THE NEW ZEALAND

WHEAT AND FLOUR INDUSTRY:

MARKET STRUCTURE AND POLICY IMPLICATIONS

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Research Report No. 124

Agricultural Economics Research Unit
Lincoln College

April 1982

ISSN 0069-3790

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Lincoln College, Canterbury, N.Z.

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PREFACE

This report is an abridged version of a masterate thesis undertaken by Mr B. Borrell under the supervision of Dr A. Zwart within the Department of Agricultural Economics and Marketing at Lincoln College.

The subject of physical distribution of wheat and flour within New Zealand addressed by the authors of this report should be of considerable interest to wheatgrowers, participants in the marketing chain, and New Zealand flour consumers. In that cost reductions seem likely by a relaxation of controls on the distribution system, it is hoped that this report will attract feedback to enable further constructive and more meaningful use of the model that has been evolved.

P. D. Chudleigh
Director

ACKNOWLEDGEMENTS

The authors would like to thank the Research Division of the Ministry of Transport for financial assistance in carrying out the study.

SUMMARY AND CONCLUSIONS

The basic aim of this study has been to seek a more rationalised market structure for the New Zealand wheat and flour industry. Current policy constraints are seen to insulate the market from its underlying economic forces. These forces include the economies of scale present in the milling and transport sectors of the market and inter-regional competition. The policy constraints relate to the policy instruments of Government, namely milling quotas, standardised wheat and flour pricing, import controls, and fixed inter-regional trade flows.

The fact that policy constraints have been insulating the market from its true economic forces for a long period has prevented structural adjustments within the market. Not surprisingly the industry's problem is seen as one of structural realignment. The task of the study has been to seek the location, number and size of mills, the inter-regional trade flows for wheat and flour including the selection of appropriate modes of transport, and regional price differentials that more accurately acknowledge and align the market's structure with the economic forces of the market. The results of the model used to analyse this problem indicate that substantial improvements in the market's performance could be achieved.

In chapter two the market structure of the existing industry was depicted as dispersed and fragmented. A market structure resembling that of the existing industry was represented using a capacitated transhipment model. In this model quantity constraints were used to represent milling quotas and other quantitative restrictions of the existing industry. The solution of this model provided estimates of the opportunity costs imposed by these constraints. This information indicated that the value of short term marginal changes that could be achieved by allowing extra bulk shipments to the North Island, and by allowing greater milling at North Island mills would be significant.

To measure the values of possible long term structural changes it was necessary to remove constraints from the model and take account of potential economies of scale. When transportation constraints were dropped and the economies of scale of shipping and port handling were acknowledged, the model showed that $1.87 m. could be saved. This represents a saving of 10 per cent over current costs of the industry and resulted from transporting all wheat to the North Island by bulk ship. This contrasts with the existing industry where four modes of transport are used to transport wheat to the North Island.

When milling constraints were dropped, further centralisation of the shipping operation became apparent. The solution to this problem showed that no flour should be transported from the South to the North Island, but instead that extra wheat should be transported to the North Island by bulk ship and subsequently be milled to flour at current mill locations of the North Island. This was shown to result in a further cost reduction of $2.26 m. which is a further 12 per cent saving over marketing costs of the current industry.

When the scale economies of milling were represented in the model, it was shown that further centralising the milling operations of the industry would lead to even greater cost reductions. The best solution to this problem showed it was only necessary to have five mills in New Zealand compared to the current number of 21. These were shown to be located at Mount Maunganui, Wellington, Christchurch, Dunedin and Invercargill. This resulted in an additional cost reduction of $1.84 m., an extra 9 per cent saving over marketing costs of the current industry.

The total savings resulting from rationalising and centralising the transport, processing and handling operations of the industry represented, in full, a 31 per cent saving over current marketing costs. It was further shown that additional savings might be achieved if full rationalisation of the sources of supply for North Island wheat could be made. Examples of these savings were shown by allowing imports of Australian wheat. Such savings would result in a market where competitive spatial equilibrium prices and quantities applied. However, as production costs and therefore realistic supply functions were not included in the model, the full impact resulting from spatial equilibrium prices could not be determined. For example, it was not possible to estimate what savings in transfer costs might arise from rationalising the quantities of wheat grown within different regions of New Zealand. In theoretical terms this would further decrease costs by also centralising wheat production in New Zealand.

The increased performance shown to result from the removal of policy constraints of the model does not necessarily imply creating a free market wheat and flour industry. The results establish market structure norms for the industry; and they do not imply any specific conduct for the industry. They do, however, raise some important questions concerning what market conduct might be required to achieve the norms suggested by the model. It is in this realm that the results raise implications for policy makers concerned with New Zealand's wheat and flour marketing policy. In an industry where there is a single authority responsible for marketing, the potential for directing the industry towards a particular structure exists as the central authority has the power to implement and co-ordinate the findings of the market model.

CHAPTER 1

INTRODUCTION

Often the markets of an economy fail to achieve the objectives of economic policy. As a result, Government policy makers may become involved in the resource allocation decisions of certain industries. The expedience of policy makers is to use a variety of intervention devices or policy control instruments in an attempt to better achieve economic policy objectives. However, the economic implications of such controls on the organisation of an industry can be complex, as can be the economic choice between the many feasible alternative ways of organising an industry.

