AGRICULTURAL ECONOMICS RESEARCH UNIT

LINCOLN COLLEGE

OPTIMUM SIZE, NUMBER & LOCATION OF FREEZING WORKS IN THE SOUTH ISLAND, NEW ZEALAND — A SPATIAL ANALYSIS

by

R. J. Brodie & W. O. McCarthy

Agricultural Economics Research Unit
Market Research Report No. 7
May, 1974

THE AGRICULTURAL ECONOMICS RESEARCH UNIT

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CONTENTS

1. INTRODUCTION*

The meat industry is New Zealand's largest export earner and in recent years has been responsible for approximately 40 per cent of total export earnings.[1] For the industry to maintain or improve its competitive position in export markets it is important to have an efficient assembly, processing and distribution system. One aspect of such a system involves the size and location of freezing works.

Recent papers by Burridge[6], Pilling [31], Ward [44] , and Morrison, Cooper et al. [29] , have discussed factors affecting the location of New Zealand freezing works, but no attempt has been made to relate these factors through use of quantitative models. The questions such models would normally attempt to answer include:-

(a) What is the most efficient locational pattern (size, number and location) of freezing works in New Zealand?

(b) What are the significant cost factors involved in such a system?

(c) How does the existing system compare with a theoretically most efficient system?

(d) How should the existing system be changed to cater for increasing numbers of livestock for slaughter, and changing processing requirements?

The last question involves decisions such as whether to upgrade or expand existing facilities, or to establish new facilities at alternative locations. These are important issues in New Zealand at present, with a number of proposals for new works, including the King Country, Central Otago, Northern Southland and the West Coast.

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* We appreciate assistance from John Rodgers who provided the computer programme.

[1] New Zealand Meat Producers' Board Annual Report 1973. Of around 660,000 tons of meat exported in 1973, approximately 300,000 were lamb, 195,000 beef and veal and 103,000 mutton.

The objective of this study is to set up a mathematical model and indicate how it can answer such questions. However the area of interest is the South Island rather than New Zealand. For the former, the model will determine the optimum size, number and location of freezing works.

One difficulty in such an approach is that social and political implications of location may be difficult, if not impossible, to quantify. However, given reasonable assumptions, models can be constructed which are capable of generating a range of good solutions which will provide a choice for policy makers.

2. SPECIFICATION OF THE PROBLEM

2.1 Livestock slaughter in New Zealand:

The slaughter of livestock in New Zealand takes place on farms, in rural slaughter-houses and domestic abattoirs, and in freezing works.[2] Most of the meat for export comes from freezing works although small quantities of specialised products are exported from meat packing houses. With diversification in export markets for meat products and their correspondingly different packing requirements, investigations have been made into the possibility of establishing specialised meat packing houses.[3] Rural slaughter-houses and abattoirs have the function of supplying the domestic market although there is some competition from freezing works. In some areas such as Nelson, the freezing works includes an abattoir which supplies Nelson City. Because of the relatively small role freezing works play in the domestic market relative to the export market[4] and difficulties in defining that role, it was decided that this study would be concerned only with the export flow of meat from these works. Meat packing houses are not considered. Further, because the majority of New Zealand's meat exports consists of beef and sheep meats, other livestock slaughter is not included. The assumption will also be made that the entire operation of slaughter, processing and packing will take place at the same location.

2.2 General aspects of freezing works location:

Burridge [5] attempts to analyse the evolution of factors affecting the location of freezing works in New Zealand over the last hundred years. He claims that failure of works in the past has been partly due to disadvantages in location, but also to lack of capital and bad organisation. The one stable locational factor has been the influence of transportation, especially the presence of rail access.

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[2] "Freezing works" is essentially a New Zealand term. The corresponding terms used overseas are meat slaughter works or meat processing plants. The authors prefer the latter and use it in the technical discussions.

[3] For example, the New Zealand Meat Producers' Board commissioned a report in 1971 on Siting of Meat Export Packing Houses.

[4] About 15 per cent of the output from New Zealand Freezing Works goes to domestic markets.

Other significant factors include the availability of livestock, labour, water, and means of effluent disposal.

Since the 1920s only three multi-product export works have been built in New Zealand.[5] The two in the North Island later closed. The only one in the South Island is Alliance which was opened in 1960. Mostly, existing works facilities have been expanded, rather than establishing new works. The existing locational pattern has evolved from past influences and, considering that factors such as technology, transportation and the institutional framework have changed, it is likely not to be optimal.

The pattern does not suggest that works are as livestock orientated as could be expected. Although some are centrally located in areas of high livestock density others have port locations.

It is informative to examine overseas trends in locational patterns. Williams and Stout [48] in discussing developments in livestock slaughter in the United States note a tendency towards slaughter in areas of livestock production. One reason for this is that with modern means of transport, such as the development of in-transit refrigeration, there are cost advantages in transporting processed products as opposed to livestock. They consider the shift in the United States has been impeded by immobility of existing facilities due to the high investment involved, bias in freight rates and a reluctance of firms to move from existing external economics such as the availability of experienced labour. Parsons and Guise[29], in an Australian study, confirm the desirability to have smaller production orientated plants. However care must be taken not to generalise the United States and Australian cases to New Zealand, because overland transport distances from livestock production areas to domestic markets or export ports are not as great in New Zealand. Parsons and Guise caution that although a production orientated plant may have reached most economies to do with scale of plant, unit costs may still be high due to a low annual utilisation of capacity or variability in supply of livestock.

Another trend in the United States reported by Williams and Stout [48] and Huie [19], is the increase in the number of plants which specialise in the slaughter of one type of livestock. This is particularly evident in beef processing. New Zealand has traditionally had mutton and lamb processing plants, or integrated mutton, lamb and beef processing plants. However, as already noted, with the increase in beef production there are already some small beef-only plants in the North Island and there may be a case for some in the South Island also.

[5] Although over the last 2-3 years a number of solely beef processing plants have been built in the North Island.

Recently large capital investments have been undertaken in New Zealand to meet the stricter hygiene standards required for entry into the United States markets. There have also been investments in the development of new facilities to allow for more specialised processing of meat products. With further large investments anticipated in both these areas, now may be the time to close down or reduce the capacity of badly located plants and establish new plants at better locations.

Due to increased livestock numbers in the 1960s and projected increases for the 1970s there has been considerable discussion as to the feasibility and location of new works in the South Island. This included commissions of inquiry by the Meat Producers' Board and independent feasibility studies by interested parties. Following the Burges and Patrick [4] report, a committee was established by the Meat Producers' Board to decide on the site for the next freezing works in the South Island [34]. After considering existing capacities in different regions, projected livestock increases for the 1970s, and listening to submissions from interested parties, the committee recommended that the site for the next works should be in the vicinity of Gore. The proposed works for Central Otago was rejected partially on the grounds that the works which service that area could well take care of any future killing supplies coming from that area. More recently a detailed study has been carried out on the feasibility of having a West Coast regional abattoir with an export licence[35].

2.3 Specific aspects of freezing works' location:

The location of freezing works (processing plants) is part of the general distribution problem associated with primary production. Such a system may be conceptualised by examining the spatial temporal flow of products from producer areas to demand areas. This can be represented as -

$$(S) \xrightarrow{(AM)} (PP) \xrightarrow{(DM)} (D)$$

where -

(S) is the set of actual and potential supplies of raw products.

(AM) is the set of actual and potential transportation systems for transferring raw products from production areas to processing facilities.

(PP) is the set of actual and potential processing facilities (this could include the spatial separation of stages of processing and storage facilities).

(DM) is the set of actual and potential transportation systems for transferring processed products to demand areas.

(D) is the set of actual and potential demands for processed products.

This section is concerned with identifying cost factors which vary with different locational patterns of PPs.

The factor of main importance is the supply of livestock. This includes present supplies, potential supplies and the possibility of buying competition from other PPs and other sources. Due to climatic variations in parts of the South Island some regions' supplies may also be subject to variations in their seasonal distributions.[6] Availability of supply is an important cost factor because unit processing costs vary both with capacity of a plant and the variability in the utilisation of that capacity. Because this study is considering more than one type of livestock (beef cattle, sheep and lambs), their complementarity in supply is important.

The meat processing industry has traditionally been a labour intensive industry, and so the availability and reliability of labour are important. Such factors as the presence or absence of other high labour demand industries in the area and the existence of off-peak alternative employment are relevant. Other considerations include the likelihood of developing good industrial relations.[7]

Allowance needs to be made for the cost of production inputs varying at different locations. This includes energy requirements such as coal, oil and electricity, and availability of large quantities of water some of which must be potable. With the increased emphasis on the control of pollution, variations in the cost of efficient effluent disposal at different locations are relevant.

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[6] For example, the Waitaki region is subject to droughts.

[7] Such factors as smaller plants and a rural working environment may be important but would be difficult to quantify.

Other factors such as variations in land rent, availability of capital, local body taxes, presence or absence of service facilities, and the state of the transport system, may be included depending on the degree of detail of the study.[8] Broader political, social, and economic implications such as regional development could also influence decisions.

Finally the transportation network and location of markets should be considered. The relative cost of transporting livestock and other production inputs compared with the cost of distribution of processed products is relevant. These costs may be affected by government legislation or may not represent a competitive system. In some areas, transhipment points, for example where road meets rail, may provide a lower cost location because of savings in terminal costs. Other meeting points such as a road junction may provide a strategic location.

2.4 Statement of the Study Problem:

Following the general discussion above, the problem which this study investigates may now be specified.

If supplies of livestock and demands for processed products are assumed to be given, three types of costs enter into consideration of processing plant efficiency. These are:

(a) Assembly Costs (AC); which cover the costs of transporting livestock from farms to PPs. These costs can usually be assumed to be linear with respect to quantity.

(b) Distribution Costs (DC); which cover the costs of transporting processed products to domestic markets or export ports. A linear relationship with respect to quantity can again usually be assumed.

(c) Processing Costs (PC); which cover costs of assembling other production inputs, and the actual processing of products. This cost category could be extended to cover broader social, political and economic factors if required. Unit processing costs may vary from location to location due to different costs of production inputs and availability of supply. They will usually be non-linear with respect to the quantity processed because of economies of scale in processing methods and perhaps variability in supply of livestock. Unit PC at different locations is complex in this study due to joint processing of different types of livestock.

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[8] See Morrill, 1970 [28] and Smith, 1971 [40].

The objective can now be precisely stated. This is to determine for the South Island the size, number and location of freezing works processing, given supplies of cattle, sheep and lambs, so that total assembly, processing and distribution costs are minimised.

Data requirements will depend on how the model is specified but can be considered under five categories:

(a) Supply
(b) Demand
(c) AC
(d) DC
(e) PC.

3. METHOD OF APPROACH

3.1 Choice of Model:

Previous studies in this series, namely McCarthy et al. [26] and Higham et al.[18] provide detailed discussion of available models and their modifications.

Briefly the basic model used here is that of Logan and King [23] as further developed by Ferguson et al. [13] , building on the work of Stammer [42] . One of its major advantages is its lack of restrictions about the shape of the processing cost function. Consequently it adapts easily to the problem of joint processing costs.

3.2 Supplies, demands and basing points:

3.2.1 General

The discrete, or network structure of the model requires supplies, demands and potential processing points to be represented as points in space connected by actual or potential transportation routes.

Domestic demands are mainly concentrated in urban areas, so can quite easily be represented discretely, but in some cases there may be a need for aggregation. Also, export demands can be represented at the appropriate export ports.

Potential processing plants are discrete in nature, but some criterion has to be developed to limit the number of sites.

Supplies are more difficult to represent because they are dispersed through space. It is not practical [9] to consider individual farms as supply points, so their supplies must in some way be aggregated into supply regions. Hence the problem arises as to what is a supply region.

Due to the static nature of the model, a representative time period has to be chosen. Because of the seasonal nature of supply, a year is appropriate, but problems arise in deciding on a representative year.

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[9] In terms of a manageable computer matrix.

3.2.2 Factors influencing supply

Accurate forecasting of current and future production patterns is difficult. Production trends are dependent on a large range of factors including climatic, economic (e.g. price), social, political and institutional. A number of studies have estimated future livestock production in New Zealand.

Pilling [31] reviews previous attempts at estimating future livestock numbers in the South Island. He then makes short run forecasts using regression analysis. Alternative approaches include an econometric analysis by Rayner [36] of future sheep numbers in New Zealand, and a regional linear programming approach by Johnson [20]. Indications of likely future trends in beef production are given by McClatchy [27] and Campbell [6]. Recently some subjective forecasts have been produced by the Ministry of Agriculture and Fisheries[10] of likely livestock numbers for 1978-79. The figures for these forecasts were prepared by local farm advisory officers, and include ranges by regions, and expected prices.

Based on these studies some simple generalisations are:

(a) Sheep numbers are unlikely to decline in any regions in the South Island.

(b) Given good prices some regions will substantially increase their sheep numbers.

(c) The current trends of increases of beef cattle numbers should continue in most regions.

The likelihood of steady increase in supplies nullifies the concept of a representative year. Thus, before any substantial policy implications can be derived, the dynamic implications of increasing supplies must be considered.

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[10] Agdata June 1972.

Nearly every year livestock production in some area of the South Island is subject to some kind of stress due to floods, droughts and disease.[11] As certain areas will be affected differently by different seasonal variations, problems arise in aggregating supplies to be represented at a set of points. This problem could be reduced by using simulation techniques[12] or using a set of lesser time periods such as months.

3.2.3 The Concept of a Supply Region

Richardson [37] outlines three theoretical criteria for defining regions:

(a) Homogeneity: implying some underlying uniform characteristic within the region (for example - production pattern).

