(M_t - M_{t-1})$	$\Delta^w P_{B_t}$	$\Delta^w P_{M_t}$	$\Delta^w P_{P_t}$
Beef	0.140	-0.580	-0.007	-0.057
Mutton	0.346	0.110	-0.707	0.031
Pork	0.319	0.108	0.019	-0.633

TABLE 8.26

TIME PERIODS REQUIRED FOR NINETY-FIVE PER CENT ADJUSTMENT TO EQUILIBRIUM (DYNAMIC RETAIL MEAT MODEL, WHOLESALE-TO-RETAIL MARGIN EQUATIONS).

Wholesale-to-Retail Margin for:-	Periods	Weeks
Beef	19.86	258
Mutton	7.06	92
Pork	7.66	100

however, the situation is one of simple price levelling, as only the change in its own wholesale price is shown as being significantly different from zero. In general the non-significant coefficients were quite small; the associated variables may therefore be considered as having no noticeable effect in the determination of the margins.

Finally, Table 8.26 indicates the time period required for adjustment to equilibrium. This has largely been discussed above; however a further conclusion can be drawn. The adjustment period required for beef shows the extreme slowness with which meat retailers adjust their margins. With the basic New Zealand model specifying retail price as equal to wholesale price plus the margin, retail price takes a long time to reach equilibrium, and only then does the adjustment to equilibrium quantity demanded begin. It cannot be expected that equilibrium is ever likely to occur in the New Zealand meat market. This however does not decrease the power of the dynamic concept. To project future demand levels on other than the long-run coefficients is conceptually unacceptable. If in such projections the time of each change in the determining market forces can be specified, a much more accurate result would be achieved.

This concludes the detailed discussion of the model considered 'best' in both a statistical and an economic sense. Other model variants estimated will now be discussed, but only in broad outline. Emphasis will be placed mainly on their differences to the model chosen, and discussed above.

Alternative Meat Model Variants Estimated by Ordinary Least-Squares

First of the three variants estimated which will be discussed was a static retail demand model.[1]

1. The specification of these variants is discussed in Chapter 5, pp. 131-133.

This model was identical to the dynamic model above, apart from the exclusion of the distributed lag formulation. A general statement of the estimated static model is shown in Table 8.27.

A major feature of the static retail demand model is the marked increase in the autocorrelation present. Only the mutton demand equation is shown as being free from this problem, the significance of which has been commented on above. In general the autocorrelation problem was of sufficient magnitude to create serious doubt as to the usefulness of the model results, as the standard errors are untrustworthy. In all cases the autocorrelation indicated is positive.

While confidence in the estimated significance from zero of the coefficients must be reduced, one point stands out clearly. The size of the variable coefficients in general fall between the short- and long-run coefficients estimated by the dynamic retail model, indicating that by constraining all the adjustment to changed market forces to one time period, bias of the coefficients from their true quarterly value probably occurs. The operation of the static constraints does not, however, allow the true long-run value to be estimated.

In most equations the coefficient of determination was markedly reduced, those equations where the adjustment period in the dynamic model was greatest, were reduced the most. While all the coefficients of determination remain significantly different from zero at the one per cent level, the proportion of the variation in the dependent variables which has been explained is not very satisfactory.

The statistical properties of this model variant were the major reason for not preferring it. This coupled with the unsatisfactory theoretical interpretation placed upon the economic properties suggested that the dynamic formulation is the superior model. The results have been presented here for direct comparison of the respective achievements

TABLE 8.27

ORDINARY LEAST-SQUARES ESTIMATE OF THE NEW ZEALAND STATIC RETAIL MEAT MODEL.

$$\log Q_{DB_t} = 1.419 - \underset{(0.074)}{0.476^{***}}\log P^r_{B_t} + \underset{(0.070)}{0.325^{***}}\log P^r_{M_t} + \underset{(0.138)}{0.167}\log P^r_{P_t} + \underset{(0.099)}{0.376^{***}}\log Y_t + \underset{(0.016)}{0.087^{***}}S_1 + \underset{(0.015)}{0.082^{***}}S_2 - \underset{(0.016)}{0.034^{**}}S_3$$

$R^2 = 0.801^{***}$
$K = 1.1393$

$$\log Q_{DM_t} = 5.743 + \underset{(0.108)}{0.278^{**}}\log P^r_{B_t} - \underset{(0.102)}{0.549^{***}}\mathrm{Log}\, P^r_{M_t} - \underset{(0.201)}{0.823^{***}}\log P^r_{P_t} + \underset{(0.144)}{0.162}\log Y_t - \underset{(0.023)}{0.026}S_1 - \underset{(0.023)}{0.036}S_2 - \underset{(0.023)}{0.033}S_3$$

$R^2 = 0.634^{***}$
$K = 1.7843$

$$\log P^r_{P_t} = 2.651 + \underset{(0.077)}{0.103}\log P^r_{B_t} - \underset{(0.063)}{0.083}\log P^r_{M_t} - \underset{(0.032)}{0.149^{***}}\log Q_{DP_t} + \underset{(0.086)}{0.192^{**}}\log Y_t - \underset{(0.014)}{0.023}S_1 - \underset{(0.014)}{0.016}S_2 + \underset{(0.018)}{0.067^{***}}S_3$$

$R^2 = 0.404^{***}$
$K = 0.8834$

$$\log {}^{w}P_{B_t} = 0.961 + \underset{(0.084)}{0.585^{***}}\log {}^{E}P_{B_t} + \underset{(0.046)}{0.130^{***}}\log A_{B_t} - \underset{(0.027)}{0.003}\log A_{M_t} + \underset{(0.041)}{0.095^{*}}\log Q_{SP_t}$$

$R^2 = 0.603^{***}$
$K = 0.7943$

$$\log {}^{w}P_{M_t} = 0.150 + \underset{(0.151)}{0.608^{***}}\log {}^{E}P_{M_t} + \underset{(0.083)}{0.172^{**}}\log A_{B_t} + \underset{(0.049)}{0.074}\log A_{M_t} - \underset{(0.074)}{0.212^{***}}\log Q_{SP_t}$$

$R^2 = 0.429^{***}$
$K = 0.5564$

$$M_{B_t} = -23.807 + \underset{(0.050)}{0.290^{***}}I_t - \underset{(0.074)}{0.061}\,{}^{w}P_{B_t} - \underset{(0.354)}{0.494}Z_1 - \underset{(0.135)}{0.407^{***}}\Delta {}^{w}P_{B_t} - \underset{(0.111)}{0.119}\Delta {}^{w}P_{M_t} + \underset{(0.078)}{0.147^{*}}\Delta {}^{w}P_{P_t}$$

$R^2 = 0.547^{***}$
$K = 0.4767$

$$M_{M_t} = 8.057 + \underset{(0.042)}{0.029}I_t - \underset{(0.042)}{0.475^{***}}\,{}^{w}P_{M_t} - \underset{(0.285)}{0.960^{***}}Z_1 + \underset{(0.101)}{0.107}\Delta {}^{w}P_{B_t} - \underset{(0.092)}{0.515^{***}}\Delta {}^{w}P_{M_t} + \underset{(0.064)}{0.137^{***}}\Delta {}^{w}P_{P_t}$$

$R^2 = 0.834^{***}$
$K = 0.6994$

$$M_{P_t} = 1.064 + \underset{(0.056)}{0.187^{***}}I_t - \underset{(0.061)}{0.581^{***}}\,{}^{w}P_{P_t} + \underset{(0.380)}{0.100}Z_1 + \underset{(0.141)}{0.026}\Delta {}^{w}P_{B_t} + \underset{(0.089)}{0.043}\Delta {}^{w}P_{M_t} - \underset{(0.089)}{0.293^{***}}\Delta {}^{w}P_{P_t}$$

$R^2 = 0.789^{***}$
$K = 0.3298$

of the dynamic and static assumptions.[1]

The remaining two variants, the dynamic and static wholesale demand models, were estimated to give some measure of the market forces which influence the demand for lamb, and the importance of lamb in the market for meat in New Zealand. As was discussed earlier no retail price information was available for lamb.