The New Zealand wheat and flour industry is one industry which has attracted considerable statutory intervention. Government involvement in the industry is aimed at reducing the inter-year variability of wheat supplied to the market and to ensure "orderly" marketing of the industry's product.

Many of the controls used by Government in the wheat and flour industry have been in effect since before the inception of the New Zealand Wheat Board in 1965. Essentially, these controls have imposed rigidities on the industry. Although the wheat and flour industry is dependent on other markets of the economy which have undergone enormous technological and economic change, the rigidities of policy have only permitted relatively small changes in the structure and conduct of the wheat and flour industry. For this reason, long run organisation changes necessary to maintain the marketing efficiency of the industry may not have been able to occur.

In recent years, marketing costs associated with assembly, storage, milling and distribution of wheat and flour (the primary areas of Government involvement) have been significant, totalling approximately $20 m. in the year ended 31 January 1979. Because of the significance of these costs and because of the effects of the current policy controls, a study of the industry's marketing efficiency is considered a worthwhile area of study. Accordingly, the primary objective of this study is to examine the efficiency of the market organisation in the New Zealand wheat and flour industry.

To achieve this objective a market model is used firstly to describe the existing industry and, secondly, to study the effects of reducing some of the policy controls. As the current Government controls largely effect the spatial organisation of the industry, the market model used in the study is designed to examine problems concerning transportation, inter-regional trade and facility (processing plant) locations. The model uses the transportation algorithm and heuristic procedures discussed in other reports published by the Agricultural Economics Research Unit (Higham et al, 1972 and McCarthy et al, 1972).

The study includes an examination of the wheat and flour industry in New Zealand as it extends from farm gate to baker or retailer. In the following chapter the basic functions and problems of the industry are discussed. In chapters 3 and 4 a description of the model used to represent the industry's problems is detailed. The results of this model are in chapter 5. This is followed with a final chapter discussing the limitations and policy implications arising from the results.

CHAPTER 2

OUTLINE OF THE INDUSTRY

2.1 Introduction

The purpose of this chapter is to describe the basic functions and problems of the industry. This requires a brief examination of the basic structure and conduct of the New Zealand wheat and flour market.[1]

2.2 Basic Functions

The primary function of the industry is to meet New Zealanders' inelastic demand for approximately 220,000 tonnes of flour per annum (Borrell, 1980, p. 8-9). This demand is regionalised in accordance with population density, and is therefore predominantly in the North Island with a large proportion of that demand in the Auckland and Hamilton regions. This pattern of demand must be satisfied from dispersed South Island supply regions or from imported Australian wheat. Considering the bulky nature of the products, wheat and flour, the logistical problem of the industry is a large one. Voluminous products must be transported considerable distances to the market place. En route these products may require transhipment several times; all wheat must be transhipped in the process of milling wheat to flour; transhipment may also be required when different modes of transport must be used over long journeys, and other transhipment is necessary when either wheat or flour must be stored to bridge the gap between harvest time and the period when flour is required by consumers up to 10 months later.

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[1] For a more detailed examination see Borrell (1980) chapters 2 and 3.

A secondary function of the wheat and flour industry is to supply inputs to the stockfood industry. This industry provides a market for wheat of inferior quality that is graded as unsuitable for milling. It also provides a market for the by-products of flour milling, namely bran and pollard. In this way the stockfood industry absorbs most surplus wheat products. Only rarely has New Zealand exported any wheat.

The basic problem involved in carrying out the functions of the industry is an economic one of satisfying the demand for flour at least cost.

2.3 The Basic Problem

On farm costs, storage costs, transport costs, processing costs, and product prices are all market signals which can be used to guide the agricultural industry in decisions concerning industrial organisation. In theory, only where these guides lack distortions and are readily available and understood by entrepreneurs, will they relay correct demands to producers within the wheat and flour industry, as well as transmitting supply conditions to consumers. Under these circumstances the market mechanism will operate to co-ordinate internally the allocation of resources. This is a competitive market situation where the conduct of the industry will be determined by the forces of supply and demand; prices and profits will be at their optimum and output levels and distributional patterns will be those which enable the market to achieve a Pareto optimum.

Unfortunately market imperfections are common characteristics of agricultural markets and may require some form of external intervention to be corrected. It is perhaps for this reason that the New Zealand Government has developed a specific policy of intervention in the wheat and flour industry.

Although the demand for flour is inelastic and relatively constant from year to year, the supply of New Zealand milling grade wheat is variable between years. Accordingly the trade flows also vary from year to year and in years of domestic shortfall Australian wheat must be imported. It is perhaps the volatile nature of the wheat and flour market that is seen by Government to create market imperfections, and the subsequent intervention has directly and indirectly altered the structure and conduct of the industry from that of a competitive market industry.

2.4 The Structure of the Industry

A unique and influential part of the industry's market structure is the presence of a quasi-government marketing authority, the New Zealand Wheat Board (NZWB). This authority has complete control of the purchase and sale of wheat and flour, including the quantitative control of all imports of product under industry control. The Board also has complete responsibility for transportation and storage, most of which is carried out by farmers, brokers, transport operators and the Railways Department under contract to the Wheat Board. Under the instructions of the NZWB, brokers organise the movement of wheat from "on" or "off" farm storage by trucks or trains to either local flour mills, temporary port storage facilities or to grain consolidators.