(b) Nodality or polarisation: where emphasis is placed on the dependence of some critical characteristic or activity (for example markets, transport network).

(c) Regions defined by policy: (defined in terms of convenience and unity in economic decision making).

The practical definition used here for separating supplies into regions uses all these three criteria. The homogeneity concept is important in that it isolates geographic characteristics. Also important is the nodal or polarisation concept. Supply regions in the South Island can be considered as catchment areas with their supplies either converging to one or two central points within the region for processing, or leaving the region via only a few road and rail exits. The points of convergence will depend on nodal characteristics of the area such as the transportation and communication patterns.

A fourth important consideration relates to the homogeneity of any subset of the total supply set. Because of the static and discrete nature of the model, ideally each supply region should have supplies with similar physical and temporal characteristics, with the only variation being the quantity of their supplies.

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[11] For example extensive flooding in South Otago and Southland in the spring of 1972, markedly reduced lamb numbers.

[12] McCarthy et al. [25] demonstrate a simulation approach.

3.2.4 Supply Statistics

3.2.4.1 Data Sources:

There were five useful sources of supply statistics:

(a) Annual county census statistics for all types of livestock (Department of Statistics).

(b) Annual sheep returns (Department of Statistics).

(c) Annual killing supply figures for sheep and lambs at all export works on a district basis. (South Island Freezing Companies' Association.)

(d) Weekly returns of kills at different export works for for lambs, sheep and cattle (South Island Freezing Companies' Association).

(e) Slaughter figures by regions, for abattoirs and meat export works (Ministry of Agriculture & Fisheries).

For all of the above the county is the smallest unit for data. To use any smaller unit to build supply regions would entail extensive field work. The census statistics in (a) are supplied by individual farmers on a confidential basis, and are only available at the aggregated level of counties.

Problems can occur in using both large and small supply regions. Large supply regions detract from the spatial nature of the model, while smaller regions have the problem of not having a homogeneous subset of supply. The criterion of having minimum sized supply regions equal to the minimum sized potential plant was not considered particularly relevant for this study.[13] This was because there were regions with smaller supplies, which were too distinct to be aggregated. Also, with the Stammer modification to the Logan and King method, the possibility of not reaching a good solution is reduced.

Taking account of data limitations and the four criteria outlined in the previous section, the regions outlined in Figure 1 and Table 1 were selected.

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[13] Ferguson [12] elaborates on the reasons for using such a criterion.

FIGURE 1

SUPPLY REGIONS AND KILLING DISTRICTS

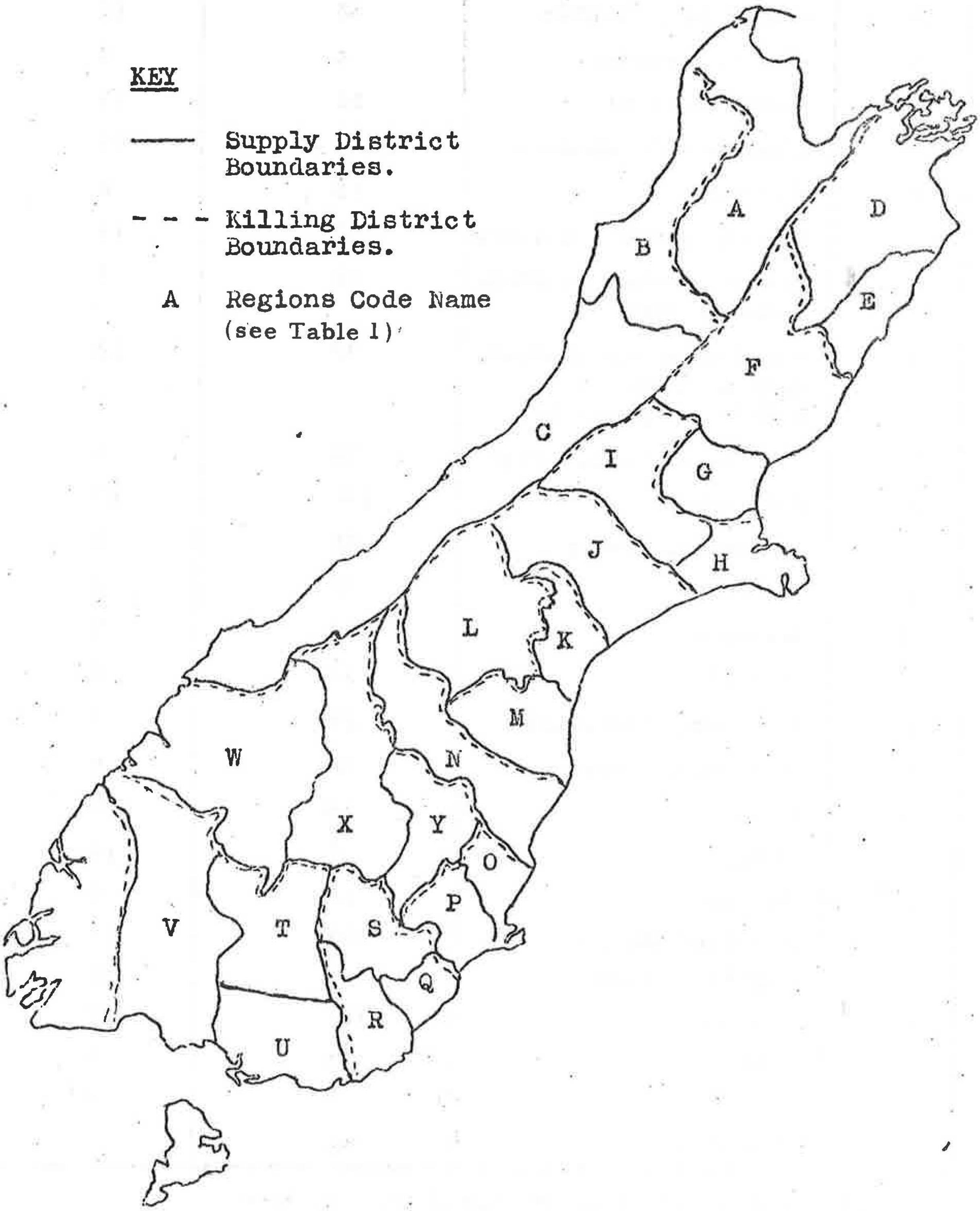

TABLE 1

Supply Regions and Killing Supplies

Regions Code Name	Counties within Region	Sheep and Lamb Supply 10^4 LE[a]	Beef Supply 10^4 LE[a]
A	Golden Bay, Waimea	32	12
B	Buller, Inangahua	4	4
C	Grey, Westland	12	13
D	Marlborough, Awatere	48	14
E	Kaikoura	10	6
F	Amuri, Cheviot, Waipara	90	14
G	Ashley, Kowai, Rangiora Oxford, Eyre	58	5
H	Paparua, Mount Herbert, Akaroa, Wairewa, Halswell, Ellesmere	77	12
I	Tawera, Malvern, Selwyn	58	5
J	Ashburton	185	13
K	Geraldine, Levels	78	8
L	Mackenzie	31	5
M	Waimate	73	7
N	Waitaki	83	5
O	Waihemo, Waikouaiti	29	3
P	Peninsula, Taiera	36	6
Q	Bruce	50	6
R	Clutha	93	16
S	Tuapeka	65	9
T	Southland (North)	191	15
U	Southland (South)	446	34
V	Wallace	186	17
W	Lake	16	3
X	Vincent	39	6
Y	Maniototo	40	5

[a] For discussion of LE (lamb equivalents) see later.

Most of the northern regions have satisfactory boundaries, but the boundaries between regions in South Otago and Southland have limitations. Southland County, because of its large area and high livestock density, was divided into two regions. The criteria for the division was based on available information. This included a description of subregions by Herlihy [17] , and the number of livestock farms in the different livestock instructorates within the province. The likelihood of there being more larger sized farms in the northern group was also allowed for.

3.2.4.2 Sheep and Lambs Data:

The data used were killing supplies for different districts. Some of these districts contain more than one supply region. The criterion used to subdivide the district supplies was similar to that used by Pilling [31] . Lambs were divided according to the percentage of lambs tailed in each region, and the sheep supplies were divided according to the percentage of breeding ewes in each region.[14] The approach assumes each sub-district has homogeneous livestock production patterns.

3.2.4.3 Beef Cattle:[15]

Beef cattle supplies were more difficult to estimate because no killing district supply statistics are kept. With the increased export prices for beef in the last few years, there has been a marked build-up in the number of beef cattle in the South Island. New areas of production have emerged and there has been an increased movement of livestock from store to fattening areas. These changes make it difficult to estimate an accurate spatial representation of supply. However, the consequences of not being able to obtain very precise estimates of beef killing supplies are not as deleterious as may initially appear. In the last few years about 0.2 million beef cattle per year have been slaughtered at export works, compared with over 14 million lambs and 3 million sheep. This relatively small proportion of beef cattle means beef cattle supplies will have a smaller "locational pull" than sheep and lamb supplies.[16]

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[14] The number of breeding ewes and lambs tailed were obtained from Agricultural Production Statistics and Annual Sheep Returns.

[15] Because of the marked decline in the slaughter of bobby calves and vealers at export works, their supplies will not be considered in this study.

[16] This study only considers integrated works.

There are two relevant sets of statistics from which to estimate killing supplies:

(a) Annual county livestock statistics. Beef cattle numbers are subdivided into ten categories according to age, sex and class.

(b) The annual and weekly kills at different export works.

A diagrammatic representation of life cycles of beef cattle was developed [17] (Figure 2). This life cycle was related to the annual county census statistics which give the different categories of cattle numbers at the end of January. By tracing through the county statistics from year to year the proportion of calves in year t, to one-to two-year-old heifers and steers in year t+1, and two- to three-year-old heifers and steers in year t+2, was observed for the last few years. Some counties markedly increased their numbers of one to two, and two- to three-year-old heifers and steers. These counties were assumed to be more suitable as fattening and store areas.

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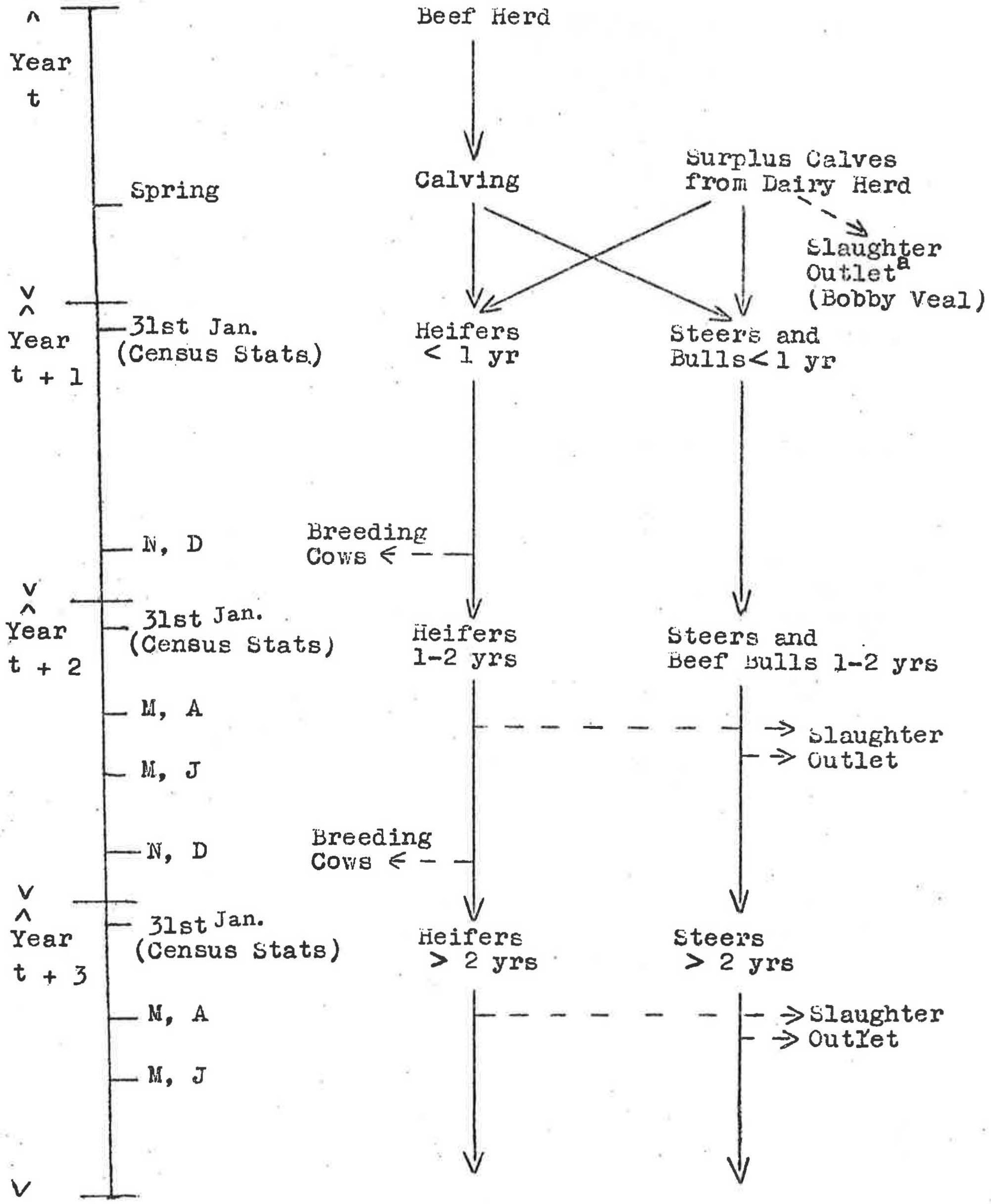
[17] Similar analyses have been made by McClatchy[27] and Pilling[31].