Ideally the wholesale demand variants should have been completely respecified in terms of meat retailers demand expectations,[2] with the influence of export price remaining as specified in the retail models. However as these variants were simply to gain an indication of the lamb demand parameters the more simple approach was decided upon.

Table 8.28 contains the estimated equations of the dynamic wholesale model variant from which the structural parameters were derived. In general this model, when compared with the dynamic retail model, is less trustworthy statistically. In all equations the coefficient of determination was acceptable, though in the demand equations lower than in the dynamic retail variant. Autocorrelation problems were, however, much greater, of the seven equations in the model three equations are indicated as having significant autocorrelation present. In general the significance levels of the demand equation coefficients are greatly reduced. One equation (pork demand reduced form) has no coefficients significantly different from zero, and another (mutton demand) has only one.

Table 8.29 contains all the simple correlation coefficients between pairs of variables used in all the wholesale demand equations. Several very high correlations between 'independent' variables are shown as

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1. This comparison must be carried out with the statistical uncertainties of the dynamic model firmly in mind however.

2. An expectations model similar to that of: J.M. Chetwin, op. cit.: for example.

TABLE 8.28

ORDINARY LEAST-SQUARES ESTIMATES OF THE ESTIMATING EQUATIONS FOR THE DYNAMIC NEW ZEALAND WHOLESALE MEAT MODEL.

$$\log Q_{DB_t} = 1.902 - \underset{(0.053)}{\overset{**}{0.138}}\log {}^{w}P_{B_t} + \underset{(0.073)}{0.021}\log {}^{w}P_{L_t} + \underset{(0.077)}{0.052}\log {}^{w}P_{M_t} + \underset{(0.074)}{0.013}\log {}^{w}P_{P_t} + \underset{(0.087)}{0.110}\log Y_t + \underset{(0.015)}{\overset{***}{0.067}}S_1 + \underset{(0.021)}{0.020}S_2 - \underset{(0.022)}{\overset{***}{0.097}}S_3 + \underset{(0.119)}{\overset{***}{0.550}}\log Q_{DB_{t-1}}$$

$$R^2 = \overset{***}{0.829} \qquad K = 2.0251$$

$$\log Q_{DL_t} = -3.967 + \underset{(0.195)}{\overset{**}{0.411}}\log {}^{w}P_{B_t} - \underset{(0.292)}{\overset{***}{0.771}}\log {}^{w}P_{L_t} - \underset{(0.256)}{0.153}\log {}^{w}P_{M_t} - \underset{(0.279)}{0.376}\log {}^{w}P_{P_t} + \underset{(0.453)}{\overset{***}{1.699}}\log Y_t - \underset{(0.058)}{0.059}S_1 - \underset{(0.062)}{\overset{***}{0.232}}S_2 + \underset{(0.081)}{\overset{***}{0.334}}S_3 + \underset{(0.141)}{0.200}\log Q_{DL_{t-1}}$$

$$R^2 = \overset{***}{0.886} \qquad K = \overset{\circ\circ}{2.5835}$$

$$\log Q_{DM_t} = 2.758 + \underset{(0.081)}{0.002}\log {}^{w}P_{B_t} + \underset{(0.119)}{0.008}\log {}^{w}P_{L_t} - \underset{(0.120)}{0.187}\log {}^{w}P_{M_t} + \underset{(0.120)}{0.157}\log {}^{w}P_{P_t} + \underset{(0.151)}{0.031}\log Y_t - \underset{(0.026)}{0.023}S_1 - \underset{(0.029)}{0.023}S_2 - \underset{(0.028)}{0.030}S_3 + \underset{(0.148)}{\overset{**}{0.330}}\log Q_{DM_{t-1}}$$

$$R^2 = \overset{***}{0.591} \qquad K = 2.2424$$

$$\log {}^{w}P_{P_t} = 3.950 - \underset{(0.096)}{0.153}\log {}^{w}P_{B_t} - \underset{(0.144)}{0.133}\log {}^{w}P_{L_t} + \underset{(0.137)}{0.197}\log {}^{w}P_{M_t} - \underset{(0.082)}{0.126}\log Q_{DP_t} - \underset{(0.186)}{0.074}\log Y_t - \underset{(0.037)}{0.021}S_1 + \underset{(0.038)}{0.040}S_2 + \underset{(0.067)}{0.090}S_3 - \underset{(0.075)}{0.044}\log Q_{DP_{t-1}}$$

$$R^2 = \overset{***}{0.468} \qquad K = \overset{\circ\circ\circ}{0.6760}$$

$$\log {}^{w}P_{B_t} = 0.188 + \underset{(0.077)}{\overset{***}{0.218}}\log {}^{E}P_{B_t} + \underset{(0.034)}{\overset{**}{0.071}}\log A_{B_t} - \underset{(0.011)}{0.011}\log A_{L_t} + \underset{(0.026)}{\overset{***}{0.074}}\log A_{M_t} - \underset{(0.034)}{0.019}\log Q_{SP_t} + \underset{(0.093)}{\overset{***}{0.729}}\log {}^{w}P_{B_{t-1}}$$

$$R^2 = \overset{***}{0.837} \qquad K = \overset{\circ\circ\circ}{1.3307}$$

$$\log {}^{w}P_{L_t} = -0.033 + \underset{(0.085)}{\overset{***}{0.569}}\log {}^{E}P_{L_t} + \underset{(0.042)}{\overset{**}{0.085}}\log A_{B_t} - \underset{(0.014)}{\overset{**}{0.031}}\log A_{L_t} + \underset{(0.029)}{\overset{***}{0.132}}\log A_{M_t} - \underset{(0.040)}{0.057}\log Q_{SP_t} + \underset{(0.083)}{\overset{***}{0.445}}\log {}^{w}P_{L_{t-1}}$$

$$R^2 = \overset{***}{0.884} \qquad K = 1.9634$$

$$\log {}^{w}P_{M_t} = 0.351 + \underset{(0.076)}{\overset{***}{0.309}}\log {}^{E}P_{M_t} + \underset{(0.046)}{\overset{*}{0.082}}\log A_{B_t} - \underset{(0.016)}{0.015}\log A_{L_t} + \underset{(0.033)}{\overset{***}{0.121}}\log A_{M_t} - \underset{(0.044)}{\overset{***}{0.172}}\log Q_{SP_t} + \underset{(0.064)}{\overset{***}{0.693}}\log {}^{w}P_{M_{t-1}}$$

$$R^2 = \overset{***}{0.876} \qquad K = 1.6111$$

TABLE 8.29

CORRELATION COEFFICIENTS FOR ALL VARIABLES USED IN THE WHOLESALE DEMAND EQUATIONS OF THE NEW ZEALAND MEAT MODELS.