From temporary storage facilities 5000 tonne bulk cargo ships are used to transport wheat from Bluff to Timaru to Auckland or Mount Maunganui. Currently these ships are operated by one shipping company operating under a one year tender contract with the NZWB.

The trade flows by bulk ship are the predominant movements of South Island wheat to the North Island. In years when New Zealand is self-sufficient in wheat production bulk shipments account for approximately half the traffic of wheat (either as wheat or as flour measured in wheat equivalents) to satisfy North Island demand for flour. This amounts to approximately 100,000 wheat equivalent (w.e.) tonnes. The remaining 100,000 (w.e.) tonnes are transferred by train or by container shipping under contract with transport operators, grain consolidators who prepare the grain for transportation, and the Railways Department.

Approximately half of this remaining 100,000 (w.e.) tonnes destined for the North Island is in the form of flour. This occurs because milling quotas allocated to South Island mills by the NZWB allow for surplus production in the South Island. There is a total of fourteen mills in the South Island, all of which are located in Canterbury or South Canterbury.

In the North Island there are a total of seven mills. These are located at Auckland, Mount Maunganui, Wellington and Palmerston North and are larger than most mills in the South Island (see Borrell, 1980, p. 22). Throughout the country as a whole, mill sizes range from those milling less than 4,000 tonnes of flour per annum to one in Auckland milling 70,000 tonnes per annum. The seven larger North Island mills have a combined annual milling capacity of approximately 165,000 tonnes of wheat compared to 130,000 tonnes for the fourteen South Island mills.

The allocation of quotas among mills does not vary greatly from year to year. It is perhaps for this reason that in years when the production of wheat is below a level of self-sufficiency it has been the South-North trading in wheat rather than flour that has been cut. Bulk ships have been used to service the trading of wheat from Australia to the North Island rather than on the South-North route. In the two years (ending 31 January) 1975 and 1976 more than 135,000 tonnes were imported in each year and therefore transported from Australia. In 1977 only 10,000 tonnes was imported from Australia. For a full statistical history of New Zealand imports of wheat see Borrell (1980, p.25).

In summary, the structure of the industry can be described as one where the marketing operations of transportation, storage and milling are each carried out by diverse means. The industry is notably decentralised and whilst the Wheat Board is a sole marketing and decision making authority designed to integrate and co-ordinate the market, still many private and independent organisations are involved, including farmers, brokers, port authorities, shippers and other transport operators, millers and bakers. To this extent the structure of the wheat and flour industry is dispersed and fragmented. By contrast the conduct of the industry is notably centralised.

2.5 Conduct of the Industry

Pricing behaviour of the industry, the geographical and distribution decisions, the degree of competitiveness or co-operation practised, and the adjustments of quality and quantity of the industry's products are all aspects of conduct which are determined largely by the Government wheat and flour marketing policy. In this way the conduct of the industry is centralised, and is quite different than that which would be expected in a competitive market.

2.5.1 Policy Objectives in the New Zealand Wheat and Flour Industry

Without being able to determine all the objectives or measure all the separate effects of policy on all groups in society, it is unlikely that policy can ever seek socially optimal solutions. However, if policy makers can ensure that the measurable benefits arising from an industry exceed its measurable costs, this will at least allow policy makers to presume that the set of policies chosen will lead to an improvement rather than a deterioration of national welfare.

The obvious and measurable primary benefit arising from the wheat and flour industry is the supply of flour for New Zealand consumers. The obvious and measurable costs of the industry are the financial costs relating to wheat growing, transportation, handling and processing. If New Zealand consumers' demands for the end products can be assumed to be completely inelastic and the prospects of exporting unlikely, it is reasonable to assume that the ultimate or primary policy objectives of Government for this industry should simply be to provide the fixed amount of flour required by New Zealanders each year at minimum costs. This however, does not appear to be the objective actually pursued under the wheat and flour marketing policy.

The precise policy objective Government has for the wheat and flour industry is not clear. The Wheat Board Act 1965 specifies "Self-Sufficiency" as the major objective for the industry. Chudleigh et al (1978) suggest otherwise. Their study concludes that stable prices would appear to have been the policy objective pursued. These objectives are only important if they ensure the supply of flour at minimum cost, and should be, therefore, at most, intermediate or secondary objectives.

If primary and secondary objectives have become confused it is likely that the minimum cost imperative which is necessary to maintain efficiency in the industry has not received the priority it deserves. The effect of this on the conduct of the industry might best be seen by analysing the effectiveness of the actual policy mechanisms which are currently in use in the industry.

2.5.2 Policy Instruments

The Wheat Price

A most important instrument of the wheat and flour marketing policy has been the Government's fixing of the wheat price.

The theory of price equilibrium in spatially separated markets indicates that prices in different localities should differ by less than the transfer cost if the total transfer cost is to be kept to a minimum. Trade flows should then only occur internationally, inter-regionally or intra-regionally if the cost of transport and handling the product does not exceed the price differences that exist in the absence of trade.