FIGURE 2

A DIAGRAMATIC REPRESENTATION OF THE BEEF PRODUCTION AND SLAUGHTER LIFE CYCLE



a Bobby Veal Slaughter is not very important in the South Island.

After examining the annual slaughter figures of beef cattle in the South Island for the last five years three percentages were arrived at:

(a) $\dfrac{\text{Total cattle slaughtered at export works and abattoirs}}{\text{Beef cattle in the South Island}} = (30 \pm 4)\,\%$

(b) $\dfrac{\text{Total cattle slaughtered at export works}}{\text{Beef cattle in the South Island}} = (20 \pm 5)\,\%$

(d) $\dfrac{\text{Total cattle slaughtered at export works}}{\text{Heifer, steer, beef bulls} > 1 \text{ year}} = (70 \pm 10)\,\%$

As most beef cattle are either slaughtered as 1-2 or 2-3 year olds, the third percentage appeared the best available way to divide up regional supplies and was used for this study.

3.2.5 Representation of Demand

For the last decade, the New Zealand Meat Producers' Board has had a policy for diversifying markets for meat products. The opening up of such markets has meant that meat products have had to be presented in a greater number of ways. With this greater range of output going to different destinations, there are limitations in representing export demand as a homogeneous flow, passing through the nearest export port.

Past studies have estimated domestic demand by multiplying per capita consumption by the population in the specified area.[19] Further discussion on how domestic demand is estimated is in the next sector.

With the recent high prices, by-products have played an increasingly important role in the output from export works. Because most by-products have more durable properties, they can be easily stored and transported, and export flows are usually sent to the nearest port.

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[18] For example, Cassidy [8].

3.2.6 Potential Processing Points

For this study it was decided to deviate from the traditional "point trading", basing point representation of potential processing points.[19] This was to allow for a greater range of choice for potential processing sites, which also meant existing plants could be more realistically represented.[20]

Potential processing sites were chosen according to four criteria:

(a) Each supply region capable of supplying a minimum sized plant on its own should have a potential site.

(b) All existing export plants.

(c) Export port locations.

(d) Main urban centres.

Initially a simple representation was made, with the intention of a more complex representation to follow, if needed. The sites chosen are given in Table 2 and Figure 3.

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[19] Cassidy [8] discusses the choice of representative basing points.

[20] The Stammer modifications to the Logan and King solution procedure meant a greater range of potential sites could be realistically considered.

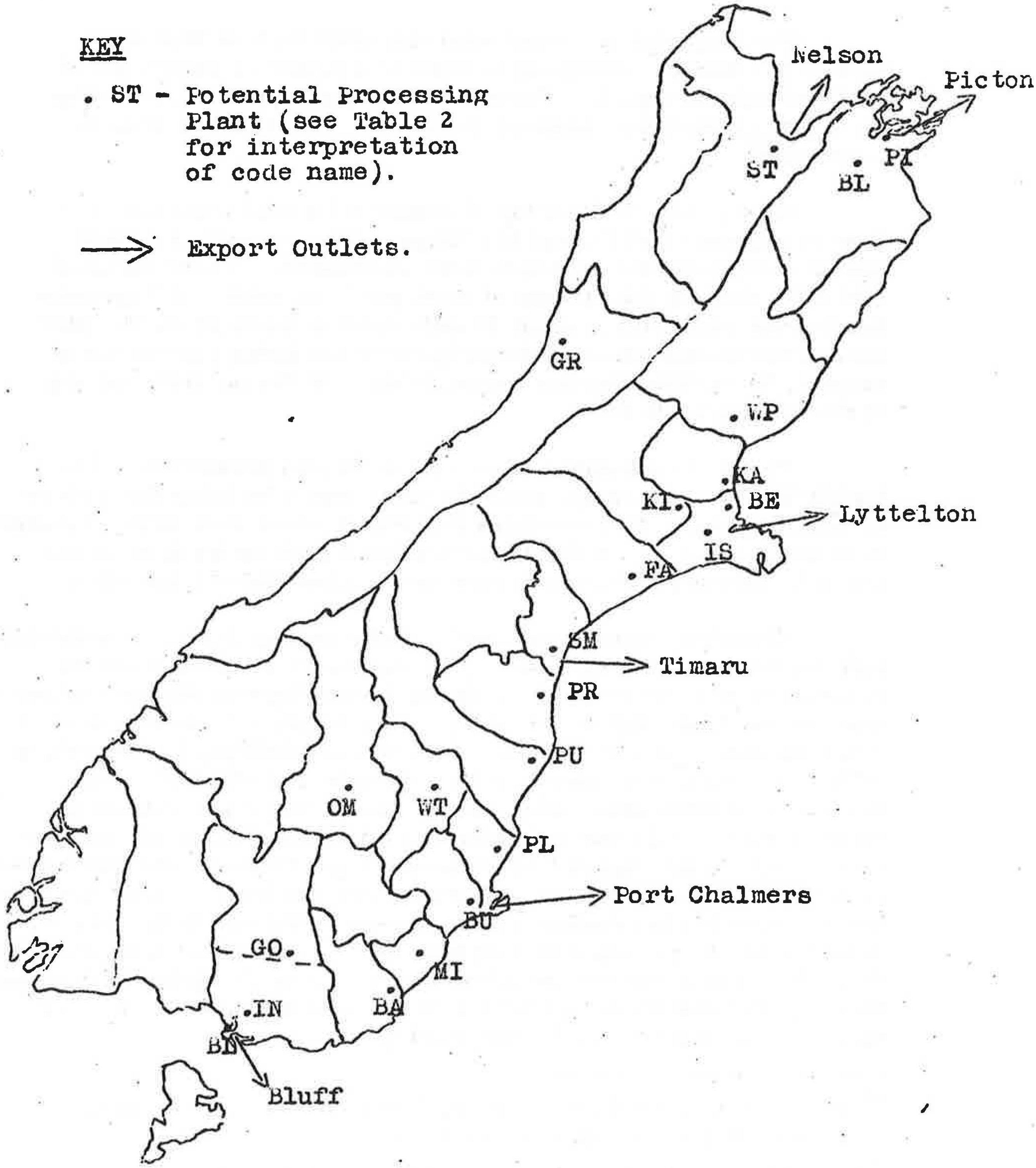
TABLE 2

Potential Processing Points

Potential Processing Points	Code Name	Existing Freezing Works
Stoke	ST	1
Blenheim	BL	-
Picton	PI	1
Greymouth	GR	-
Waipara	WP	-
Kaiapoi	KA	1
Belfast	BE	2
Islington	IS	1
Kirwee	KI	-
Fairfield	FA	1
Smithfield	SM	1
Pareora	PR	1
Pukeuri	PU	1
Palmerston	PL	-
Burnside	BU	1
Milton	MI	-
Balclutha	BA	1
Gore	GO	1
Invercargill	IN	1
Bluff	BL	1
Omakau	OM	-
Waipiata	WT	-

FIGURE 3

Potential Processing Points and Export Outlets



3.3 Transportation Costs:

3.3.1 Government Legislation

This Section is concerned with the per unit assembly and distribution costs for all potential processing plants. Before estimating these costs it is necessary to consider any government legislation inhibiting the use of alternative modes of transport.

The licensing of commercial transport in New Zealand is usually justified as attempting to achieve a better co-ordination of road and rail transport. Theoretically it was aimed at preventing excessive competition resulting in the unnecessary duplication of services.[21]

Goods service licensing of commercial road transport was first introduced in 1933, and in 1936 measures to protect freight traffic on Government Railways were introduced. These included a 30 mile limit on the cartage of most goods by road. A Transport Act in 1962 raised the general 30 mile restriction to 40 miles, plus some other modifications. Investigations are being carried out at present, to consider further modifications and the possible raising of the 40 mile limit.[22]

There are a number of exceptions to rail protection. The legislation does not apply, when the route which includes the railway is longer by more than one-third than the shortest road route available. Also the cartage of perishable commodities such as fresh meat are exempt, although chilled or frozen meat comes under legislation.

Livestock cartage was made totally exempt from any restricting legislation in 1961. Polaschek [32] discusses changes since the removal of this restriction. With the farmer free to choose whatever mode of transport suited best there was a substantial decline in livestock numbers carried by rail. Carriers specialising in the cartage of livestock have been able to offer a flexible and efficient service in cartage of livestock, with, in many cases, rates approximating those of rail. This specialisation has stimulated technical improvements such as the change from two-axle rigid frame trucks and trailers, to large multi-axle vehicles with multi-axle trailers. There has also been a trend to use smaller trucks as feeder vehicles to the larger vehicles which specialise in long haul work. Polaschek estimates that there has been a marked reduction in most rates charged. For example, he estimates that there has been a 20 per cent reduction in the long haul cartage of lambs in the last eight years.

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21 A review of the relative costs of different modes of transport is provided in Bressler and King [3] .

22 The Ministry of Transport is making a detailed study of the entire transport industry in New Zealand.

3.3.2 Existing Flows

The transportation movements to and from export works can be classified as follows:

(a) Input Flows

(i) Livestock - Sheep and lambs
- Beef cattle

(ii) Other Production Requirements
- Labour
- Energy
- Production commodities (for example cartons, chemicals).

(b) Output Flows

(i) Processed meat products
(ii) Semi or fully processed by-products.

Because of the geographic characteristics of the South Island, the number of alternative patterns of livestock flows to meat export works is restricted.[23] With most of the livestock supplies located east of the Southern Alps, these supplies can either be assembled for slaughter within their supply region, which is usually bounded by hills and rivers, or transported east to the coast. The east coast is linked by a north-south road and rail network, which allows livestock to move north or south to processing locations. There is little possibility for north south movement inland, because there are few inland bridges or passes through the ranges of hills.

Pilling [31] lists four main reasons for livestock not being slaughtered at their nearest export works. These are
(a) because of buying competition from other export works;
(b) climatic conditions causing unusually high pressure on a particular works' facilities for a short period;
(c) strikes and other stoppages;
(d) deliberate economic utilisation of works as a whole, to avoid, for example, Saturday overtime at specific works.[24]

To get an indication of the magnitude of interdistrict movements of sheep and lambs, Tables 4a and 4b were prepared (see pp 49 & 50). Data were not available to prepare a similar table for beef cattle, although it was suspected there would be an equivalent movement.

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[23] Figure 4 shows the main road and rail routes in the South Island.

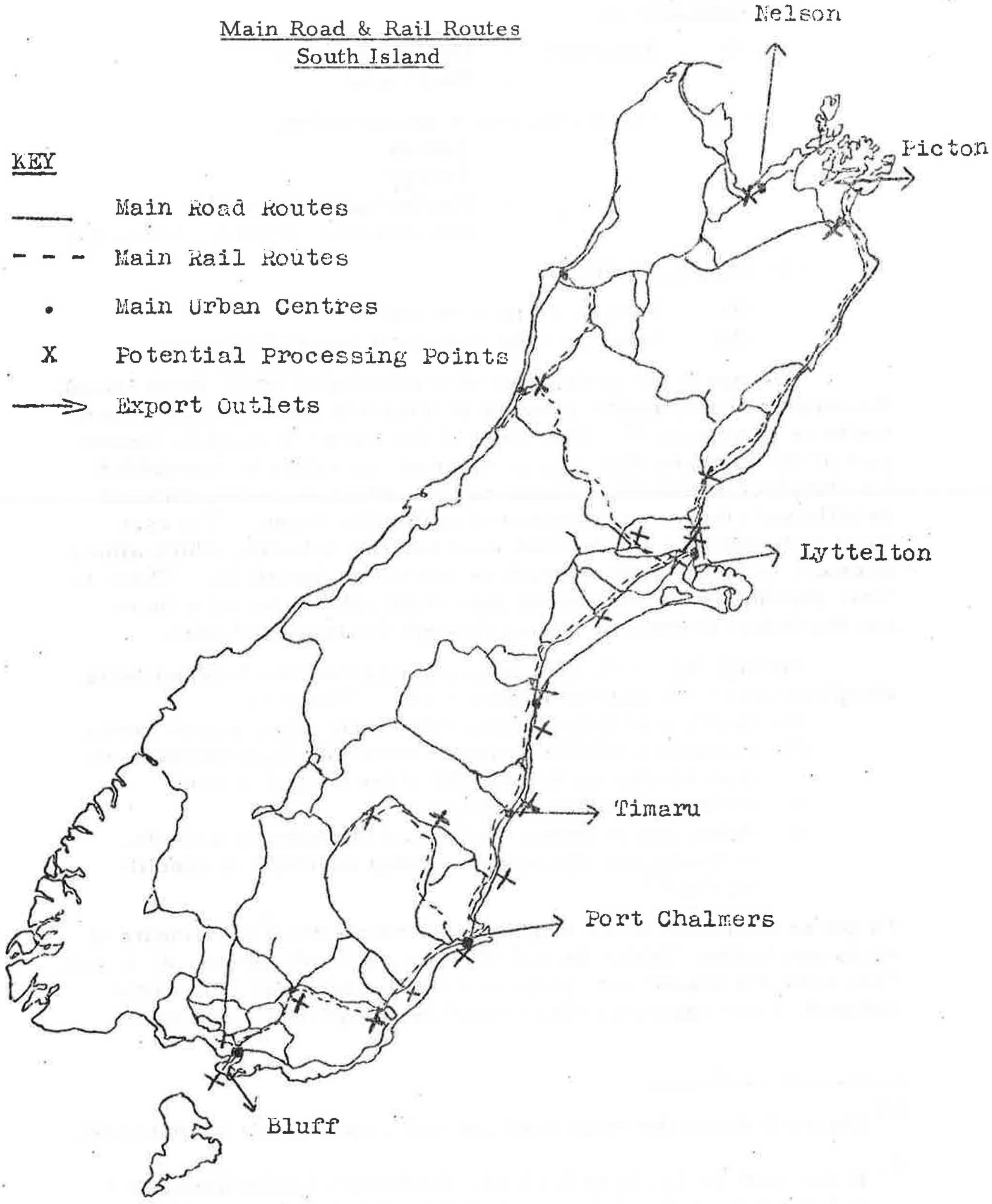
[24] In the week 26.11.72 to 2.12.72, Borthwicks Canterbury, sent 4,800 lambs to Balclutha and 5,000 lambs to Pukeuri (Christchurch Press 1.12.72).