	log ${}^{w}P_{B_t}$	log ${}^{w}P_{L_t}$	log ${}^{w}P_{M_t}$	log ${}^{w}P_{P_t}$	log Y_t	S_1	S_2	S_3	log $Q_{DB_{t-1}}$	log $Q_{DL_{t-1}}$	log $Q_{DM_{t-1}}$	log $Q_{DP_{t-1}}$	log Q_{DP_t}
log ${}^{w}P_{B_t}$	1.000												
log ${}^{w}P_{L_t}$	-0.132	1.000											
log ${}^{w}P_{M_t}$	-0.206	0.879	1.000										
log ${}^{w}P_{P_t}$	-0.253	0.394	0.498	1.000									
log Y_t	0.138	-0.253	-0.161	-0.209	1.000								
S_1	-0.194	-0.149	-0.110	-0.182	0.023	1.000							
S_2	0.097	0.093	0.188	0.269	0.007	-0.333	1.000						
S_3	0.219	0.230	0.096	0.125	0.012	-0.333	-0.333	1.000					
log $Q_{DB_{t-1}}$	-0.132	0.510	0.602	0.351	0.040	0.261	0.366	0.368	1.000				
log $Q_{DL_{t-1}}$	0.239	-0.748	-0.668	-0.533	0.548	0.125	-0.013	-0.427	*	1.000			
log $Q_{DM_{t-1}}$	0.146	-0.584	-0.625	-0.386	0.364	0.181	0.077	-0.117	*	*	1.000		
log $Q_{DP_{t-1}}$	0.066	-0.435	0.455	*	0.282	-0.072	-0.195	-0.348	*	*	*	1.000	
log Q_{DP_t}	0.319	-0.183	0.340	*	0.257	-0.214	-0.365	0.671	*	*	*	0.253	1.000
log Q_{DB_t}	-0.470	0.272	0.450	0.213	0.051	0.371	0.372	-0.494	0.427	*	*	*	*
log Q_{DL_t}	0.379	-0.616	-0.640	-0.480	0.541	-0.026	-0.435	0.350	*	0.580	*	*	*
log Q_{DM_t}	0.154	-0.623	-0.697	-0.519	0.232	0.102	-0.116	-0.167	*	*	0.628	*	*
log ${}^{w}P_{P_t}$	-0.253	0.394	0.498	*	-0.201	-0.182	0.269	0.125	*	*	*	-0.498	-0.334

*This Combination of Variables was not used in the Models.

existing. Between wholesale price of lamb, and mutton for example, the correlation coefficient is 0.879. This strong relationship probably being due to the influence of their respective export prices. Inter-correlation problems could therefore be expected in equations using several of the variable combinations for which high correlation coefficients were calculated.

The specification of the wholesale price formation equations for beef and mutton in this model is identical to those for the dynamic retail model, apart from the inclusion of the relative supply ratio for lamb.[1] The inclusion of this variable did not add to these equations. Coefficients remained approximately the same size, the coefficient of determination was not noticeably improved, and the coefficient associated with the lamb availability ratio was not significant. In general therefore this model variant was less satisfactory than the dynamic retail variant; for this reason only the structural coefficients for the lamb equation will be presented. These equations will be discussed along with the static equations for lamb from the static wholesale price variant. Other equations of the static wholesale variant are listed in Appendix E.

The first equation in Table 8.30 is the structural equilibrium wholesale demand equation, giving the long-run elasticities. In Table 8.28 the corresponding short-run (quarterly) elasticities are shown in the lamb demand estimating equation. From that equation it can be seen that, like mutton demand in the dynamic retail model, the coefficient of the lagged dependent variable was not significantly different from zero. Thus the adjustment coefficient of 0.800 is not significantly different from 1.0, and hence it is unlikely that a significant

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1. Table 8.11 contains the simple correlation coefficients appropriate to these wholesale price formation equations.

TABLE 8.30

SELECTED STRUCTURAL EQUATIONS FROM THE DYNAMIC AND STATIC NEW ZEALAND WHOLESALE MEAT MODELS.

EQUILIBRIUM Demand for Lamb.

$$\log \overline{Q_{DL_t}} = -4.959 + 0.514 \log {}^{w}P_{B_t} - 0.964 \log {}^{w}P_{L_t} - 0.191 \log {}^{w}P_{M_t} - 0.470 \log {}^{w}P_{P_t} + 2.124 \log Y_t - 0.074 S_1 - 0.290 S_2 + 0.419 S_3$$

$$\log Q_{DL_t} - \log Q_{DL_{t-1}} = 0.800(\log \overline{Q_{DL_t}} - \log Q_{DL_{t-1}})$$

EQUILIBRIUM Wholesale Price Formation - Lamb.

$$\log \overline{{}^{w}P_{L_t}} = -0.059 + 1.025 \log {}^{E}P_{L_t} + 0.153 \log A_{B_t} - 0.055 \log A_{L_t} + 0.238 \log A_{M_t} - 0.103 \log Q_{SP_t}$$

$$\log {}^{w}P_{L_t} - \log {}^{w}P_{L_{t-1}} = 0.555(\log \overline{{}^{w}P_{L_t}} - \log {}^{w}P_{L_{t-1}})$$

STATIC Demand for Lamb.

$$\log Q_{DL_t} = -5.030 + \underset{(0.185)}{\overset{***}{0.507}} \log {}^{w}P_{B_t} - \underset{(0.272)}{\overset{***}{0.933}} \log {}^{w}P_{L_t} - \underset{(0.256)}{0.205} \log {}^{w}P_{M_t} - \underset{(0.271)}{\overset{*}{0.485}} \log {}^{w}P_{P_t} + \underset{(0.328)}{\overset{***}{2.149}} \log Y_t - \underset{(0.056)}{0.083} S_1 - \underset{(0.061)}{0.025} S_2 + \underset{(0.062)}{\overset{***}{0.259}} S_3$$

$R^2 = \overset{***}{0.881}$

$K = 2.0615$

STATIC Wholesale Price Formation - Lamb.

$$\log {}^{w}P_{L_t} = 0.387 + \underset{(0.081)}{\overset{***}{0.873}} \log {}^{E}P_{L_t} + \underset{(0.049)}{\overset{***}{0.173}} \log A_{B_t} - \underset{(0.016)}{\overset{***}{0.062}} \log A_{L_t} + \underset{(0.036)}{\overset{***}{0.135}} \log A_{M_t} - \underset{(0.048)}{\overset{***}{0.129}} \log Q_{SP_t}$$

$R^2 = \overset{***}{0.809}$

$K = 1.1830$

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difference will exist between the long- and short-run elasticities.

Several important features of lamb demand in New Zealand are revealed by the elasticities in Table 8.30. The estimated price elasticity of demand is close to 1.0, and the income elasticity is greater than 2.1. Strong seasonal effects are also shown, negative in winter and positive in the spring-summer period. The static demand equation in Table 8.30 gives similar parameter estimates too. A strong cross-elasticity of demand with beef wholesale price is also evident.

The size of the relationships was surprising, especially as smaller elasticities could be expected at the wholesale level of a market than at the retail level. This expectation was shown to be correct for all meats for which both wholesale and retail estimates were made. It would appear therefore that lamb demand is highly sensitive to changes in its own price and income, while being moderately sensitive to beef price changes. Caution in accepting the estimated values is however necessary due to the problems of intercorrelation previously discussed.