Price equilibrium in this sense is not able to occur in the New Zealand wheat industry under the existing pricing arrangements. Wheat growers have not received market signals determined by the forces of supply and demand of the New Zealand wheat and flour industry. Instead, Government have fixed the price to be paid to farmers. The Department of Trade and Industry, in collaboration with other groups of the wheat and flour industry, have determined this price for Government. Even under the new wheat pricing policy, whereby the price of wheat is set according to a three year moving average of Australian f.o.b. wheat prices, the New Zealand price is standardised to all producers, payable at the farmer's nearest railway station. The transport costs from this location to either the flour mill of destination or from there to a point 35 miles from the bakers of final destination, whichever is the greater, are paid by the Wheat Board.

Effectively, under this current pricing arrangement, individual producers in the industry are insulated from the effects of differing transport costs. This means North Island farmers in close proximity to mills are confronted by exactly the same set of prices as a South Island farmer whose wheat is shipped to the North Island at an average cost of $45 per tonne (NZWB, 1978). Similarly at an intra-regional level, wheat farmers growing their product close to the Dunedin market receive the same prices as farmers $20.00 per tonne further away at Cromwell in Central Otago. On other agricultural commodities, producers in more remote locations incur higher transport costs in transferring their products to market.

Where farmers are insulated from transport costs, a form of cross subsidisation among wheat growers will occur. Farms at spatially less favourable locations can grow and sell more wheat without incurring additional transport costs. However, this deprives those farmers at true spatial advantage from the otherwise higher prices required to induce them to produce the wheat those farmers in remote locations would not produce, if confronted by spatially discounted prices. As a result of this, an opportunity cost, or producer tax, is imposed on proximate farmers to provide more remote farmers with higher prices or a producer subsidy. The consumer bears the burden of the increased total cost of transport which arises under such a scheme.

Another sector of the industry where spatial price equilibrium is not allowed to occur is in the flour milling sector.

Flour Milling Allocations

Millers are afforded complete insulation from the cost of transport inputs. This, however, would not increase total costs for the reasons described above, but it does lead to the substitution of more expensive transport inputs of a certain product form (namely flour) for the cheaper transport inputs of an alternative product form (namely wheat) which would cause costs to be greater. Although flour is only equivalent to 78 per cent the weight of wheat, more specialised, more hygienic and therefore, more expensive transportation is required in transferring this product. This would suggest that in general wheat should be milled at the point of final demand.

Economies of scale experienced in the milling of wheat to flour should also be significant factors influencing optimal mill location. Both labour, plant (capital) and throughput economies are experienced in the flour milling operation in New Zealand.[2] Therefore total costs of transport and milling may be minimised by balancing increasing per unit delivery costs of flour, against the cheaper per unit costs of assembling wheat and the decreasing costs of centralisation in the milling operation. This will minimise the aggregate transfer and processing costs and will also determine the quantity any mill in one locality should produce. Site factors relating to availability of labour, the markets for bran and pollard and external economies may also have a bearing on the location of mills if price equilibrium were allowed to occur.

The current pricing conduct prevents transport, site or agglomeration factors from influencing the structure of the milling sector in New Zealand. Instead, Wheat Board allocated flour quotas determine the location, number and size of mills. The prices paid to mills are designed mainly to keep existing mills solvent, rather than encouraging a more suitable industrial structure. The prices are calculated on a cost plus basis by the Department of Trade and Industry and, since January 1978, individual prices have been set to take account of the varying cost structures of the different sized mills operating at thirteen localities in New Zealand. Because quotas are used to structure the milling sector, pricing conduct is only a secondary variable influencing the industry's market

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2 Personal communication with flour millers and data from NZFMA confirms this fact.

organisation. However, this is based largely on historical grounds and therefore also ignores the essential economic factors discussed above. The results of this are best summarised in the comment by Judge (1979);

> "Flour milling itself is another example of regulation distorting the free enterprise system and ending up costing the consumer and the country dearly. Under the quota system for wheat one mill in the South Island was closed for health reasons as its plant and buildings were no longer suitable for milling. The mill sold at a goodwill figure in excess of half a million dollars. The consumer in the end has to pay for this and many other similar windfall profits. The profit arising from what are effectively goodwill payments comes only from an antiquated licencing system. Many modern and efficient mills today are receiving massive subsidies because they are not allowed the throughput to keep them fully operative."

Also from the statement:

> "During the whole of the 1976 year, Northern Roller Milling Co. Ltd catered for the combined trade of its mill and Aulsebrooks Allied Mills Ltd (thought to have a capacity in excess of 10,000 tonnes per annum) because of the delay in completion of the latter Company's new mill." (11th NZWB Annual Report, p. 23),

it is evident that surplus capacity is present in the industry and, it might be concluded, the allocation of milling capacity requires greater rationalisation.

There is also evidence to suggest greater industrial rationalisation could be achieved in the allocation of the industry's products between the various modes of transport.