FIGURE 4

Main Road & Rail Routes
South Island

KEY

———	Main Road Routes
- - -	Main Rail Routes
•	Main Urban Centres
X	Potential Processing Points
——>	Export Outlets



Until recently export flows of processed meat products were usually sent to the nearest export port. In the last few years the Meat Producers' Board has introduced a Meat Centralisation Scheme for United Kingdom products. All United Kingdom meat products must now be sent through Bluff or Timaru, from all export works in the South Island, except the Picton and Stoke works. The scheme[25] was introduced in order to improve the efficiency of wharf handling and hence reduce the total time spent by overseas ships in New Zealand ports. Meat exports to other export markets, are encouraged by freight subsidies[26] to co-ordinate with shipping by concentrating at suitable ports.

An increasing quantity of meat products in cartons are being exported in containers. The East Coast of North America is serviced by two container shipping companies. The A.C.T. Shipping Company uses Wellington as a container port, while the Colombus Line operates through Port Chalmers. Because the companies are in competition they have the same freight charges for containers anywhere in New Zealand.

By-products such as tallow, meat and liver meals, pelts and wool, which can be stored more easily and cheaply, are usually sent to the nearest port.

Data on domestic output flows were not readily available. The flows of meat products to different urban areas depend partially on the role played by the domestic abattoir in that area. Individual domestic abattoir slaughter figures could not be obtained either from the Department of Statistics or the Ministry of Agriculture and Fisheries. Due to lack of time, individual abattoirs were not approached. These figures were not considered particularly important because the amount of meat from export works going to the domestic markets is small compared with the export flows.

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25 Bluff and Timaru have all-weather meat loaders.

26 The subsidies are offered by the Meat Producers' Board.

3.3.3 Assembly Costs[27]

It was assumed all livestock supplies were assembled by road, except livestock travelling from the Westland and Grey counties to east coast works. The cartage of livestock over Arthurs Pass is restricted to small sized trucks, which meant rail rates were lower. The alternative road route through the Lewis Pass was considerably longer. Assembly distances by road for most other routes were the same or less than the rail distances.

In estimating the assembly costs from a supply region to different potential processing plants, the critical factor in this study is the difference in costs rather than absolute costs. For example, assume a supply region X.

Let x be the average mileage to assemble all the livestock supplies to a potential processing plant within the region.

Let $x + a_1$ be the average mileage to assemble all the livestock supplies to a potential processing plant 1 out of the region.

Let $x + a_2$ be the average mileage to assemble all the livestock supplies to a potential processing plant 2 out of the region.

Let $x + a_n$ be the average mileage to assemble all the livestock supplies to a potential processing plant n out of the region.

If it is assumed the unit rate charged per mile does not vary for distances greater than x, then it is only necessary to consider the differences in mileages (a_1, a_2 ------ a_n).

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27 Using a discrete approach to represent supply, an implicit assumption is that any subset of supply within a supply region consists of a representative spatial distribution. Thus, if supplies are being shipped out of the region via different exits, each subset of supply using a different exit is assumed to be assembled from all over the region. This potential error can be reduced by specifying smaller supply regions. Or, the final results could be carefully examined to see whether this assumption is giving rise to any significant errors. If so, calculations can always be carried out with different separations of supply.

The Ministry of Transport fixes schedules of road cartage rates for all regions in New Zealand. Within these different regions carriers must keep within the maximum and the minimum rates of the schedules.[28] The schedules are developed from detailed studies within each region involving extensive collection of data, including the accounts and waybills of selected carriers. Also, local branches of the Road Carriers' Association and Federated Farmers are consulted. In addition to these studies the Ministry of Transport undertakes detailed periodic surveys on the costs of operating trucks [24] , including a breakdown of capital, running and overhead costs.

There are no inter-regional schedules although long haul cartage rates can be arranged by contract. An unofficial schedule, developed by the Road Carriers' Association, was used as a guide for inter-district cartage rates in the northern half of the South Island. Rates on this schedule were compared with both the rates of the regional road schedules, and rail rates. The unofficial schedule appeared sound and was used where appropriate.

Each supply region was required to be represented by a homogeneous supply of sheep, lambs and beef cattle. The ratio of sheep to lambs for any district was estimated from actual district killing supplies. Long haul rates of .32c/mile for lambs and .47c/mile for sheep were used. These rates allow for a certain amount of backloading.

Using the results from a survey of works[29] it was assumed that beef cattle supplies could be represented as 60 per cent $1\frac{1}{2}$-year old heifers and steers, and 40 per cent of $2\frac{1}{2}$-year old heifers and steers. After allowing for backloading this gives a long haul rate of 3.5c/mile per average cattle beast.

Rail schedule charges are the same throughout New Zealand regardless of frequency of timetable and number of wagon loads carried. Rates were derived using these schedules with the similar assumptions for livestock mixes.

In these estimates no allowance was made for loss due to shrinkage,[30] death, or bruising which may occur on longer hauls.[31]

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28 The minimum rates are usually 10 per cent less than the maximum rates.

29 See next section.

30 Shrinkage is loss in weight that occurs in livestock during shipment.

31 Williams and Stout [48] outline United States attempts to measure losses. For the haulage distances in the South Island it was assumed these losses would not be significant.

The costs of assembling production commodities were not included in the model. Discussions with freezing works management revealed that different locations had different advantages with regard to access to production commodities. For example, oropon comes from Auckland, sulphuric acid from Christchurch, wool packs from Timaru and lime from Oamaru. It was recognised that potential inland processing sites would not have equivalent access to production commodities.

3.3.4 Distribution Costs

The export flows of meat products from export works have traditionally been distributed by rail, except in the cases of the Picton and Stoke works, which do not have rail access. The lack of rail access for the Stoke works has stimulated bulk handling methods, such as the use of pallets to store and transport carcases and cartons of meat. Some of the Southland works have also found advantages in using pallets, and Alliance has two large bulk pallet cool stores. When loading a ship a shuttle service of trucks is used to take the loaded pallets to shipside. However the 40 miles road cartage restriction prevents any changes in distribution methods for most works. In order to standardise the model, cost savings involved in the distribution by road using pallets will be excluded.

Export works product a large and varied range of outputs. The output product "mix" (depicted in Figure 5), chosen for this study, was based on results from the works survey and industrial production statistics.

It was assumed that all United Kingdom perishable products were sent to the Ports of Timaru and Bluff, except from the Picton and Nelson works. All other export products were sent to the nearest port.

All domestic output was usually sent to the nearest large urban centre. It was decided that due to the small but complex role freezing works have in domestic demand, the analysis would not attempt to take any more precise account of domestic demand than this.

In general a more realistic formulation would explicitly take into account different export demands at different ports for meat products. However such a formulation involves a larger solution matrix and computer capacity.[32] The rail rates and distances from potential plant sites to different destinations were obtained from schedules provided by the New Zealand Railways.

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[32] Ferguson et al. [13] demonstrate a model which takes an explicit account of different export demands.

FIGURE 5

Product Output Mix's

(a) Lambs

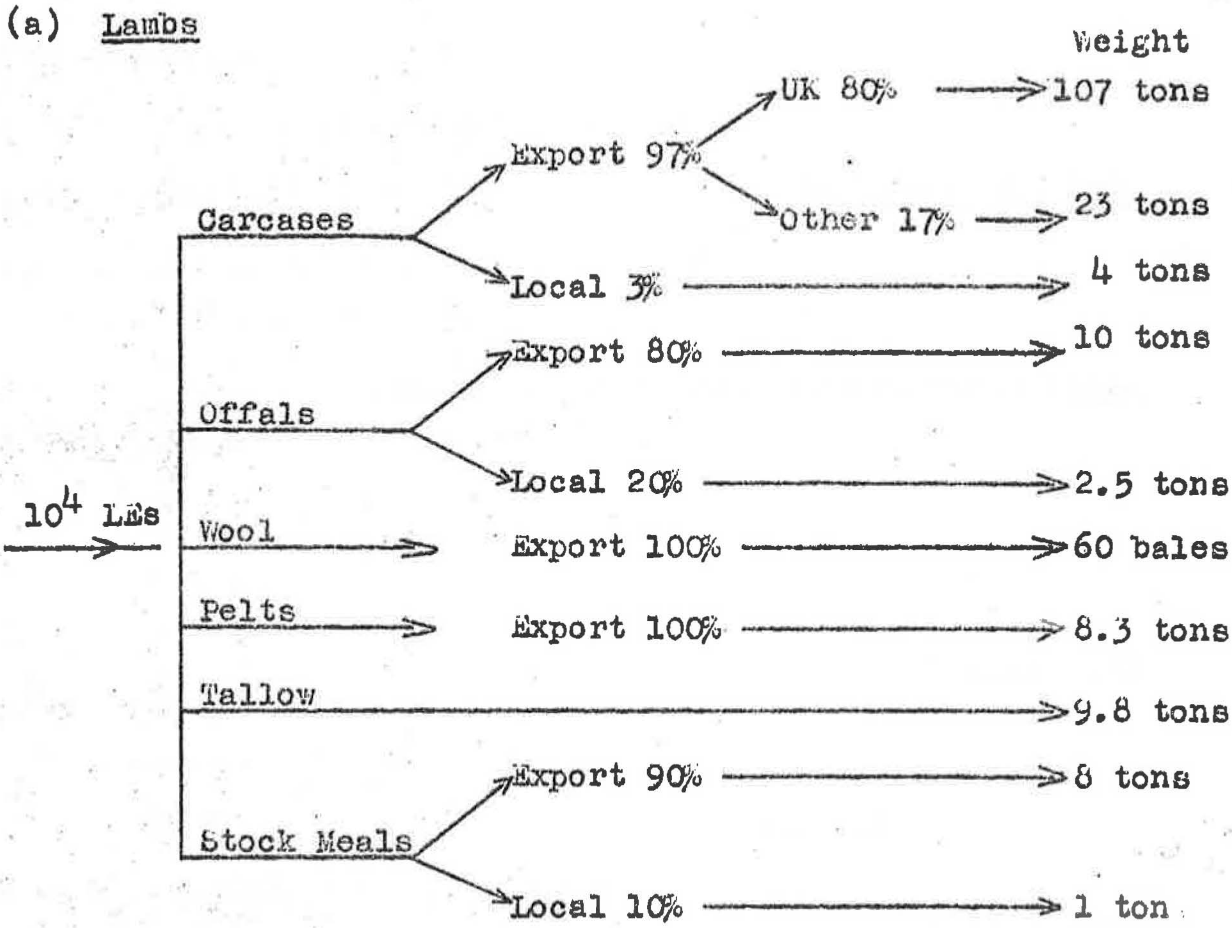

FIGURE 5 (cont'd)

(b) Sheep

Weight

- 10^4 LEs Carcases
  - Export 80%
    - UK 15% → 24 tons
    - Carcase 35% → 56 tons
    - Boned 30% → 29 tons
  - Local 20% → 32 tons

Note: Other Outputs same as Lambs above.

(c) Cattle

- 10^3 Cattle
  - Carcases
    - Export 85% (Boned) → 114 tons
    - Local 15% (Sides) → 40 tons
  - Offals
    - Export 50% → 9 tons
    - Local 50% → 9 tons

Sources: (1) New Zealand Meat Producers' Board Annual Report 1972.

(2) Industrial Production Statistics 1969-70 (Department of Statistics).

(3) Survey of Freezing Works Management.

3.3.5 Preparation of the Parent Cost Matrix

The assembly costs from different supply regions to potential processing plants, and the distribution costs from these plants, serve as the basis for the parent cost matrix in the Logan and King approach. The model in this study assumed all outputs were proportional either to lamb and sheep inputs or cattle inputs. The further assumption was made that the destinations of all outputs were known, and were independent of the quantity of throughput at any particular plant. These assumptions imply that the parent cost matrix can be expressed in a transportation format, rather than the usual transhipment format.

The parent cost matrix (Figure 6) was formed in the following manner:

(i) The differences in distances from supply regions to potential processing plants were estimated.

(ii) The assembly costs for sheep, lambs and cattle were calculated for these distances.

(iii) The distances for different output flows from potential processing plants to their respective destinations were calculated.

(iv) The distribution costs were calculated for each potential plant.

(v) The results from (ii) and (iv) were added together to form the parent cost matrix.

(vi) A dummy supply region, with supplies having zero assembly and distribution costs was added. This allowed the parent cost matrix to represent the costs of a balanced transportation problem. (i.e. Z1, Z2, Z3 in Figure 6.)

FIGURE 6 : Parent Cost Matrix

Representing the relative costs of assembling livestock and distribution processed products (units $\$10.0/10^4$ LE)

Potential Plants

Supply Regions

AS - Sheep etc. and Lambs

AB - Beef etc.