The wholesale price formation equations for lamb gave estimates similar to those for other meats. In both long- and short-run models the coefficient associated with the export price of lamb was quite large, above unity in the long-run model and just below in the static and short-run models. From these estimated coefficients it would appear that export price is the basic determinant of internal wholesale lamb prices. The availability ratios were all of expected sign and of low size except for the lamb availability ratio, the sign of which was negative and opposite to that expected. This could have been caused by intercorrelation problems with the mutton availability ratio, or it could be due to a seasonal supply-price problem. With lamb, when each new season's supply arrives on the market the wholesale price increases. This increase in wholesale price is because new seasons' lamb is the preferred commodity, and hence a quality premium is paid. Thus at a time when price is rising because of quality premium, the availability ratio falls due to the increase in supply. The effect of the quality premium could not be removed from the data and hence the lamb availability ratio coefficient could have been biased downward.

Discussion of the estimated wholesale variants of the New Zealand model has been brief. Appropriate analytical procedures for evaluating these variants were discussed fully as part of the analysis of the dynamic retail model, and hence did not require repeating. As these model variants were either statistically less trustworthy or did not in general add further to the results already outlined, no detailed conclusions have been made. Only those aspects of particular interest have been dealt with in depth; with the remainder the basic results have been included to enable a full evaluation. The static wholesale variant has not been discussed at all, being confined to Appendix E. These equations were clearly unsatisfactory statistically. Most equations having highly autocorrelated residuals.

In general the OLS estimates of the New Zealand meat model variants were of unsatisfactory quality, with the dynamic retail model being clearly the best and on the whole satisfactory. While some doubt must remain about the estimated coefficients because of possible bias due to the estimation technique, the size and sign of the estimates are generally not unacceptable. The problem of bias caused by the estimation technique will be discussed further, following an evaluation of the 'ham and bacon' models estimated by ordinary least-squares.

The Estimated 'Ham and Bacon' Models

Two 'ham and bacon' models were estimated by OLS, as described in

Chapter 5.[1] These models were; a dynamic, and a static, retail demand model. In neither case was the model at all satisfactory, suggesting that if the required data were available respecification of the 'ham and bacon' models would be desirable.

Table 8.31 details the simple correlation coefficients for the variables included in the 'ham and bacon' demand equations. The format of this table is as for the other correlation matrices presented in this chapter. Among the independent variables of the demand estimating equation there is little suggestion of direct intercorrelation problems. The most noticeable features of the table are the correlations between the dependent and independent variables. The low correlation coefficient between price and quantity variables for 'ham and bacon' suggests that there is but a slight demand relationship.

In Table 8.32 the simple correlation coefficients are given for the variables included in the wholesale-to-retail margin equation of the 'ham and bacon' models. The table indicates that strong intercorrelation problems are present in the data; of the six correlation coefficients between the 'independent' variables, three are above 0.55. Neither of the correlation matrices suggested, therefore, that good results would be achieved.

The estimated dynamic 'ham and bacon' model estimating equations are shown in Table 8.33, from which it can readily be seen that the reduced form demand equation is entirely unsatisfactory. As could have been expected from the correlation matrix, income is the only variable which had a coefficient significantly different from zero. All the other coefficients of this equation had standard errors nearly as large, or larger, than the coefficient itself. Of the overall equation statistics, the coefficient of determination was significantly different from zero

1. Chapter 5, p. 133.

TABLE 8.31

CORRELATION COEFFICIENTS FOR ALL VARIABLES USED IN THE DEMAND EQUATIONS OF THE NEW ZEALAND 'HAM AND BACON' MODELS.

	$\log Q_{DH_t}$	$\log Y_t$	S_1	S_2	S_3	$\log Q_{DH_{t-1}}$	Z_2
$\log Q_{DH_t}$	1.000						
$\log Y_t$	0.193	1.000					
S_1	0.052	0.023	1.000				
S_2	0.344	0.007	-0.333	1.000			
S_3	-0.256	0.012	-0.333	-0.333	1.000		
$\log Q_{DH_{t-1}}$	0.244	0.360	0.547	0.057	-0.334	1.000	
Z_2	-0.078	0.327	0.115	0.115	-0.115	*	1.000
$\log P^r_{H_t}$	0.092	0.701	0.005	-0.078	0.035	0.202	0.246

* This Combination of Variables was not used in the models.

TABLE 8.32

CORRELATION COEFFICIENTS FOR ALL VARIABLES USED IN THE MARGIN EQUATIONS OF THE NEW ZEALAND 'HAM AND BACON' MODELS.

	I_t	${}^wP_{H_t}$	$\Delta {}^wP_{H_t}$	$M_{H_{t-1}}$
I_t	1.000			
${}^wP_{H_t}$	0.644	1.000		
$\Delta {}^wP_{H_t}$	0.313	0.296	1.000	
$M_{H_{t-1}}$	0.579	0.576	0.015	1.000
M_{H_t}	0.683	0.626	0.171	0.915

TABLE 8.33

ORDINARY LEAST-SQUARES ESTIMATES OF THE DYNAMIC 'HAM AND BACON' DEMAND MODEL ESTIMATING EQUATIONS.

$$\log P^{r}_{H_t} = 1.547 - \underset{(0.037)}{0.040}\log Q_{DH_t} - \underset{(0.094)}{0.591^{***}}\log Y_t - \underset{(0.022)}{0.016}S_1 - \underset{(0.021)}{0.027}S_2 - \underset{(0.018)}{0.016}S_3 + \underset{(0.039)}{0.005}\log Q_{DH_{t-1}}$$

$R^2 = 0.514^{***}$

$K = 0.3090$

$$M_{H_t} = -7.074 + \underset{(0.051)}{0.120^{**}}I_t + \underset{(0.053)}{0.030}\,{}^{w}P_{H_t} + \underset{(0.057)}{0.098^{*}}\Delta^{w}P_{H_t} + \underset{(0.066)}{0.781^{***}}M_{H_{t-1}}$$

$R^2 = 0.882^{***}$

$K = 2.1959$

TABLE 8.34

ORDINARY LEAST-SQUARES ESTIMATES OF THE STATIC 'HAM AND BACON' DEMAND MODEL.

$$\log P^{r}_{H_t} = 1.584 - \underset{(0.034)}{0.037}\log Q_{DH_t} + \underset{(0.093)}{0.589^{***}}\log Y_t - \underset{(0.017)}{0.014}S_1 - \underset{(0.019)}{0.026}S_2 - \underset{(0.018)}{0.015}S_3 + \underset{(0.031)}{0.006}Z_2$$

$R^2 = 0.514^{***}$

$K = 0.3025$

$$M_{H_t} = -19.950 + \underset{(0.094)}{0.355^{***}}I_t + \underset{(0.097)}{0.247^{**}}\,{}^{w}P_{H_t} - \underset{(0.108)}{0.084}\Delta^{w}P_{H_t}$$

$R^2 = 0.532^{***}$

$K = 0.2588$

TABLE 8.35

ESTIMATED 'HAM AND BACON' DEMAND ELASTICITIES AND COEFFICIENTS.

	$P^{r}_{H_t}$	Y_t	S_1	S_2	S_3	Z_2
Long run	-25.000	14.774	-4.000	-6.750	-4.000	
Short run	-28.571	16.885	-4.571	-7.714	-4.571	
Static model	-27.027	15.919	-3.784	-7.027	-4.054	1.613

but for policy purposes a barely acceptable level of variance has been explained, and the von Neumann ratio indicates strongly the presence of positive autocorrelation.