Transportation

There are potential economies of scale in both storage and bulk shipping that may hold implications for what is an efficient transport policy for the industry. Freebairn (1967) and Dickie (1972) both report that significant economies of scale can be exploited in storing wheat. Sharp and McDonald (1971) and Chudleigh (1978) discuss the significance of economies of scale in bulk shipping; these can be considerable. Finding the optimal size of ship and the optimal size, number and location of large centralised storage facilities are complex problems (see Borrell, 1980), only solvable by analysing the trade-offs between many inter-related costs of many spatial and temporal factors. Improvements in the industry's transport policy may be possible if these economies of scale were more fully exploited.

The Wheat Board's current annual contract shipping arrangement results in ships of approximately 5,000 tonnes servicing the inter-island and trans-Tasman shipment of a guaranteed 100,000 tonnes per annum. Although there are three ships each operating this route part-time, under the present loading and unloading rates, this given tonnage could be enough to approximately occupy one ship full-time. If current loading, and particularly unloading rates from bulk ships could be increased, a single 5,000 tonne ship could transport substantially more wheat cargo. As the economies of bulk shipping involve a large fixed cost component (the capital cost) and only minor variable costs, extra volume throughput of cargo would substantially reduce the cost per tonne of wheat shipped.

It is apparent that the main factor currently retarding unloading rates from bulk ships in Auckland and Mount Maunganui is that ships must discharge directly to trucks. This can take up to four days and even longer if bad weather interrupts the operation. In many ports of other countries discharge of grain from ships is conveyed directly to port storage facilities allowing quick turn round of ships.

The current North Island demand for flour requires approximately 220,000 wheat equivalent tonnes to be transferred to the North Island annually. Although the bulk ocean shipping of wheat is probably the cheapest mode of transport available for transferring wheat equivalents to the North Island, it has been Wheat Board policy to also send wheat and flour by other more expensive modes of transport. This has been considered to give the Wheat Board a flexible, multi-mode routing strategy to secure the logistics of the industry.

Because there are only short-term buffer storage facilities in the North Island, flexibility is considered crucial to secure the steady flow of wheat and flour to the North Island. Flexibility allows the Wheat Board to cover the contingencies introduced by transport strikes and hold-up sometimes experienced with current bulk shipping. However, if adequate buffer storage facilities were available in the North Island, such contingencies could be less important as large buffer storage could ensure an uninterrupted flow of wheat to North Island mills. Moreover, without the need for a multi-mode routing strategy, the full tonnage of wheat equivalents could be transported by bulk ship to the North Island, thus enabling the economies of shipping to be exploited. This might enable total industry costs to be reduced if the savings in transport costs from substituting existing transport inputs with the increasingly less costly alternative inputs, outweighed the extra but decreasing per unit cost of port buffer storage.

2.6 Summary

Because of the nature of Government policy influence in the New Zealand wheat and flour industry, the normal workings of the market mechanism do not guide the conduct of operators in this industry. Whilst Government involvement may be necessary in an industry where the market mechanism fails to achieve economic policy objectives, still the underlying economic and market forces must not be ignored in designing policy control instruments.

It has been suggested in this chapter that the current policy determined conduct of the industry may be insulating operators from several very important, innate economic and market forces. The influence of this on the organisation of the industry, it has been purported, may have created an interaction of market conduct and structure that has produced a market performance to which significant improvements could be made.

The next chapter seeks to construct a mathematical model that incorporates the important economic forces of the wheat and flour market. It is intended that this model will then be used to analyse which aspects of market structure and conduct might help improve the performance of this industry. The model will seek to show the potential performance of a perfect market. In this model costs are minimised in supplying flour to New Zealand consumers. In an industry where there is a single authority responsible for marketing, the potential for directing the industry towards such a perfect market exists as the central authority has the power to implement and co-ordinate the findings of the market model.

CHAPTER 3

METHODOLOGY - THE TRANSHIPMENT MODEL

3.1 Introduction

This chapter seeks to embody the theoretical concepts raised in Chapter 2 in a mathematical model of the industry. It is intended that this model be used to determine the industrial organisation that might improve market performance of the wheat and flour industry in New Zealand.

3.2 Selection of Type of Model

The nature of the problem discussed in chapter 2 suggests that many aspects of Government policy have insulated the wheat and flour industry from the economic forces that underlie its markets. It is hypothesised that the rigidities of policy have prevented necessary structural adjustments occuring in the industry and that the lack of structural change may be a factor restricting the market performance of this industry. For this reason, a primary feature of the proposed model is that it be able to show the long term structural responses which might occur if the economic forces of the market were able to influence the industry. To effectively model and analyse such economic forces, an essential feature of the methodology is that it must take simultaneous account of the multi-staged product flows involved in the industry. These include the flows of grain and flour from farms through to mills and, through storage facilities, via the different modes of transport to the eventual delivery points where flour is required in New Zealand. Specifically, the methodology must be able to analyse the structural changes necessary to determine the location, number, and size of marketing facilities, as well as the quantity flows of the industry's products that will minimise the sum cost of purchase, assembly, storage, processing and distribution of wheat and flour.

Because of the aggregate nature of the problem, the determination of appropriate locations for marketing facilities will be a problem of selecting among general regions rather than precise localities. For example, the problem may be to determine whether milling should occur at Ashburton; no attempt will be made to determine where in Ashburton milling should occur. In this way, space can be treated as discrete regions rather than a continuum of infinitely small potential sites.