**** Indicate Routes not considered

	ST	BL	PI	GR	WP	KA	BE	IS	KI	FA	SM	PR	PU	PL	BU	MI	BA	GO	IN	BL	OM	WP
AS	0	261	267	697	780	814	824	862	955	1010	1116	****	****	****	****	****	****	****	****	****	****	****
AB	0	217	231	563	630	641	640	683	780	862	969	****	****	****	****	****	****	****	****	****	****	****
BS	0	110	116	35	182	216	230	268	286	401	426	460	****	****	****	****	****	****	****	****	****	****
BB	12	99	112	0	123	134	145	166	357	367	446	479	****	****	****	****	****	****	****	****	****	****
CS	328	451	457	0	502	435	411	349	309	461	495	531	****	****	****	****	****	****	****	****	****	****
CB	331	429	442	0	433	298	276	237	337	460	487	509	****	****	****	****	****	****	****	****	****	****
DS	204	0	4	902	605	634	645	674	762	810	876	917	1122	****	****	****	****	****	****	****	****	****
DB	192	0	13	763	491	494	502	533	629	712	789	622	991	****	****	****	****	****	****	****	****	****
ES	229	0	3	****	125	165	175	210	294	339	404	444	617	****	****	****	****	****	****	****	****	****
EB	215	0	13	****	62	73	81	115	212	294	372	404	545	****	****	****	****	****	****	****	****	****
FS	****	****	****	****	0	38	48	84	171	221	289	329	535	****	****	****	****	****	****	****	****	****
FB	****	****	****	****	0	12	20	53	150	232	310	343	512	****	****	****	****	****	****	****	****	****
GS	****	****	****	****	103	0	10	46	134	183	251	291	497	664	793	****	****	****	****	****	****	****
GB	****	****	****	****	113	0	8	42	139	221	254	331	501	625	687	****	****	****	****	****	****	****
HS	****	****	****	****	180	52	29	0	102	94	164	204	410	576	704	****	****	****	****	****	****	****
HB	****	****	****	****	179	45	24	0	108	138	216	284	418	543	605	****	****	****	****	****	****	****
IS	****	****	****	****	217	89	66	36	0	78	147	187	392	560	688	****	****	****	****	****	****	****
IB	****	****	****	****	192	59	38	13	0	105	183	216	385	510	572	****	****	****	****	****	****	****
JS	****	****	****	****	298	172	149	100	121	0	26	66	271	439	568	****	****	****	****	****	****	****
JB	****	****	****	****	226	92	72	30	69	0	40	73	242	367	429	****	****	****	****	****	****	****
KS	****	****	****	****	466	340	317	268	289	129	0	40	336	413	542	****	****	****	****	****	****	****
KB	****	****	****	****	357	223	203	161	200	94	0	33	202	327	389	****	****	****	****	****	****	****
LS	****	****	****	****	395	267	244	196	219	131	0	40	245	411	538	****	****	****	****	****	****	****
LB	****	****	****	****	296	163	142	100	139	99	0	33	202	327	389	****	****	****	****	****	****	****
MS	****	****	****	****	****	482	459	410	433	273	26	0	94	260	421	****	****	****	****	****	****	****
MB	****	****	****	****	****	355	334	293	331	228	27	0	73	198	288	****	****	****	****	****	****	****
NS	****	****	****	****	****	589	566	484	505	348	97	72	0	113	243	389	****	****	****	****	****	****
NB	****	****	****	****	****	459	439	3268	407	303	103	77	0	76	137	316	****	****	****	****	****	****
OS	****	****	****	****	****	648	625	576	599	439	192	166	108	0	122	271	299	418	398	413	393	236
OB	****	****	****	****	****	532	511	469	508	405	204	179	116	0	56	235	255	384	383	407	309	183
PS	****	****	****	****	****	****	****	****	****	****	****	298	240	123	0	117	142	264	309	325	394	237
PB	****	****	****	****	****	****	****	****	****	****	****	346	283	164	0	150	170	299	356	380	****	****
QS	****	****	****	****	****	****	****	****	****	****	****	346	290	175	42	3	0	113	157	171	****	****
QB	****	****	****	****	****	****	****	****	****	****	****	358	295	170	0	13	10	134	190	215	****	****
RS	****	****	****	****	****	****	****	****	****	****	****	422	365	250	124	75	0	87	131	145	****	****
RB	****	****	****	****	****	****	****	****	****	****	****	414	331	225	63	67	0	101	157	161	****	****
SS	****	****	****	****	****	****	****	****	****	****	****	404	347	233	106	57	32	0	45	58	****	****
SB	****	****	****	****	****	****	****	****	****	****	****	374	311	187	23	27	4	0	56	80	****	****
TS	****	****	****	****	****	****	****	****	****	****	****	604	547	433	306	257	182	0	45	58	****	****
TB	****	****	****	****	****	****	****	****	****	****	****	551	488	364	199	204	137	0	56	80	****	****
US	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	185	0	14	****	****
UB	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	147	0	24	****	****
VS	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	185	-0	15	****	****
VB	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	147	0	24	****	****
WS	****	****	****	****	****	****	****	****	****	****	****	382	324	206	245	197	219	53	0	19	38	145
WB	****	****	****	****	****	****	****	****	****	****	****	371	309	184	168	172	189	67	36	63	0	106
XS	****	****	****	****	****	****	****	****	****	****	****	338	281	166	174	126	139	121	165	179	0	106
XB	****	****	****	****	****	****	****	****	****	****	****	371	309	184	139	143	154	162	219	243	0	106
YS	****	****	****	****	****	****	****	****	****	****	****	232	175	60	176	249	262	244	289	302	25	0
YB	****	****	****	****	****	****	****	****	****	****	****	265	202	78	128	240	251	259	315	340	99	0
	ST	BL	PI	GR	WP	KA	BE	IS	KI	FA	SM	PR	PU	PL	BU	MI	BA	GO	IN	BL	OM	WP
Z1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Z2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Z3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

3.4 Processing Costs:

3.4.1 Introduction

Economies of scale occur when there are reductions in average costs arising from increases in the scale of an operation. In relation to the size of processing plants economies of scale can be defined as equivalent to a falling long run average cost (LRAC) function or curve when the size of processing plants is identified by a homogeneous input or output. [33] The LRAC function represents an envelope curve of short run average cost functions of different sized plants. Thus, any point on a LRAC curve will identify the size of the plant which will process that input or output at "least cost".

The relationship expressed by a LRAC function is static and does not show what happens to costs as the scale of production is increased over time. Hence for an industry undergoing rapid technological change it is necessary to identify which time period the LRAC function is representing as Pratten [33] indicates.

Traditional economic theory suggests that the LRAC function will eventually start curving upwards. This is usually explained by inefficient management. [34] However, such potential diseconomies could be difficult to measure and as will be indicated later, little empirical evidence has yet been produced to show they exist. No attempt will be made to measure management efficiency in this study.

Even without considering this aspect there are many problems involved in estimating a realistic LRAC function. In past studies of this nature[35] there has been a single product input or output, but because sheep and beef involve different processes the LRAC function will have to represent a multi-product input and output.

Other factors which may influence average costs of processing are those relating to external economies or agglomerating economies. Major difficulties arise when attempts are made to include them within a deductive framework and it has not been attempted here. [36]

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[33] Pratten [33] discusses some of the dimensions of scale to which economies may relate.

[34] Pratten [33] provides a more detailed discussion of this aspect.

[35] For example, Logan and King [23] , Cassidy [8] , Ferguson [12] .

[36] Smith [40] review some alternative ways of including these factors.

3.4.2 Empirical Estimation Techniques

Ideally a set of SRAC functions should be estimated before the envelope curve of the LRAC function is derived. Smith [39], Dennis [10] and Haldi and Whitcomb [16], review three general approaches to this problem:

(a) Experimental estimation techniques.[37]
(b) Statistical estimation techniques.
(c) Synthetic estimation techniques.

(a) Experimental Techniques:

This approach involves controlled experiments in which inputs are varied and output costs are estimated. However, there are few situations where a "controlled environment" is practical or even possible. In the case of meat processing plants, with more than one species of livestock as inputs, and a large array of outputs, the technique is not feasible.

(b) Statistical Techniques:

This approach involves the statistical analysis (usually regression) of time series or cross sectional cost data obtained from existing processing plants.

Time series relies on historical accounting data. Even if data are available, there are major problems in identifying cost changes not due to differences in scale. Haldi and Whitcomb outline some of these other problems. These include:

(i) variations in demands and available supplies;
(ii) non-homogeneous outputs and inputs;
(iii) plants being of different ages and hence newer plants may have technological improvements unrelated to scale, which were not available to older plants;
(iv) construction costs may vary with location;
(v) different technologies may be induced by different locations due to different relative factor costs of inputs (for example, labour and energy).

These factors usually lead to a complex statistical identification problem.

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[37] Smith [39] and Haldi and Whitcomb [16] do not explicitly mention this approach.

Cross-sectional studies usually involve a detailed cost breakdown of different inputs leading to an industry cost profile. However, like time series, this approach also has identification problems.

A further conceptual problem, noted by Friedman [15] , relates to the use of accounting data in statistical analysis. If plants make the mistake of having a larger or smaller capacity than the optimal sized plant, the loss resulting from this mistake will be capitalised in accounting records.

The problems outlined above are not insurmountable. However to overcome them the data and computational requirements are usually quite large. Johnston[21] and Ferguson [12] indicate such procedures.

(c) Synthetic Techniques:

A third approach known as the synthetic or engineering technique, does not initially concentrate on cost relationships. In this method physical input-output relationships are determined from engineering planning techniques and in-plant measurements, [38] and then synthetic cost estimates are derived for different sized plants to give a set of SRAC functions, from which a LRAC function can be derived.

The synthetic method implicitly assumes plants are the sum of their balanced constituent parts, thus ignoring the possibility of inefficient management of large scale plants. Another criticism is that statistical tests of reliability cannot be applied to the estimates.

A further disadvantage is the high research input required to develop good estimates. This is because in-plant measurements are time consuming, and expertise in engineering is needed to develop realistic model plants.

Advantages of this approach are its flexibility in considering different technologies and different institutional restraints, such as manning requirements imposed by unions, and other factors which may be relevant in a long run planning model.

A fourth, more subjective, approach to estimating economies of scale is through a questionnaire or interview. This aims at utilising the knowledge and experience gained by management within a specific industry. Bain [1] employed this technique to survey twenty different manufacturing industrires in the United States. Its reliability depends

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[38] Dennis [10] gives a good survey of the different ways to estimate these basic relationships.

on the quality of the questionnaire, and the number of qualified people who answer it. If research resources are limited, it may be the only feasible technique available. Alternatively it may be used in conjunction with other approaches.

A fifth method has been suggested by Stigler [43] .[39] The technique is centred around the hypothesis: "those sizes of plants which have a minimum average cost, will be the sizes of plants which survive best in the market place". This approach, known as the "survivor technique", must be applied over a period of time. It has similar identification problems to the statistical approach, and if too many market imperfections exist, it may be even more difficult to obtain meaningful results.

3.4.3 Empirical Studies

Review of empirical cost studies of industrial plants are given by Smith [39] , Johnston [21] , Walters [45] and Pratten [33] . Most of the evidence supports the generalisation that:

> "As the size of plant increases from small to medium, average costs decline."

However, little evidence has been produced to show average costs increase, as the size of plant increases beyond a certain point. Bain [1] concluded that the LRAC curves for most industries is more likely to be L shaped than U shaped.

Studies of costs in meat slaughter and packing plants have indicated that an L shaped curve provides a reasonable representation for a large range of output. These include a United Kingdom study by Smith [41] , United States studies by Bain [1] , Logan and King [22] , Wissman [49] , Franzman and Kuntz [14] , Huie [19] ; and Australian studies by Cassidy [8] and Parsons and Guise [30] . The study by Parsons and Guise is the most relevant to the New Zealand situation, because it considers more than one species of livestock. No empirical studies[40] of this type have been carried out in New Zealand.

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[39] Weiss [46] provides a good review of this approach.

[40] Cost relationships in meat works are briefly discussed in Proceedings of 12th Meat Industry Research Conference Session III(1970). Morrison, Cooper <u>et al.</u> (private communication), are of the opinion that average capital costs per unit of capacity decline as size of works changes from small to medium.

3.4.4 Freezing Works in New Zealand

For orientation in subsequent discussion, the following background on freezing works' operation is presented.

Freezing works have evolved from merely slaughter houses with facilities for freezing edible products, to more complex processing plants. Further changes are taking place at present.[41]

Sheep and lambs use the same facilities for processing while most stages of beef processing require separate facilities from those for sheep and lambs. However both processes can be approximately grouped into the same six stages[42] as follows:

(i) Pre-slaughter - the handling of livestock in the yards in preparation for slaughter.

(ii) Slaughter and Dressing - the killing of the animal and the separation of all the by-products from the carcase.

(iii) Cooling Floor (and conditioning) - the carcase is chilled or prepared for freezing.

(iv) Packing - carcases (fresh or frozen) are boned or cut up.

Further processing may occur depending on the market requirements.

(v) Freezing - the edible meat products are frozen and stored.

(vi) Processing of by-products.[43]

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[41] For example, extension of packing facilities and upgrading facilities to meet the new hygiene regulations.

[42] There are a greater range of by-product activities associated with sheep and lamb processing.

[43] More detailed descriptions of these activities are given by Earle and Oldfield [11] for beef; Borthwicks [2] for sheep; Chisholm [9] for by-products.