The margin equation was considerably better as regards statistical acceptability. No evidence of autocorrelation of residuals was present, and there was a satisfactory coefficient of determination. In addition three of the four equation coefficients were significantly different from zero at the ten per cent level or better. The long-run structural coefficients from this equation were;

$$\overline{M_{H_t}} = 35.178 + 0.548\ I_t + 0.137\ {}^{w}P_{H_t}$$

$$(M_{H_t} - M_{H_{t-1}}) = 0.219\ (\overline{M_{H_t}} - M_{H_{t-1}}) + 0.098\ \Delta\, {}^{w}P_{H_t}$$

which compares quite well with the dynamic retail model margin equation coefficients. Of the long-run coefficients, probably only the wholesale price coefficient is not significant. Because of the intercorrelation problems discussed earlier, however, some doubt as to the accuracy of the above estimate must exist.

The estimated static 'ham and bacon' demand model is shown in Table 8.34. Comparison with the dynamic model estimated shows, for the demand equation, little difference either in statistical properties on the size of the coefficients. In this equation a shift variable for the 1965 trichinosis outbreak was included. It seems to have performed almost an identical function in the estimating equation as the lagged value of quantity demanded did in the dynamic model.

The static margin equation is, like the demand equations, not acceptable. The coefficient of determination is barely acceptable although significantly different from zero, and the von Neumann ratio indicates strong positive autocorrelation. This, added to the presence of intercorrelation, makes the equation untrustworthy.

From the above discussion, and the estimated 'ham and bacon' deman parameters shown in Table 8.25, it will be evident that the model has no been satisfactory. Major re-specification of this model would therefor be desirable.

The direction of any re-specification in the 'ham and bacon' is deserving of comment. Unlike other meats consumed in New Zealand, both ham and bacon can be stored for periods of greatest demand, without the ultimate sale price declining.[1] With both these meats stock-piling of supplies for seasons of greatest sales is a major feature of its marketing. Stock demand equations for each season would thus be an important addition to this model, as well as an aggregate supply function. Unfortunately, as was discussed in Chapter 5, this was not possible because of data limitations. Another important advance would be to separate bacon demand from ham demand, again data limitations preclude this.

Although the models estimated for 'ham and bacon' demand have shortcomings in both an economic and statistical sense, some general conclusions as to the size of demand parameters can be made. Overall, the demand for 'ham and bacon' appears unresponsive to price. Although the price elasticities of demand estimated were very large (Table 8.35) they were probably not significantly different from zero. Demand is, however, likely to be sensitive to income changes. As to the measures of the income elasticities achieved, it is probable that they are untrustworthy.

1. Chapter 5, pp. 124-127.

The Two-stage Least-squares Estimates of the New Zealand Meat Demand Model

In Chapter 6 several alternative procedures applicable to the estimation of the New Zealand model parameters were discussed. At the conclusion of that chapter it was indicated that both OLS and two-stage least-squares (2SLS) estimates of parameters would be made, and depending upon the 2SLS estimated error covariance values, three-stage least-squares estimates might be made. Previous sections of this chapter have been concerned with the OLS parameter estimates, and a discussion of their statistical and economic properties. This section will be concerned with the 2SLS parameter estimations, and the differences between the 2SLS and OLS estimates. There were, however, difficulties encountered in obtaining 2SLS estimates for all the model parameters. These difficulties, which were largely unresolved, will form a large part of the discussion, along with modifications which could be made to counter them.

An estimate of model coefficients for two variants of the New Zealand meat model was attempted using the 2SLS method. In both variants the independent variables' variance-covariance matrix for each of the demand equations could not be inverted.[1] Subsequent investigation showed that these matrices tended to singularity.[2] The implication of this singularity is that intercorrelation problems were present. A linear combination of some independent variables was explaining (or nearly explaining) one other independent variable. The two variants for which 2SLS solution was estimated were the dynamic retail demand model

1. Other equation matrices (the wholesale price formation and the wholesale-to-retail margin equations) did not suffer from this problem which occurred when the individual equation variance-covariance matrices were being inverted (i.e. the second stage of the estimation procedure).

2. The characteristic roots and vectors of these matrices were calculated.

and the dynamic wholesale demand model.

An analysis of this problem, and its implications for the New Zealand model, will be made later in this section. Prior to that discussion, those equations of the dynamic retail model which were able to be estimated by 2SLS will be described, and some results from the wholesale model will also be presented. The dynamic retail model equations for which 2SLS estimates of their coefficients were obtained are the wholesale price formation equations and the wholesale-to-retail margin equations. Table 8.36 contains the estimating equations for the beef and mutton wholesale price and margin equations.

The equations detailed in Table 8.36 are directly comparable with the equivalent OLS estimates in Table 8.10. Coefficients of determination, von Neumann ratios, and standard errors for the 2SLS solutions were not computed because the complete model was not estimated. Without the complete model little advantage would be gained by estimating these statistics. Moreover, Witherell holds that standard t-, F-, and autocorrelation tests are likely to under-estimate the significance of 2SLS parameter estimates.[1]

A comparison of Table 8.36 with Table 8.10 shows that the 2SLS parameter estimates do not vary markedly from the OLS estimates. The sign of each coefficient is the same in both tables (apart from the constant for the mutton margin equation), and in general the values of the alternative estimates are similar. In the wholesale price formation equations the coefficient values were very close, differences mostly being in the second or third place of decimals, with two estimates being identical. The differences were however larger in the margin equations, but again smaller than could have been expected. As a full discussion

1. W.H. Witherell, Dynamics of the International Wool Market: An Econometric Analysis, Unpublished draft Dissertation, Princeton, 1967.

TABLE 8.36

TWO-STAGE LEAST-SQUARES ESTIMATES OF SELECTED ESTIMATING EQUATIONS FOR THE DYNAMIC RETAIL MEAT DEMAND MODEL.

$$\log {}^{w}P_{B_t} = 0.257 + 0.211\log {}^{E}P_{B_t} + 0.097\log A_{B_t} + 0.048\log A_{M_t} - 0.0006\log Q_{SP_t} + 0.714\log {}^{w}P_{B_{t-1}}$$

$$\log {}^{w}P_{M_t} = 0.265 + 0.308\log {}^{E}P_{M_t} + 0.056\log A_{B_T} + 0.109\log A_{M_t} - 0.148\log Q_{SP_t} + 0.722\log {}^{w}P_{M_{t-1}}$$

$$M_{B_t} = -3.875 + 0.042I_t + 0.016\,{}^{w}P_{B_t} - 0.254Z_1 - 0.461\Delta^{w}P_{B_t} - 0.031\Delta^{w}P_{M_t} - 0.134\Delta^{w}P_{P_t} + 0.885M_{B_{t-1}}$$

$$M_{M_t} = 0.015 + 0.052I_t - 0.230\,{}^{w}P_{M_t} - 0.545Z_1 + 0.271\Delta^{w}P_{B_t} - 0.771\Delta^{w}P_{M_t} + 0.029\Delta^{w}P_{P_t} + 0.532M_{M_{t-1}}$$

TABLE 8.37

TWO-STAGE LEAST-SQUARES ESTIMATES OF SELECTED STRUCTURAL EQUATIONS FOR THE DYNAMIC RETAIL MEAT DEMAND MODEL.