By delimiting space to a set of potential locations where wheat might be produced, milled and finally demanded as flour, it is possible to represent the basic problem diagrammatically (Figure 3.1).

FIGURE 3.1

Diagrammatic Representation of a Transhipment Model

Known Source Regions		Potential Mill Facilities		Known Final Demand Regions
S(1)		F(1)		D(1)
S(2)		F(2)		D(2)
.	Wheat Flow From Sources To Mills	.	Flour Flow From Mills to Destinations	.
.		Processing Costs		.
.	Assembly Costs	.	Delivery Or Distribution Costs	.
S(M)		F(T)		D(N)

Figure 3.1 shows that the fundamential problem is to minimise the total assembly, processing and distribution costs of the industry

by selecting the most appropriate trade flows of wheat and flour between initial source regions and final demand regions via the most appropriate potential mill facilities. Any combination of product flows between S(I), F(J) and D(K) are feasible (where I=1,2,...M; J=1,2,...T; K=1,2,...N). For example, S(2) could supply mill F(5) with wheat, F(5) in turn could supply D(1) and possibly D(4) as well. All feasible combinations could be represented by arrows in a more complex flow diagram; different modes of transport could be represented in a complex diagram, as could the transhipment of wheat via port storage facilities. Rather than attempting such a complex diagram, a convenient way of summarising all the details of the problem in a formalised and consistent manner is to present an algebraic statement of the problem.

3.2.1 Algebraic Statement of the Problem

The problem can be broken into two major components, the objective function and the constraints.

(i) The Objective Function

$$\begin{aligned}\text{Minimise TC} = {} & \sum\sum T_{ij} X_{ij} + \sum_{i}\sum_{k} T_{ik} X_{ik} + \sum_{i}\sum_{n} T_{in} X_{in} \\ & + \sum_{j} P_{j} X_{ij} + \sum_{k} P_{k} X_{ik} + \sum_{n} P_{n} X_{in} \\ & + \sum_{j}\sum_{d} T_{jd} Z_{jd} + SY_{s} + \sum_{n}\sum_{d} T_{nd} Z_{nd} \\ & + \sum_{k}\sum_{n} T_{kn} Y_{kn} + \sum_{n} P_{n} Y_{kn} \\ & + \sum_{m} P_{m} Y_{sm} + \sum_{m}\sum_{n} T_{mn} Y_{mn} + \sum_{n} P_{n} Y_{mn}\end{aligned} \qquad (1)$$

where: TC = Total cost.

X_{ij} = amount of wheat transferred from i^{th} production region to the j^{th} South Island mill.

T_{ij} = transport cost of moving each unit of X_{ij}.

X_{ik} = amount of wheat transferred from the i^{th} production region to the k^{th} South Island port.

T_{ik} = transport cost/unit X_{ik}.

X_{in} = amount of wheat transferred directly from the i^{th} production region by rail to the n^{th} North Island mill.

T_{in} = transport cost and consolidators charges/ unit of X_{in}.

$P_j = f(X)$ = milling cost per tonne of wheat at the j^{th} mill. ($\frac{dP_j}{dX_j} < 0$)

$X_j = \sum_i X_{ij}$ = amount of wheat milled at South Island mill j.

$P_k = g(X_k)$ = per unit storage and loading charge at k^{th} South Island port. ($\frac{dP_k}{dX_k} < 0$).

$X_k = \sum_i X_{ik}$ = amount of wheat delivered and loaded at South Island port k.

$P_n = h(X_n)$ = per unit milling cost at the n^{th} North Island mill. ($\frac{dP_n}{dX_n} < 0$).

$X_n = \sum_i X_{in} + \sum_k Y_{kn} + \sum_m Y_{mn}$ = amount of wheat milled at North Island mill n.

T_{jd} = transport cost/unit Z_{jd}.

$Y_s = \sum_k X_k$ = amount of wheat transported by bulk ship.

$S = q(Y_s)$ = per unit shipping cost of bulk shipping. $(\frac{dS}{dYs} < 0)$

Z_{nd} = amount of flour in wheat in wheat equivalents transferred from the n^{th} North Island mill to the d^{th} final demand region.

T_{nd} = transport cost/unit of Z_{nd}.

Y_{kn} = amount of wheat transferred by container ship from the k^{th} South Island port to the n^{th} North Island mill.

T_{kn} = transport cost/unit of Y_{kn}.

Y_{sm} = amount of wheat received at the m^{th} North Island port.

$P_m = r(Y_{sm})$ = per unit storage and unloading cost at the m^{th} North Island port. $(\frac{dPm}{dYsm} < 0)$.

Y_{mn} = amount of wheat transported from the m^{th} North Island port silo to the n^{th} North Island mill.

T_{mn} = transport cost/unit of Y_{mn}.

In general terms:

X refers to wheat from farms.

Y refers to wheat that is transhipped.

Z refers to flour shipments.

f, g, h, q, r are cost functions.

It can be seen from equation (1) that the objective function seeks to minimise costs. For reasons of simplicity and practicality, only measurable costs are included. These are the obvious costs arising from the marketing activities of the industry. The costs shown as functions in the definitions are decreasing cost functions. These model the economies of scale experienced in some marketing activities. As such, these effectively make the objective function a non-linear function.