A 1970 paper by Morrison, Cooper et al. [29] discusses the design of freezing works for the future. It is noted that meat processing in New Zealand has traditionally been a disassembly or separation process, with little or no processing of the separated products. But with the world market for meat products requiring more sophisticated products, it is predicted that meat processing will need to become more of a disassembly/reassembly process. This will involve further processing of meat products, and a greater extraction of edible protein from waste products.[44]

With these likely developments, existing works, which have their freezing and frozen storage facilities immediately adjacent to the slaughter areas, have limitations and could be involved in expensive alterations. Earle and Oldfield [11] in discussing future trends in beef processing, confirm the predictions of Morrison, Cooper et al., and also predict that some aspects of meat processing will become more mechanised. Other aspects such as meat packing may require more labour. The labour requirements for meat packing are of a different type and some operations are more suited to female labour.

Other developments could include the spatial separation of different stages of the processing operation. More labour intensive activities such as meat packing, may be more suited to be at larger urban centres. The introduction of shift work could be also considered. Some aspects of by-product processing which require greater quantities of throughput to be of an economic size, could take place in more centralised locations.

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[44] Shortland [38] discusses some of the possible future uses of by-products.

3.4.5 Study Approach

The objective of this section is to outline an approach to estimate a LRAC function, for the processing of different combinations and quantities of sheep, lambs, and beef cattle. Sheep and lambs use the same facilities, and after investigating their seasonal supply characteristics, it was considered reasonable to consider their supplies as being complementary.[45] Beef processing was considered as an independent operation, except for the joint use of such facilities as cold stores and engine rooms. Labour used in beef processing, and sheep and lamb processing, is to a certain degree complementary due to different seasonal killing peaks.[46]

In the estimation of unit processing costs, and the associated economies of scale, four complementary approaches were chosen.

(a) A review of past overseas studies was made to help understand what the significant cost factors might be.

(b) All the freezing works in the South Island were visited and works managers interviewed:

(i) To get a general understanding of how different sized freezing works functioned at different locations.

(ii) To obtain opinions from works managers, and to gain their confidence to answer a questionnaire. The questionnaire was based on a review of previous study approaches, and was aimed at finding the physical requirements of different sized works at different locations.[47]

(c) Morrison, Cooper et al. were approached in an attempt to obtain cost data.[48]

(d) Any other relevant material such as Freezing Companies' annual reports were studied.

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[45] See Section 3.4.7.

[46] See Section 3.4.7.

[47] See Appendix 1 for questionnaire outline.

[48] Morrison, Cooper et al. are consulting entineers and architects and have been responsible for most of the design and construction of meat processing plants in New Zealand in the last few years.

The objective was to approximate the synthetic approach. A direct application of statistical analysis, using cost data, was rejected because of the anticipated difficulties in getting access to sufficient data. The survivor technique was considered only useful as a general qualitative guide. Too many qualifications and assumptions would have to be made, before it could be used as a quantitative tool.

3.4.5 Estimation of the LRAC Function

(a) Past Studies:

Past studies when estimating processing costs, usually divide costs into capital or fixed costs, and operating or variable costs.

(i) Capital costs relate to plant, equipment and land. They are usually expressed on an annual basis, in the form of interest, depreciation and insurance.

(ii) Operating costs relate to manpower, utilities, and other miscellaneous services. The costs associated with these services are not fixed. The degree with which different services can be varied will depend on technical relationships and the existing institutional structure. For example, utility requirements such as water and electricity vary directly with throughput, but manpower requirements cannot be varied so freely due to union restrictions. It may only be possible to vary management services on an annual basis.

Australian studies by Cassidy [8] and Parsons and Guise [30] have indicated that economies of scale were more significant for capital costs. Cassidy estimated a very flat average variable cost curve, with a difference of only $0.69 per head for a plant with a daily capacity of 100 cattle compared with one of 600 cattle. By comparison there was a $4.50 difference in overhead costs.

Parsons and Guise concluded the capacity of the plant appeared to have no significant effect on unit costs of operation. They considered main savings in unit costs of operation would come more from a high monthly utilization of capacity. However, their study showed a similar relationship between capital costs and capacity as did Cassidy's.

(b) Operating Costs:

On the basis of results for the above studies it was considered that the differences in unit operating costs, directly due to variations in scale, would probably not be a significant cost factor, for the range of plant capacities investigated in this study. Accordingly they have not been incorporated in the scale curve which therefore consists of capital costs only.

A major source of economies of scale for unit operating costs could arise from the indivisibility of manpower services in small plants. Nevertheless the data collected in the questionnaire did not offer any evidence to support this. However, such data is subject to identification problems such as accounting or institutional conventions. Extensive in-plant studies may be the only satisfactory way to obtain accurate estimates. Data collected by means of the questionnaire on the use of utilities also did not offer any satisfactory evidence.

On a priori grounds it was expected there would be little variation in unit operating costs with different sheep processing capacities. Most of the operations for small one or two chain works are merely duplicated for plants with greater capacities. However, it would be difficult to make similar generalisations for beef processing because of the different technologies used in slaughter and dressing. Smaller plants can use an "on the bed" system, while plants with large capacities use a more mechanised (intermittent or continuous) "on the rail" system.[49]

However if there was considerable variation in average weekly throughput this could markedly affect unit operating costs. This aspect will be discussed later.

(c) Capital Costs:[50]

The total capital costs of an integrated lamb, sheep and cattle processing plant will depend on the magnitude and combination of lamb, sheep and cattle processing capacity. Sheep and lambs use the same processing facilities so by using an equivalence ratio they can be assumed to be a homogeneous input with respect to capacity requirements. Such an equivalence ratio could be arrived at by considering the differences in time taken for processing sheep and lambs and the differences in freezing and storage capacity requirements for the processed products.

The New Zealand Freezing Works industry uses an equivalence ratio of 1.25 sheep and 1 lamb to 1 lamb equivalent (LE) ratio. This ratio was used for this study.

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[49] Huie [19] describes the different systems.

[50] Appendix 2 gives a breakdown of capital costs for an integrated plant.

In a modern integrated processing plant the early stages of processing sheep and cattle are independent operations using separate facilities. However there exists the possibility of joint use of facilities such as offices, workers' amenities, workshops, engine room and boiler plant, by-product processing facilities, cooling stores and so on.[51]

A cost function representing total capital costs for different sized integrated processing plants in the South Island will have two independent variables.

$$\text{i.e.} \quad Y = f(X_1, X_2)$$

$$X_1, X_2 > 0$$

where

Y is the total capital costs of integrated plants in the South Island with processing capacities of X_1 lamb equivalents per day and X_2 cattle equivalents per day.

This implies a three dimensional cost surface rather than the usual two dimensional cost curve.

Because of limited data on costs of integrated works it was decided to apply a restriction on the above cost function.

$$\text{i.e.} \quad Y = f(Z)$$

where

$$Z = X_1 + kX_2; \quad X_1, X_2 > 0$$

and k is derived from extraneous information and may be considered as an equivalence conversion ratio between the capital costs for sheep and cattle processing capacity.

Parsons and Guise [30] apply a similar restriction when estimating a capital cost function for export abattoirs in Australia. To arrive at values for the equivalence ratios for different species of livestock (sheep, cattle, calves and pigs), they regress the total costs of combined operations (excluding interest and depreciation) against the numbers of different species of livestock processed.

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51 The extent of joint use of facilities will be determined by the degree of complementarity in seasonal distributions of lamb and sheep, and cattle killing supplies. After examining graphs of these seasonal distributions (see footnote 56), it was assumed the extent of joint use would not vary among South Island works.

An alternative approach was used for this study. This was based on comparison of the ratios of the average capital cost per unit of different sized separate sheep and cattle plants.

Thus $k = \frac{a}{b}$

where

a = Average capital costs per cattle equivalent unit of daily capacity of different sized cattle processing plants

and b = Average capital costs per lamb equivalent unit of daily capacity of different sized sheep processing plants.

The estimation of the total capital cost function was based on data supplied by Morrison, Cooper et al. and data collected by the questionnaire. Both sets were supplied in confidence so only results will be presented. The data supplied by Morrison, Cooper et al. consisted of estimates of the capital costs of sixteen plants, both integrated and separate. The estimates were derived from actual and planned plants and were based on 1972 prices. Because not all the plants had the same range of follow-on facilities, adjustments were made to account for these deviations.

On the basis of the cost data on separate processing plants, a value of 12 was arrived at for k. Using this value the following cost function was determined.[52]

$$\hat{Y} = 1.1 + .99Z$$

where $\hat{Y}$ is the total capital costs of integrated plants in the South Island in \$m.

And Z is the daily capacity of different sized plants in units of 10^3 LE

$$Z = X_1 + kX_2 \;;\; X_1, X_2 > 0$$

The equation was adjusted so it could be represented as an annual cost by working out the interest and depreciation rates on the capital involved. A standard bank interest rate of 8 per cent was used.[53] The depreciation rate was derived from the Inland Revenue Department's depreciation rate schedule for buildings and equipment. An overall rate of 6.8 per cent was arrived at.

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52 Parsons and Guise estimated a function of the same algebraic form. It was not possible to compare the coefficients directly because their study also included the processing of calves and pigs and the different seasonal distribution of killing supplies in Australia.

53 This was the same rate as used by Wylliams [50] in estimating the cost of a cattle processing plant.

Thus $\hat{Y}_a = 0.163 + 0.147Z$

where $\hat{Y}_a$ is the annual capital costs of integrated plants in the South Island.

In order to determine the <u>daily</u> capacity requirements (i.e. Z) of processing any combination of annual throughput of sheep and cattle, estimates need to be made of the expected annual utilisation of the sheep and cattle facilities. Such estimates can be obtained by looking at historical data and measuring the equivalent number of days that the <u>daily</u> sheep and cattle capacities are fully utilised for the different works in the study area.[54] This measure is referred to as loading days in the industry.

Thus, given an annual supply of

S_a lamb equivalents of sheep and lambs, C_a cattle equivalents of cattle,

and L_s loading days for sheep and lambs, L_c loading days for cattle,

$$X_1 = \frac{S_a}{L_s} \qquad X_2 = \frac{C_a}{L_c}$$

However a further complication could occur. The implicit assumption in a static analysis is that every supply region has an annual killing supply which is a homogeneous subset of the total killing supply. This implies that killing supplies of every region have the same seasonal characteristics and hence no two regions' supplies will be complementary. The validity of this assumption needs investigation.

Due to lack of data it was not possible to estimate directly the seasonal distribution of regional supplies, so a less satisfactory indirect approach was employed to investigate whether the degree of homogeneity assumption was correct. Three sets of data were developed.

(a) The loading days at different works for the last five seasons (Table 3).

(b) Movement of L and S from supply regions to different works.[55]

(c) Seasonal distributions of kills at different works.[56]

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[54] An average cost per LE throughput can be obtained by dividing $\hat{Y}_a$ by $(S_a + kC_a)$.

[55] Similar data were not available for cattle.

[56] Graphs were plotted for S, L, S and L, and C for all of the freezing works in the South Island for the 1970-71 and 1971-72 seasons. Copies are available from the senior author.

After examining these sources of evidence, it was decided to assume each region's supplies of L and S would be equivalent to $L_S = 110$ and each region's supply of cattle equivalent to $L_C = 70$.[57]

Data for (b) above was supplied on a confidential basis so is presented in an aggregated form (Tables 4a and 4b). These tables indicate that approximately 10 per cent of L and S killing supplies are not killed at the closest works. These movements can be explained by buying competition, strikes and other stoppages and climatic conditions.

From this meagre evidence it was concluded that a large proportion of supplies (approximately 90 per cent) would not be complementary with other regions' supplies. Accordingly this analysis assumes individual region killing supplies are a homogeneous subset of total supply.

[57] The graphical analysis showed a high degree of complementarity between L and S killing supplies.

TABLE 3

Loading Days

Works	Season				
	67-68	68-69	69-70	70-71	71-72
(a) Sheep and Lambs					
ST	135	139	139	147	145
PI	98	103	101	111	90
KA	130	132	126	110	116
BE_1	108	103	105	97	103
BE_2	120	119	122	114	117
IS	111	112	107	98	117
FA	113	118	120	111	121
SM	122	135	132	125	130
PA	125	120	105	119	111
PU	78	79	71	81	79
BU	78	77	87	96	109
BA	107	100	110	112	108
GO	111	112	105	116	113
IN_1	-	76	83	91	96
IN_2	119	117	114	116	118
BL	-	77	70	78	75
(b) Cattle					
BE_1	90	107	131	107	97
BE_2	156	178	184	172	127
IS	110	129	153	132	122
PA	-	-	-	-	68
PU	-	-	52	50	44
BU	-	-	48	49	50
BA	96	96	111	110	103
IN_1	-	-	72	70	,54
IN_2	-	59	75	81	69
BL	25	25	24	29	21

Source: South Island Freezing Companies Association.

TABLE 4(a)

Percentage Inter-provincial Movement of Livestock Killing Supplies

Killing Province		Killing Supply Province					
		Nelson	Marlborough	West Coast	Canterbury	Otago	Southland
(a) 1970-71 Season							
Nelson	L	99.0	1.0				
	S	100.0					
Marlborough	L	1.5	98.5				
	S	3.6	96.4				
Canterbury	L		2.3	2.2	88.8	6.6	0.1
	S		1.4	2.7	85.5	8.4	2.0
Otago	L				11.1	83.7	5.2
	S				10.3	81.8	7.9
Southland	L				2.6	13.5	83.9
	S					9.3	80.7
(b) 1971-72 Season							
Nelson	L	96.8	3.2				
	S	99.8	0.2				
Marlborough	L	0.2	97.5	1.2	1.1		
	S	0.1	94.9	0.6	4.4		
Canterbury	L		1.8	2.2	90.0	6.0	
	S		2.2	3.7	89.5	7.2	0.4
Otago	L				9.6	85.3	5.1
	S				14.6	74.3	11.1
Southland	L				0.2	13.0	86.8
	S					13.3	86.7

Source: South Island Freezing Companies Association.