$$\log \overline{{}^{w}P_{B_t}} = 0.899 + 0.733\log {}^{E}P_{B_t} + 0.339\log A_{B_t} + 0.167\log A_{M_t} - 0.002\log Q_{SP_t}$$

$$\log {}^{w}P_{B_t} - \log {}^{w}P_{B_{t-1}} = 0.286(\log \overline{{}^{w}P_{B_t}} - \log {}^{w}P_{B_{t-1}})$$

$$\log \overline{{}^{w}P_{M_t}} = 0.953 + 1.108\log {}^{E}P_{B_t} + 0.201\log A_{B_t} + 0.392\log A_{M_t} - 0.532\log Q_{SP_t}$$

$$\log {}^{w}P_{M_t} - \log {}^{w}P_{M_{t-1}} = 0.278(\log \overline{{}^{w}P_{M_t}} - \log {}^{w}P_{M_{t-1}})$$

$$\overline{M_{B_t}} = -33.696 + 0.365I_t + 0.139\,{}^{w}P_{B_t} - 2.209Z_1$$

$$M_{B_t} - M_{B_{t-1}} = 0.115(\overline{M_{B_t}} - M_{B_{t-1}}) - 0.461\Delta^{w}P_{B_t} - 0.031\Delta^{w}P_{M_t} - 0.134\Delta^{w}P_{P_t}$$

$$\overline{M_{M_t}} = 0.032 + 0.111I_t - 0.491\,{}^{w}P_{M_t} - 1.165Z_1$$

$$M_{M_t} - M_{M_{t-1}} = 0.468(\overline{M_{M_t}} - M_{M_{t-1}}) + 0.271\Delta^{w}P_{B_t} - 0.771\Delta^{w}P_{M_t} + 0.029\Delta^{w}P_{P_t}$$

of the OLS estimates has already been made, no repeat analysis of the interpretation to be placed on the results will be included here.

Table 8.37 lists the structural equations derived from the estimating equations of Table 8.36. The equations in Table 8.37 are comparable with the OLS estimates in Table 8.14. As could be expected from the previous comparison, the differences between the coefficients is not great. There also appear to be no systematic differences between coefficient estimates, suggesting that if the OLS results are biased, no systematic bias exists. The most important conclusion which can be made from this comparison is that any bias in the OLS estimates for this model over the 2SLS estimates is not very great, allowing greater confidence to be placed in the OLS structural estimates.

In using the 2SLS method of estimation in place of OLS, the random error is being re-distributed according to the structural relations implicit in the economic model. Depending upon the model therefore, that re-distribution can be large or small, affecting the estimated coefficients accordingly. If it can be assumed that the equations of the dynamic retail model estimated by 2SLS were unaffected by the problems which prevented the estimation of the demand equations, then the small change in the coefficient values estimated suggests that the re-distribution of the error by the 2SLS method was indeed small. Hence the OLS estimates can, in this model, be considered as relatively unbiased by the estimation procedure used. It will be later argued as part of the discussion on the problems encountered with the 2SLS procedure, that the four equations above can be assumed free of the complications which arose with the demand equations estimated by the 2SLS method.

Several more tables of results from the 2SLS estimate of the dynamic retail variant are shown below. These tables make the comparisons between the coefficients estimated by the two methods simpler. Table 8.38

should be compared with Table 8.20, Table 8.39 with 8.21, and Tables 8.40, 8.41, and 8.42 with Tables 8.23, 8.24, and 8.25 respectively.

Initially, in an endeavour to overcome the problem of a singular matrix in the demand equations, the second stage demand equation matrices were inverted with each variable in turn excluded. Each combination of pairs of variables was also deleted. In no case did this result in the matrix becoming non-singular, this suggested that the problem lay more in the 2SLS method of estimating the systematic component of each endogenous variable, than in the individual equation specification resulting in singularity by chance. The cause of the singularity was therefore sought from the basic relationships expressed by the model, and in the 2SLS estimation method. This is discussed further in a later section of this chapter.

As was outlined previously the singular matrix problem also occurred with the 2SLS estimate of the dynamic wholesale variant of the basic model. The same ad hoc procedure of deleting variables for the final 2SLS estimation was again used, and for the lamb demand equation was successful. The deleted variable here being wholesale price of pork. This result will be given, along with the lamb equilibrium wholesale price formation equation. While the wholesale price formation equations for the other meats were also estimated, the coefficients were little different to those estimated for the retail model, and will not therefore be given.[1]

A comparison of the estimating equations in Table 8.43 with the OLS equivalents in Table 8.28 enables similar conclusions to those drawn to those made in the comparison of 2SLS and OLS estimates of the dynamic

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1. As was explained in the OLS estimates, the wholesale price formation equations for beef and mutton were the same in both wholesale and retail model variants, apart from the inclusion of the availability ratio for lamb.

TABLE 8.38

DYNAMIC RETAIL DEMAND MODEL LONG-RUN WHOLESALE PRICE FORMATION ELASTICITIES (TWO-STAGE LEAST-SQUARES ESTIMATES).

Wholesale Price of:-	$E_{P_{B_t}}$	$E_{P_{M_t}}$	A_{B_t}	A_{M_t}	Q_{SP_t}
Beef	0.733	-	0.339	0.167	-0.002
Mutton	-	1.108	0.201	0.392	-0.532

TABLE 8.39

DYNAMIC RETAIL DEMAND MODEL SHORT-RUN WHOLESALE PRICE FORMATION ELASTICITIES (TWO-STAGE LEAST-SQUARES ESTIMATES).

Wholesale Price of:-	$E_{P_{B_t}}$	$E_{P_{M_t}}$	A_{B_t}	A_{M_t}	Q_{SP_t}
Beef	0.211	-	0.097	0.048	-0.006
Mutton	-	0.308	0.056	0.109	-0.148

TABLE 8.40

DYNAMIC RETAIL DEMAND MODEL LONG-RUN WHOLESALE-TO-RETAIL MARGIN COEFFICIENTS (TWO-STAGE LEAST-SQUARES ESTIMATES).

Wholesale-to-Retail Margin for:-	I_t	${}^wP_{B_t}$	${}^wP_{M_t}$	Z_1
Beef	0.365	0.139	-	-2.209
Mutton	0.111	-	-0.491	-1.165

TABLE 8.41

DYNAMIC RETAIL DEMAND MODEL SHORT-RUN WHOLESALE-TO-RETAIL MARGIN COEFFICIENTS (TWO-STAGE LEAST-SQUARES ESTIMATES).

Wholesale-to-Retail Margin for:-	I_t	${}^wP_{B_t}$	${}^wP_{M_t}$	Z_1
Beef	0.042	0.016	-	-0.254
Mutton	0.052	-	-0.230	-0.545

TABLE 8.42

DYNAMIC RETAIL DEMAND MODEL WHOLESALE-TO-RETAIL MARGIN MARGIN ADJUSTMENT COEFFICIENTS (TWO-STAGE LEAST-SQUARES ESTIMATES).

Change in the Margin for:-	Nerlove Adjustment Coefficient ($M_t - M_{t-1}$)	$\Delta{}^wP_{B_t}$	$\Delta{}^wP_{M_t}$	$\Delta{}^wP_{P_t}$
Beef	0.115	-0.461	-0.031	-0.134
Mutton	0.468	0.271	-0.771	0.029

TABLE 8.43

TWO-STAGE LEAST-SQUARES ESTIMATES OF LAMB DEMAND AND WHOLESALE PRICE FORMATION EQUATIONS - DYNAMIC WHOLESALE DEMAND MODEL.