It will be recalled from the previous chapter that it is reasonable to adopt a cost-benefit approach in assessing and analysing alternative Government policy measures. Such an approach seeks to minimise costs and maximise benefits. In the objective function of equation (1), benefits are not included. These are not considered to be variable, hence it is only sought to minimise costs.

The overall benefit associated with this problem is assumed to be the consumption of flour. Because of the inelastic demand for this product this benefit can be incorporated in the model as a constraint; that is a fixed targetted amount of product. Although it may be naive to assume there is only one benefit arising from the industry's activities, certainly this is the primary benefit and purpose of the industry and probably the only benefit that can be measured in practical terms. Other benefits, for instance, the employment a flour mill might create for a depressed region, can not be easily measured.

The nature of the objective function with its consideration of simplicity and practicality is designed to guide the model towards a restricted, but pragmatic set of solutions which, although unlikely to reveal a social optimum, might be able to indicate whether changes in the industry's structure and conduct could lead to improvements in the industry's market performance.

(ii) <u>The Set of Constraints</u> Minimisation of the objective will be undertaken subject to the following five basic constraints:

(a) $$\sum_j Z_{jd} + \sum_n Z_{nd} = FD_d \qquad \text{for all } d \qquad (2)$$

where: FD_d = final demand for flour (measured in w.e. tonnes) in the d^{th} region.

The social objective of supplying consumers with flour can be represented as a constraint in the problem. Unless solutions to the problem meet the targetted regional demands for flour they are infeasible solutions. The model must ensure that the combined flour transferred from South and North Island mills to any demand region must be equal to the final demand in that region.

(b) $$\sum_j X_{ij} + \sum_k X_{ik} + \sum_n X_{in} = FS_i \qquad \text{for all } i \qquad (3)$$

where: FS_i = wheat production in region i.

For solutions to be feasible it is also necessary to reconcile other product flows. This constraint ensures that the supply of wheat received at South Island mills, South Island ports, and that transferred directly to the North Island from South Island regions, does not exceed the quantity of wheat produced in that region. Without the upper constraint FS_i the model might demand more wheat than is available from favoured regions. No lower limit is required since it is realistic that the demands for milling grade wheat are less than the total amount of wheat produced or available from sources including Sydney.

(c) $$\sum_i FS_i \geq \sum_d FD_d = \sum_j X_{ij} + \sum_n X_{in} + \sum_n Y_{mn} + \sum_n Y_{kn}$$

$$\text{for all } i,\ m,\ k \qquad (4)$$

Further reconciliation must be made to ensure that production of wheat from all regions is at least sufficient to meet the requirements for flour in all demand regions (in w.e. tonnes) and also that the amount of wheat available is at least equal to that transferred to mills.

(d) $\sum_i X_{ik} = Y_{ks} + Y_{kn}$ for all k (5)

where Y_{ks} = the amount loaded to bulk ship at k.

Another reconciliation required to ensure the feasibility of the solution is that wheat arriving at loading ports must equal that loaded to bulk and container ships.

(e) $Y_{sm} = \sum_m Y_{mn}$ for all n (6)

The amount of wheat loaded to bulk ship from South Island ports must equal that discharged to North Island port storage facilities. In addition all product flows must be greater than or equal to zero:

$$X_{ij}, \; X_{ik}, \; X_{ik}, \; X_{in}, \; X_{jd}, \; X_{nd}, \; \geq 0. \qquad (7)$$

Basically, the constraints of the problem describe the many feasible marketing flows or industrial structures modelled. Additional constraints could be used to modify the market structure. For instance, the amount milled at a certain South Island mill ij could be modelled with an upper capacity constraint A; hence

$$\sum_i X_{ij} \leq A .$$

The actual size of the problem, defined in equations (1) - (7), will depend on the number of source regions, the number of mills, ports, and final demand regions. However, even with a modest number of each, the algebraic statement indicates that the wheat industry problem is complex.

Because of the non-linearities of the objective function, standard linear programming (L.P.) techniques are not suitable to solve the problem defined above. The assumption of assumed linear functions which is associated with linear programming is valid to study short-term marginal changes in costs, but is not valid in the longer term where long run average costs and economies of scale are to be considered. Furthermore, the size of the current problem would be computationally burdensome if it were formulated as a standard L.P. problem.

One method that does meet the requirements of the wheat industry problem is the facility location model. This involves the use of iterative solution procedures in conjunction with heuristic rules for solving the transhipment programming model. This provides a methodology suitable for analysing long-term structural changes in a system of complex marketing flows. Accordingly, this methodology allows the complex multi-staged product flows of the industry to be modelled, while the iterative solution procedure and heuristic rules allow the effects of non-linear costs to be analysed.