TABLE 4(b)

Sheep and Lamb Movement for Slaughter

Season	Total Kill (10^6 LE)	% Normal Haul[1]	% Medium Haul[2]	% Long Haul[3]
1967-68	16.5	89.1	9.5	1.4
1968-69	17.0	88.5	9.5	2.0
1969-70	16.8	88.2	10.0	1.8
1970-71	17.3	87.2	10.2	2.6
1971-72	17.7	88.4	9.4	2.2

Source: South Island Freezing Companies Association.

1 Normal Haul was defined as movement to the closest works.

2 Medium Haul was defined as movement to works within approximately 100 miles of the nearest works.

3 Long Haul was defined as all other movements.

4. RESULTS AND DISCUSSION

4.1 Results:

Two slightly different specifications of the model were investigated. In the first there was no restriction on the annual capacity of any potential plant, and in the second the annual capacity of any potential plant was restricted to 3 million LEs, except for Invercargill which was restricted to a capacity of 6 million LEs.[58]

The solution procedure used was the modified Logan and King approach. The problem of joint processing costs for lambs, sheep and cattle was overcome by using conversion ratios. Progressively lower cost solutions were obtained by using the Stammer modifications and heuristic forcing procedures. Initially it took six to eight iterations to reach a "stable"[59] solution, but later with the greater use of heuristic forcing techniques, low cost "stable" solutions were obtained with fewer iterations.[60]

A range of low cost solutions are presented in Table 5.[61] In the uncapacitated case five to seven plants usually appear and in the capacitated eight to nine.

Areas of high livestock density - for example South Otago and Southland - are always serviced by a plant. In all low cost solutions plants are export orientated.

Consider the uncapacitated case. In the lowest cost solution (Solution 3) plants only occur at five locations compared with the fourteen locations actually existing. This consolidation is achieved by greatly expanding capacity at four locations (Islington, Smithfield, Balclutha and Invercargill) and locating a new plant at Blenheim (rather than Picton).

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[58] Invercargill was restricted to 6 million LEs because of the high concentration of killing supplies in the surrounding area.

[59] According to Logan and King criteria.

[60] The extent to which heuristic forcing strategies should be used appears rather arbitrary.

[61] Figure 6 gives some examples of livestock flows for "low cost" solutions.

Note that Solution 4 has the same number of plants as Solution 3. The only change is that Invercargill has enlarged at the expense of Balclutha but has had to draw stock from further away and hence the total cost has increased.

There are a number of solutions which are similar in terms of cost (for example, Solutions 2, 6 and 8), but differ markedly in locational pattern. This is a situation in which the actual locational pattern could well be decided by political or social considerations (that is, non economic criteria might become important).

Alternatively a high cost solution (say Solution 13) might be chosen in preference to a low cost one because of its regional development advantages.

The capacitated case indicates the relative cost penalty of more smaller works rather than fewer larger works. Thus the difference in cost between Solution 3 and Solution 26 (the best capacitated solution) is $0.304 m., or 17.8 per cent.

In general the results indicate that the optimum and other low cost solutions consist of fewer, larger and more centralised processing plants than exist at present. These results have occurred because the unit throughput cost savings in processing from having larger plants, are greater than the difference between unit assembly costs per mile for livestock and unit distribution costs per mile for processed products, where unit assembly costs per mile are greater than unit distribution costs per mile.

TABLE 5 : Results : Relative Costs and Associated Combined Capacities

Potential Plant		Present Throughputs[a]	(a) Uncapacitated Case: Capacities (in 10^4 LEs)																		(b) Capacitated Case[(c)]: Capacities (in 10^4 LEs)									
Solution No.			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Stoke	ST*	41										44	44	139	44	44	44	44	48	48		44			116	126				
Blenheim	BL		130	130	126	126	126	126	126	126	126	62	62		82				78	78	130		130				130	130	130	130
Picton	PI*	52														62	72	62				72		126						
Greymouth	GR																		29	29										
Waipara	WP													125	108				104	104										
Kaiapoi	KA*	65											368						63	63	300	300		300						
Belfast	BE**	202										368				368	358	368					167							
Islington	IS*	124	344	357	348	348	348	348	348	348	348				88				89	89			177		300	300	300	300	300	300
Kirwee	KI																		63	63										
Fairfield	FA*	99											198	408	350				198	198	253	274	209	259	275	265	261	242	242	242
Smithfield	SM*	86	520	507	520	520	488	488	488	520	520	520		202	202	520	520	520	122	122	300	300	300	300		300	300	290	202	290
Pareora	PR*	134											322						80	80					300					
Pukeuri	PU*	161												120	120				88	88									199	
Palmerston	PL																		32	32								111		
Burnside	BU*	157					179	197	175										48	48										199
Milton	MI											98				98						300								
Balclutha	BA*	175			388	218	159	93					577	207	207				176	176	300		300	298	292	292	300	300	300	292
Gore	GO*	174	577	577				319	434	487	487			370	370		577	577	280	280	300	300	300	300	300	300	300	300	300	300
Invercargill	IN**	495	702	702	891	1061	973	702	702	683	702	1181	702	702	702	1181	702		682	600	600	600	600	600	600	600	600	600	600	600
Bluff	BL*	234																702		82		83								
Omakau	OM								109	90									48	48	90		90	90	90	90	82			
Waipiata	WP																		45	45										
	Relative Cost[b]		1.795	1.793	1.708	1.741	1.760	1.810	1.739	1.803	1.803	1.965	2.099	2.039	2.133	1.970	1.859	1.975	2.880	3.054	2.024	2.185	2.108	2.021	2.058	2.051	2.051	2.012	2.052	2.044
	Number of Plants in Solution		5	5	5	5	6	7	6	6	6	6	7	8	10	6	6	6	18	19	8	9	9	8	8	8	8	8	8	8

(a) Does not sum to model throughputs because of model assumptions.

(b) Units $\$10^6$M (Note, the model only evaluates relative cost and not total costs.)

(c) All plants restricted to 300 except for IN which was restricted to 600.

* Existing works.

** Two works.

FIGURE 6

Examples of the Flow of Livestock
in "Low Cost" Solutions

Example 1

Uncapacitated Model with
Relative Cost of $1.796M

KEY

⟶ Sheep and Lamb Flows

- - → Cattle Flows

BL Processing Plants
in Solution

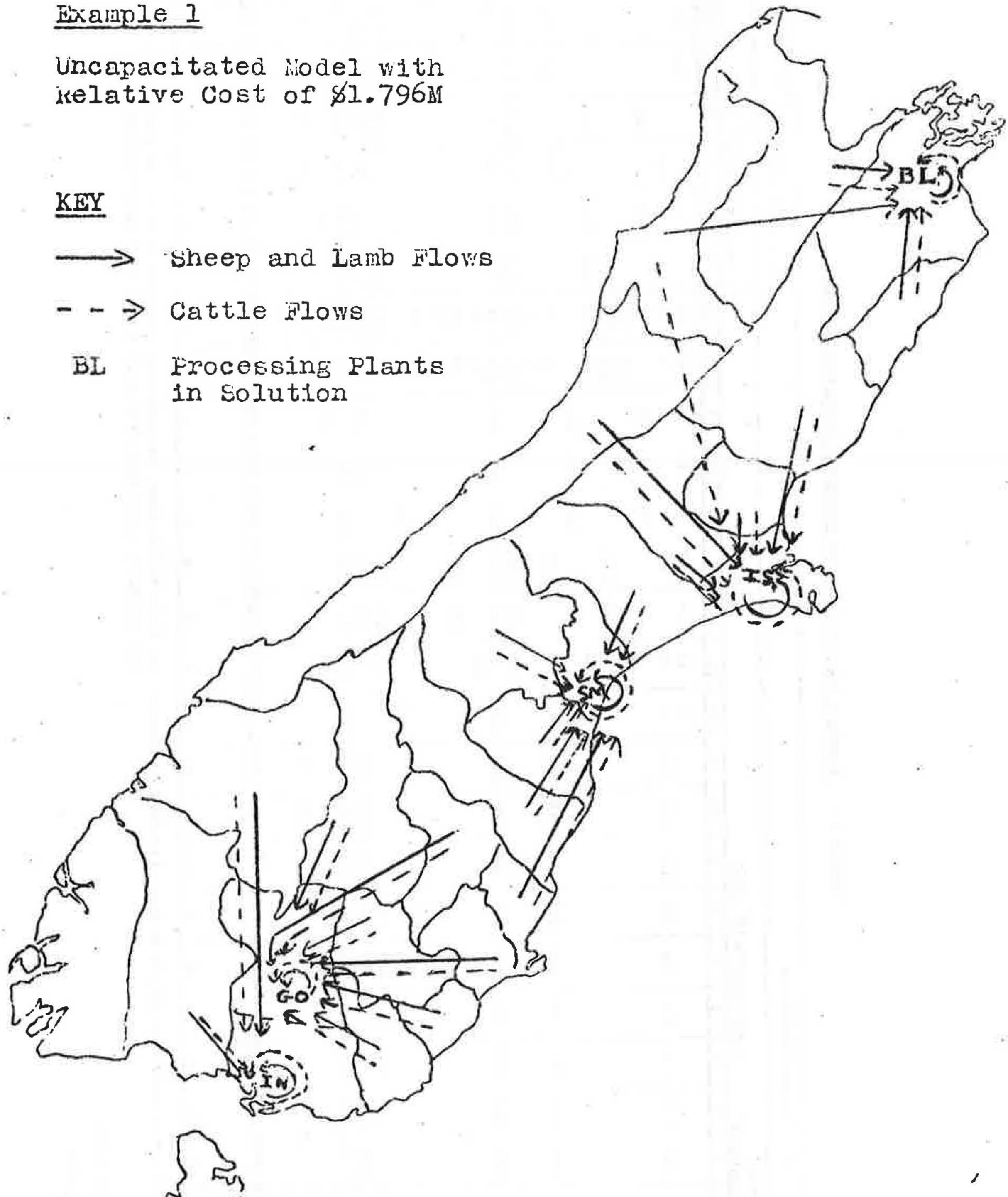


Figure 6 (cont'd)

Example 2

Uncapacitated Model with
Relative Cost of $1.739M

KEY

——> Sheep and Lamb Flows

- - > Cattle Flows

BL Processing Plants
in Solution

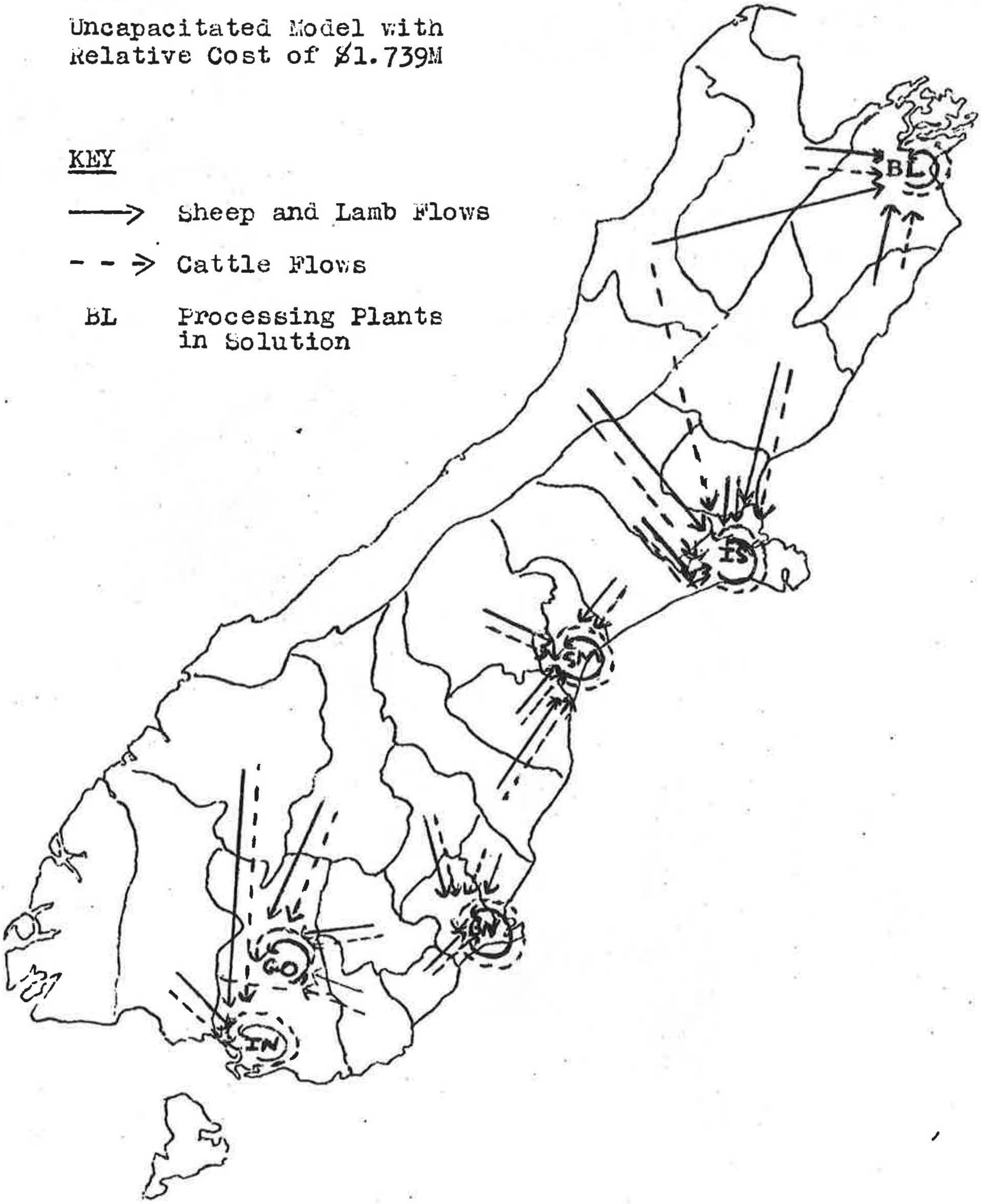


Figure 6 (cont'd)