Estimating Equations.

$$\log Q_{DL_t} = -4.756 + 0.444\log {}^{W}P_{B_t} - 1.514\log {}^{W}P_{L_t} + 0.022\log {}^{W}P_{M_t} + 2.026\log Y_t - 0.085S_1 - 0.268S_2 + 0.288S_3 + 0.002\log Q_{DL_{t-1}}$$

$$\log {}^{W}P_{L_t} = -0.053 + 0.561\log {}^{E}P_{L_t} + 0.081\log A_{B_t} - 0.028\log A_{L_t} + 0.136\log A_{M_t} - 0.052\log Q_{SP_t} + 0.462\log {}^{W}P_{L_{t-1}}$$

Structural Equations.

$$\log \overline{Q_{DL_t}} = -4.766 + 0.445\log {}^{W}P_{B_t} - 1.517\log {}^{W}P_{L_t} + 0.022\log {}^{W}P_{M_t} + 2.030\log Y_t - 0.085S_1 - 0.269S_2 + 0.2895S_3$$

$$\log Q_{DL_t} - \log Q_{DL_{t-1}} = 0.998(\log \overline{Q_{DL_t}} - \log Q_{DL_{t-1}})$$

$$\log \overline{{}^{W}P_{L_t}} = -0.099 + 1.043\log {}^{E}P_{L_t} + 0.151\log A_{B_t} - 0.052\log A_{L_t} + 0.253\log A_{M_t} - 0.097\log Q_{SP_t}$$

$$\log {}^{W}P_{L_t} - \log {}^{W}P_{L_{t-1}} = 0.538(\mathrm{Log}\ \overline{{}^{W}P_{L_t}} - \log {}^{W}P_{L_{t-1}})$$

retail variant. The demand equation coefficients have changed relatively more than the wholesale price formation coefficients which are little different to the OLS estimates. The 2SLS estimates of the demand coefficients do however have marked differences. The signs are all as expected a priori in the 2SLS equation (unlike the OLS estimates), with some change in coefficient value noticeable.

The above remarks can be repeated for the structural estimates shown in Table 8.43, compared with the OLS structural estimates in Table 8.30. In the demand equation the price-elasticity of demand for lamb has been markedly increased, the seasonal effects and cross-elasticity with beef price reduced, with the high income-elasticity little changed. The adjustment elasticity of 0.998 will almost certainly not be significantly different from 1.0, thus short- and long-run estimates coincide for lamb demand. The wholesale price formation equation, as previously noted, has little change over the values estimated by OLS.

Within the limits with which confidence can be placed on the 2SLS estimates which were obtained, it would appear therefore that for all equations apart from the demand equations, the OLS estimates are not greatly biased in either the wholesale or retail dynamic variants of the New Zealand meat model. Regarding the demand equations little can be said as, apart from the lamb wholesale demand equation, no 2SLS estimates are available. However, having regard to the causal chain expressed within the model, a greater degree of difference between the OLS and 2SLS estimates could be expected in the demand equations. The lamb demand equation which was estimated (albeit with the pork price coefficient restricted to zero) tends to confirm this.

Singular Matrix Problems with Two-stage Least-Squares Parameter Estimation

As was outlined previously singular matrices in some of the equations prevented their estimation by 2SLS. There were several possible causes of this singularity, and to aid the discussion of the causes the basic 2SLS system will be briefly outlined.

Consider the general linear model discussed in Chapter 6.[1] By normalising for the first jointly dependent variable, the general form of the first equation may be stated in matrix notation as;

$$y_1 = -Y_2A_2 - XB + U_1$$

where y_1 = a(T x 1) matrix of observations on the first jointly dependent variable

Y_2 = a $[T \times (m-1)]$ matrix of observations on the (m-1) predetermined variables included on the right hand side

A_2 = an $[(m-1) \times 1]$ matrix of coefficients

X = a (T x r) matrix of observations on the predetermined and exogenous variables included in the equation

B = an (r x 1) matrix of coefficients

and U_1 = a (T x 1) matrix of random disturbances with T, m, and r as defined in Chapter 6.

In general it can be expected that U_1 will be correlated with Y_2, the jointly dependent variables. Two-stage least-squares to remove this correlation, replaces Y_2 with an equal size matrix $\hat{Y}_2 = (Y_2 - V)$. The estimated matrix $\hat{Y}_2$ is a set of instruments estimated in such a manner as to remove correlation with U_1. The method of estimating $\hat{Y}_2$ is by OLS regressions of the variables in Y_2 on all the predetermined variables in the model, and then using the systematic 'component' of

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1. Chapter 6, pp. 137-140.

each variable to act as an instrument in $\hat{Y}_2$. Ordinary least-squares regression is then carried out on the relation:

$$y_1 = -\hat{Y}_2 A_2 \quad XB + (U_1 - VA_2)$$

when V = the disturbance matrix estimated by the first stage regression with dimensions $\left[T \times (m-1)\right]$.

The 2SLS estimation procedure is thus one case of the instrumental variable approach to simultaneous relations, with the instrumental variables (i.e. all the predetermined and exogenous variables in the model) rather arbitrarily chosen.

Although arbitrarily chosen these variables do have some optimal properties. They are by assumption uncorrelated with the disturbances, and have close causal connections with the dependent variables. It often happens in 2SLS, however, that the problem of singularity occurs in the individual equation variance-covariance matrices at the second stage.[1] This must be due to the method of selecting the instrumental variables used in the determination of the instruments to replace the jointly dependent variables on the right hand side of each equation.

The above singularity can also arise from few or zero degrees of freedom in the model observation matrix. This occurs when the number of explanatory variables tends to, or is greater than, the number of observations. In the above notation that is when:

$$(M - 1) + R \geqslant T$$

This was not the case in the New Zealand model, where $T = 52$ and $(M - 1) + R = 31$. It is to this problem though that most of the

1. F. Jackson, Victoria University, Wellington, personal communication.

recent literature has been devoted.[1]

Both Kloek and Mennes, and Fisher have suggested alternative procedures to overcome the singularity problem due to lack of degrees of freedom. Broadly these alternatives are concerned with either the use to which the predetermined instrumental variables were being put, or in providing an alternative method for choosing which predetermined variables should be used as instrumental variables. As the instrumental variables used to calculate the adjusted observation matrix are of critical importance, a 2SLS procedure adjusted by a less arbitrary selection of the instrumental variables could be successful with a model which possessed the problems shown by the New Zealand meat market model.

Fisher's method for selecting which predetermined variables should be used as instrumental for each endogenous variable to be replaced,[2] could provide the selection procedure required. As Fisher notes, the use of instrumental variables common to all 'explanatory' endogenous variables can give rise to multicollinearity problems in the final equation observation matrix.[3] It would seem likely that this has in fact occurred with the demand equations of the New Zealand model.

This approach would appear the most useful in solving the problem of obtaining a 2SLS solution to the New Zealand meat model. By using Fisher's method of selecting instrumental variables on the basis of their importance as implied by the complete model, in determining the 'explanatory' endogenous variables, a satisfactory causal chain can be

1. For example: T. Kloek and L.B.M. Mennes, "Simultaneous Equation Estimation Based Upon Principal Components of Predetermined Variables", Econometrica, Vol. 28, 1960, pp. 45-61.
and
F.M. Fisher, "Dynamic Structure and Estimation in Economy-wide Econometric Models", The Brookings Quarterly Econometric Model of the United States, edited J.S. Dusenberry et al., Rand McNally and Co., Chicago, 1965, pp. 589-630.

2. F.M. Fisher, ibid, pp. 625-633.

3. F.M. Fisher, ibid, pp. 622.

built up while at the same time multicollinearity problems would be reduced.

There were other possible causes of the singular matrix problems with the New Zealand model. The most important of these was the limitation the computational facilities places upon the mathematical manipulation. The computer used for these estimations was an I.B.M. 1620 with added storage capacity, a relatively small machine to handle matrices as large as this model required. This capacity limitation meant that to stay within the machine's storage limits, the estimation procedure had to be carried out in several steps, with rounding of arithmetic values occurring at each step. While the rounding was limited as far as possible, the rounding necessary in association with some degree of multicollinearity, could have resulted in the singular matrices.

The method outlined above for achieving a 2SLS solution have as yet not been applied to these models. This was partly due to the lack of available computer routines for a period of late 1967- early 1968, during which new computer facilities were being installed. It is, however, hoped to solve this problem of estimation methodology as part of further research into the New Zealand market for meat.

On the basis of the above discussion it will now be evident that the equations which were estimated by 2SLS are valid, despite the fact that neither model was capable of complete estimation by 2SLS. Undoubtedly a modified 2SLS procedure such as that envisaged would alter the values of some estimated coefficients, it is held though that the estimates obtained are as valid as the 2SLS estimation method and its implied choice of instrumental variables.

The only way in which these estimates could be invalidated rests upon the logic of the model. If the estimated equations depended largely upon the equations for which coefficients could not be estimated serious doubt about their reliability would result. For the equations of the dynamic retail variant which were estimated, the direction of causation in the model is clearly from the estimated equations to the demand equations which could not be estimated. The only market force in the opposite direction is the demand influences in the availability ratios. Greater confidence can therefore be placed in these estimates.

One other equation of the dynamic retail variant requires discussion. This equation is the pork wholesale-to-retail margin equation. With pork the direction of causation, unlike the other meats, is from the retail level to the wholesale level. The pork margin equation is thus largely dependent upon the equation which could not be estimated by 2SLS. It is of interest that the coefficients derived for the pork margin equation by the 2SLS procedure were probably untrustworthy, suggesting that the relationships within the model were of great importance. The pork margin equation estimated by 2SLS was:

$$\begin{aligned} M_{P_t} = \; & 112.703 + 1.081\, I_t - 7.500\, {}^{W}P_{P_t} + 4.210\, Z_1 + \\ & 2.710 \Delta^{W}P_{B_t} + 0.595 \Delta^{W}P_{M_t} + 2.482 \Delta^{W}P_{P_t} - 6.431\, M_{P_{t-1}} \end{aligned}$$

The adjustment coefficient (α_c) estimated was therefore 7.431, which is analogous to the situation of an exploding cobweb cycle. Put in terms of the structural equation, the result was:

$$\overline{M_{P_t}} = 15.167 + 0.145\, I_t - 1.009\, {}^{W}P_{P_t} + 0.567\, Z_1$$

$$\begin{aligned} M_{P_t} - M_{P_{t-1}} = \; & 7.431 \left(\overline{M_{P_t}} - M_{P_{t-1}}\right) + 2.710 \Delta^{W}P_{B_t} + 0.595 \Delta^{W}P_{M_t} + \\ & 2.482 \Delta^{W}P_{P_t}. \end{aligned}$$

The above structural coefficients are all of larger magnitude than the OLS estimates, while the adjustment coefficient is some twenty-three times larger than its OLS counterpart. Some coefficients are also of changed sign, the coefficient attached to the $\Delta^{w}P_{P_t}$ variable in the adjustment equation now being opposite to that expected. For these reasons this equation is not to be trusted.

Summary and Discussion of the Model Estimates

There have been several variants of the New Zealand meat model estimated by two methods presented as part of these results, as well as the naive demand functions and the estimated 'ham and bacon' model. Some drawing together of the results is therefore necessary. This will now be done along with some general comments on these models.

Of the meat model variants estimated by OLS, the dynamic retail model is clearly the best. This model had fewer statistical deficiencies than any other, as well as being the most acceptable on economic grounds. It is therefore suggested that if a complete model of the New Zealand meat market is desired for policy purposes this variant would be the most suitable. For isolated economic parameters, however, where 2SLS estimates were achieved it is suggested that these be used.

A wholesale model must be used if lamb demand parameters are required. It is thought likely that in view of the non-significance of pork price in the OLS estimate of the lamb demand equation, the 2SLS estimate of both the demand function and the wholesale price formation equation would be the better estimate.

Unfortunately the 'ham and bacon' model was not at all satisfactory, and as suggested earlier, considerable re-specification of this model would be desirable in view of its statistical properties, especially the strong autocorrelation exhibited. The pork demand equation too indicated that autocorrelation was present.

The parameter estimates cannot be checked against estimates made by other researchers. The only other estimates of the New Zealand meat market relationships being those of Court,[1] which were calculated on average annual data for the eleven years 1950-1960 inclusive. Court estimated demand elasticities for beef, mutton, and all pigmeats combined using Engel, Cournot, and Symmetry restrictions. Only the income, price, and cross-elasticities of demand for beef and mutton are, therefore, comparable. Court's price and cross-elasticities were noticeably higher than those estimated here, while non-significant income-elasticities were estimated for both meats. These income-elasticities were negative for beef and positive for mutton, a surprising result when compared to both the time-series and cross-section results achieved here. Using the same model, (i.e. three simple demand functions) but without the above restrictions, Court achieved OLS estimates similar to those which he estimated with restrictions.[2] The differences were therefore not due to the use of restrictions, but probably due to very high intercorrelation between the 'independent' variables.

At the outset of this research it was decided that a simple set of demand functions would not be adequate for policy use. Being able to estimate the level of per person demand, given the retail prices, would not be of great advantage if the retail price levels of the future could not in fact be estimated. It was therefore decided to estimate the influence of the export prices for each meat in the determination of wholesale and retail prices, taking account at each stage of the relevant internal forces which could modify that export/internal price relationship. There was, however, no need to cease here, the price making forces on each overseas market could have been specifically

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1. R.H. Court, op. cit., pp. 24-27.
2. R.H. Court ibid, pp. 26-27.

included. However, in view of the wealth of demand studies available for each major overseas market for New Zealand meat, and because New Zealand's pattern of trade is likely to change substantially in the future, the scope of the model was restricted to the New Zealand market.

If a simple set of demand functions had been decided upon, the problem of simultaneous estimation would probably not have arisen. It is to be expected, however, that a more complete economic model will contain inter-relationships which the simpler model ignores. The relative breadth of a model thus influences greatly the estimation procedure to be used.

The remaining section of this work will look at the research programme as a whole, drawing methodology conclusions as well as the overall implications of this research for policy. The detailed results shown in this chapter are the major vindication of the New Zealand meat model specified in Chapter 5. The fact that the 2SLS estimation procedure in its standard form was not able to estimate all the coefficients does not cast doubt upon the basic economic model. Some minor changes to that model would none the less be desirable, given the necessary data. This too will be discussed in the remaining section.

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2. An Analysis of Factors which cause Job Satisfaction and Dissatisfaction among Farm Workers in New Zealand, R.G. Cant and M.J. Woods. 1968
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