Example 3

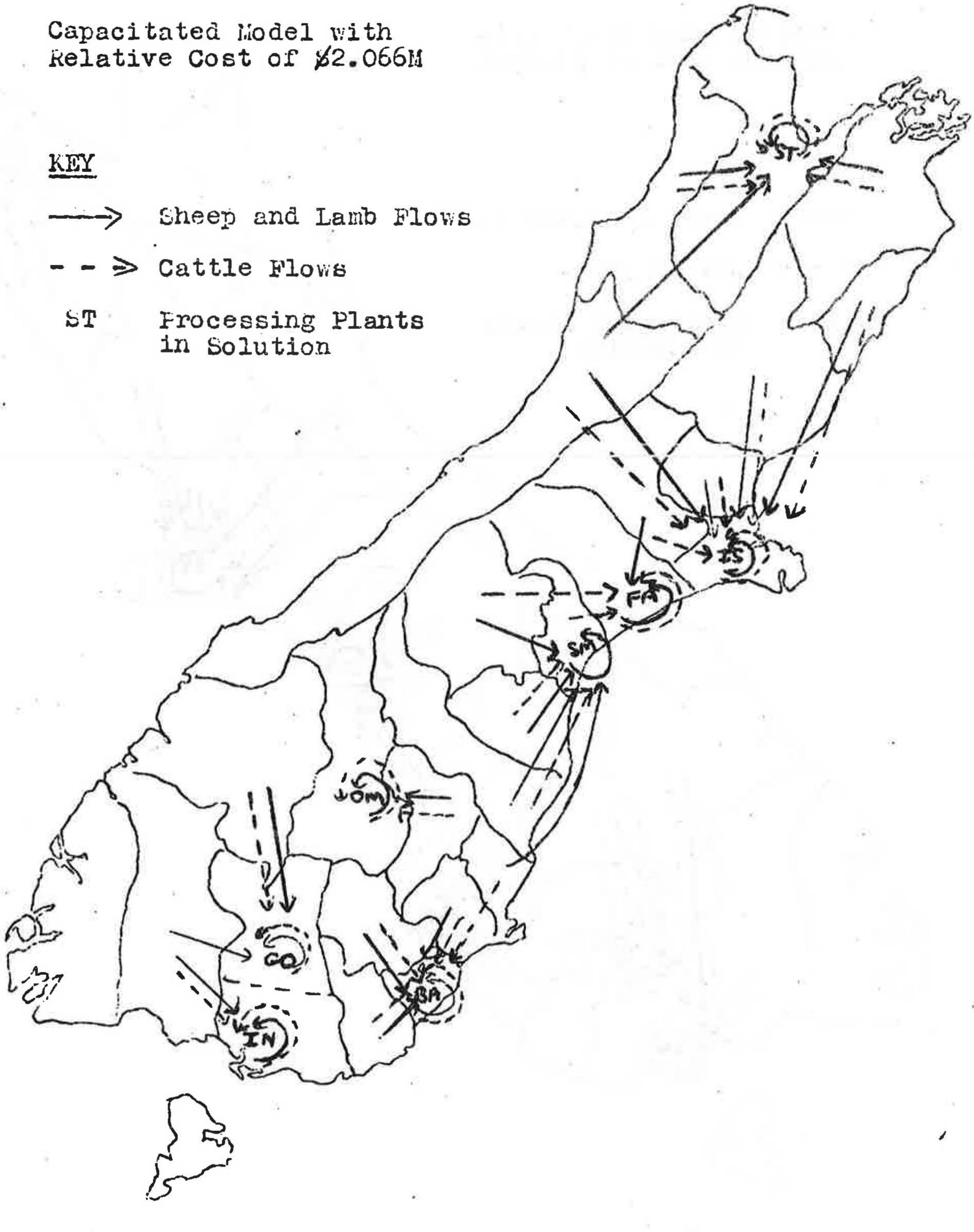
Capacitated Model with
Relative Cost of $2.066M

KEY

——> Sheep and Lamb Flows

- - > Cattle Flows

ST Processing Plants in Solution



4.2 Sensitivity of the Results:

Before any policy implications can be drawn it is necessary to consider the stability of solutions with respect to variations in the input parameters and changes in some of the simplifying assumptions which were made.

The results have occurred because the unit throughput cost savings from having larger plants are greater than the differences between unit assembly costs per mile and unit distribution costs per mile. Table 6 examines in which direction the input parameters would have to change to have a decentralising (i.e. supply region orientated) influence on the locational pattern of low cost solutions.

Consider the stability of the low cost solutions if the assumption of regional supplies being homogeneous subsets of total killing supplies is weakened. If some of the killing supplies from different regions have different seasonal peaks and are complementary this implies that centralised facilities will require a lower total daily killing capacity and there will be lower total capital costs. Thus a centralised locational pattern will have cost advantages over a supply region orientated locational pattern, where the different processing plants' daily capacities have to accommodate the seasonal peaks of their regional supplies.

The centralised locational patterns are also stable if economies of scale in operating costs are assumed (a steeper LRAC function will have a centralising influence, see Table 6). If external or agglomerating economies and the cost of other production inputs[62] are included the results will still be stable.

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[62] Costs of production inputs are higher for inland processing plants.

TABLE 6

Changes in Parameters which will have a Decentralising Influence on Low Cost Solutions

Parameter	Change	Comment
Supply	Increase in Regional Supplies	Allow for larger processing plants in supply regions
Transport Costs	Increase in unit AC/mile or decrease in unit DC/mile.	Difference in unit AC/mile and unit DC/mile will increase.
Processing Costs	Flattening of LRAC function	Unit cost advantages from having larger plants will be not as great.

4.3 Policy Implications and Further Research:

The results generated in this study provide an efficiency index or "benchmark" with which the existing structure of the industry can be compared. They indicate that there would be an annual cost saving of approximately $1 m. from any one of the low cost solutions.[63] When compared with the total cost of assembly, processing and distribution, this represents approximately a 2-3 per cent cost saving.[64,65]

Because of the static and long run nature of the model, the results offer little direct guide as to desirable change in the existing structure of the industry. To investigate this problem the model would have to be reformulated to include the actual costs of the existing structure. Costs to be included would be: costs of maintaining and upgrading existing facilities to meet processing requirements: costs of expanding existing facilities: and costs of establishing new facilities. Such a problem would best be evaluated in a dynamic framework which would also include projected increases in livestock supplies and changes in export demands. Thus, little can be said about the recommendations for new works in such areas as Northern Southland, Central Otago and the West Coast.

Other problems which the methodology demonstrated here could be adapted to investigate, include:

(a) Investigation of changes in transportation methods (e.g. the greater use of containers).

(b) Investigation of the use of different export ports for different markets.

(c) Investigation of the spatial separation of the different stages of processing.

(d) Investigation of the roles export works and domestic abattoirs should play in supplying domestic demand.

(e) Assessment of the "costs" of regional development and decentralisation.

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[63] The costs of the existing locational pattern of freezing works was evaluated within the model.

[64] This was based on a cost estimate given by Freezing Works Management.

[65] This percentage would probably be increased if the cost advantages from greater utilization of capacity and economies of scale in operating costs were included.

(f) Investigation of the advantages and disadvantages of alternative forms of ownership of processing facilities.

4.4 Conclusion:

In Section 1 four questions were posed:

(a) What is the most efficient locational pattern (i.e. size, number and location) of freezing works in New Zealand?

(b) What are the significant cost factors involved in such a system and how do they relate together?

(c) How does the existing system compare with the theoretically most efficient system?

(d) How should the existing system be changed to cater for increasing numbers of livestock for slaughter, and changing processing requirements?

In this study a long run, centrally controlled, static model was used to investigate the above questions for the South Island. The results provide information to answer questions (a), (b) and (c). The most "efficient" (low cost) locational pattern in the South Island consists of fewer, larger and more centralised processing plants. This conclusion is dependent on the "balance" in relationships between assembly, distribution and processing costs. Detailed investigation of question (d) was beyond the scope of the model. Although the study highlights some of the cost advantages from having a more centralised, export orientated locational pattern, these generalisations cannot be easily put into effect for a system in which there is decentralised ownership as at present.

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APPENDIX I

QUESTIONNAIRE

Work No. .....

GENERAL

1. (i) How many mutton chains have you? ......
   (ii) Are any of these learner chains? ......
2. What is your maximum killing capacity (for 8 hour day)? ......
3. What are the limiting factors for this capacity? ......
4. What type of beef killing and dressing facilities have you? ......
5. What is your maximum killing capacity (for 8 hour day)? ......
6. What are the limiting factors for this capacity? ......
7. Comments.

OUTPUT (1971/72 season)

1. What was your lamb and mutton output? (State types)
   (a) Export
   (b) Local
2. What was your beef output? (State types, e.g. boned-out)
   (a) Export
   (b) Local
3. What were your by-product outputs? (State products and quantities.)

MANPOWER

1. Sheep and Lambs. What are your labour requirements for the following stages of production?

(a) Pre slaughter Types (e.g. foreman, butcher, assistant, etc.)

(i) Full capacity
(ii) $\frac{3}{4}$ capacity
(iii) $\frac{1}{2}$ "

(b) Slaughter & Dressing

(i) Full capacity
(ii) $\frac{3}{4}$ capacity
(iii) $\frac{1}{2}$ "

(c) Cooling floor, freezer, loading out

(i) Full capacity

(ii) $\frac{3}{4}$ capacity

(iii) $\frac{1}{2}$ "

2. Beef Types (e.g. foreman, butcher, etc.)

(a) Pre slaughter

(i) Full capacity
(ii) $\frac{3}{4}$ capacity
(iii) $\frac{1}{2}$ "

(b) Slaughter & Dressing

(i) Full capacity
(ii) $\frac{3}{4}$ capacity
(iii) $\frac{1}{2}$ "

(c) Packing

(i) Full capacity
(ii) $\frac{3}{4}$ capacity
(iii) $\frac{1}{2}$ "

(d) Freezing and loading out

(i) Full capacity
(ii) $\frac{3}{4}$ capacity
(iii) $\frac{1}{2}$ "

(e) Other

3. By-Products. What are your labour requirements for your by-product activities?

4. Office staff requirement.

Clerks (male) (female)
Typists
Other

5. What managerial staff do you have?

6. What types and numbers of technical and maintenance staff do you have?

LAND, BUILDINGS, EQUIPMENT

1. (i) What is the acreage of your property? ....

(ii) What area is occupied by plant and yards? ....

2. What is the floor area of:

(i) Your plant ....

(ii) Sheep and lamb slaughter and dressing facilities ....

(iii) Cattle ....

(iv) Freezers ....

(v) By-product facilities (disaggregate into departments if possible).

(vi) Workers ammenities ....

(vii) Offices ....

(viii) Workshop and maintenance facilities ....

(ix) Other ....

3. What equipment do you have?

4. Comments

UTILITIES

1. What are your electricity requirements?

(i)	Annual	....
(ii)	Daily at peak of season	....
(iii)	Daily at slack of season	....

2. What are your water requirements?

(i)	Annual	....
(ii)	Daily at peak of season	....
(iii)	Daily at slack of season	....

3. What are your oil requirements?

(i)	Annual	....
(ii)	Daily at peak of season	....
(iii)	Daily at slack of season	....

4. What are your coal requirements?

(i)	Annual	....
(ii)	Daily at peak of season	....
(iii)	Daily at slack of season	....

APPENDIX 2

BREAKDOWN OF CAPITAL COSTS

1. Land
2. Roading and Car Park
3. Area Lighting
4. Rail Siding
5. Fencing
6. Planting and Landscaping
7. Stormwater Drainage

8.1 Sewage Reticulation

8.2 Treatment Ponds

9. Water Reservoir
10. Stockyards
11. Beef Slaughter
12. Mutton Killing
13. Cooling Floor
14. Beef Chillers
15. Offal Processing
16. Fancy Meats
17. Pet Foods
18. Hides and Skins
19. Lamb Blast Freeze
20. Skid and Gambrel Cleaning
21. Rending
22. Meal Store
23. Corridors
24. Bag Store
25. Boning Room
26. Carton Store
27. Freezer Tunnel
28. Cold Store
29. Engine Room
30. Boiler Plant

31. Hot Water Supply
32. Compressed Air Supply
33. Cold Water Supply
34. Waste Treatment
35. Workshop
36. Vehicles
37. Laundry
38. Office
39. Vet's Offices
40. Works Laboratory
41. Works Amenities
42. Cafeteria
43. General Store
44. Fire Fighting
45. Electrical Supply

<u>Source</u>: Morrison and Cooper and Partners,
Consulting Engineers and Architects.

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