3.3 The Transhipment Problem

The transhipment model is a modified version of the transportation model (Higham et al, 1972; McCarthy et al, 1972 and Borrell, 1980). By allowing transhipment points or intermediate destinations of a multi-stage distribution problem to be modelled first as demand points (destinations) and secondly as supply points (sources) it is possible to view a transhipment problem as a set of simultaneous transportation problems. In this form the transhipment model can be solved using a transportation algorithm.[3] This determines the optimal flows of a homogenous product from a number of supply

[3] Elshafei (1973) reviews four algorithms for the solution to the transportation problem.

origins to a number of demand destinations.[4] Optimisation will be undertaken subject to the availability of set supplies and set requirements of demand in the regions considered, and given constant transport costs.

If all possible product flows of the problem defined in the algebraic statement of section 3.2.1 are viewed as involving the transportation of a product between several sets of sources and destinations, then this problem can be represented schematically as in Table 3.1.

In Table 3.1 all feasible product flows between sources and destinations can occur at the penalty of a transportation cost. These costs are represented by the 'c' sub-matrices of Table 3.1. From the positioning of the 'c' sub-matrices it can be seen that at the first marketing stage wheat can be transferred from initial supply regions (S1, S2 ..., S6), to South Island Mills (M1, M2, ..., M5), South Island Ports P1, P2, ..., P4), or directly to North Island mills by rail (NM1, NM2, ..., NM4). Wheat can also be transferred to the dummy demand (DD). It is necessary to include a dummy demand to absorb any surplus supply from the source region. Supply must exactly equal demand if the transportation algorithm is to be used to solve the transhipment problem. Surplus supply allocated to this point at zero cost allows the problem to be balanced without affecting the minimum cost solution. The supply available at any one source is given by the S_i value.

Infeasible product flows of Table 3.1 are modelled by placing an infinitely high penalty cost between source and destination. In Table 3.1 these occur where there are "∞" sub-matrices. The solution procedure will always avoid shipments along routes involving prohibitively high cost.

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4 Optimal here means minimum transport costs.

TABLE 3.1

Programming Tableau Multi-Staged Transhipment Problem

of the Wheat and Flour Industry

Sources \ Destinations		South Island Mills (M1, M2, .., .., .., MJ)	South Island Ports (P1, P2, .., .., PK)	S	North Island Ports (NP1, NP2, NPM)	North Island Mills (NM1, NM2, .., NMN)	Final Demands for Flour (All Regions) (FD1, FD2, .., .., .., ..., ..., .., .., .., ..., .., FDD)	DD	Total Supply
Wheat Supply	S1, S2, :, :, :, SI	c	c	∞	∞	c	∞	0	S_1, S_2, :, :, :, S_i
South Island Mills Flour Supply	M1, M2, :, :, :, MJ	∞ (above diagonal) ∞ (below diagonal)	∞	∞	∞	∞	c	∞	A, A, :, :, :
South Island Ports Wheat	P1, P2, :, :, PK	∞	∞ (above diagonal) ∞ (below diagonal)	c	∞	∞	∞	∞	:
	S	∞	∞		c	∞	∞	∞	:
North Island Ports Wheat Supply	NP1, NP2, NPN	∞	∞	∞	∞ (above diagonal) ∞ (below diagonal)	c	∞	∞	:
North Island Mills Flour Supply	NM1, NM2, :, NMN	∞	∞	∞	∞	∞ (above diagonal) ∞ (below diagonal)	c	∞	:, A
TOTAL DEMAND		A A .., ...	.. ..	..	.. ..	.. .. .. A	fd_1 fd_2 .. .. fd_d	dd	

The wheat allocated to primary demand points can be traced through the remaining feasible product flows of Table 3.1 and be seen to eventually end up at the final demand regions. The wheat transferred to South Island mills is further transferred, after milling, as flour (measured in wheat equivalents) to final demand regions (FD1, FD2, ..., FD13). The amounts demanded by these individual regions are given by the fd_i values which are the known consumption level in each region. Again transport costs will be incurred as the product is transferred to final demands. No cost is incurred if South Island mills supply themselves; this allows the mill to be modelled with surplus capacity.

The diagonal lines of Table 3.1 indicate where transhipment points can supply to themselves at zero cost. Hence it can be seen that the M1 South Island mill can supply to itself as a destination. The infinitely high costs in the off diagonals prevent transfers to other mills.

In effect by allowing a mill to supply to itself at zero cost a second form of dummy demand is created. With a dummy demand to absorb surplus milling capacity (without affecting the total cost of the minimum cost solution) it is possible to model South Island mills as having an unrestricted supply of milling capacity. This is given by the arbitrary large value A. In this way the cost minimising solution procedure is unrestricted in the amount it allocates to any mill. Hence it is possible to determine the optimal amount of wheat to be milled at any one mill location.

Of the remaining flows in Table 3.1, South Island ports can supply either bulk ship, or North Island mills by container; bulk ships can supply North Island ports, North Island ports can in turn supply North Island mills, and these in turn can supply final demand regions. It is not difficult to see that imports of Australian wheat could also be allowed for in the model. These could be included by specifying say, Sydney as a port supplying to bulk ship. This would require another port, P6, to supply to bulk ship, S. The amount loaded at Sydney could then be constrained at any level between zero and A and any surplus Sydney wheat could supply to the dummy demand, DD, at zero cost.

Although Table 3.1 represents all feasible transport flows of the wheat and flour industry, it does not represent the full transhipment problem of the industry. A solution to the current model would assume transport flows to be independent of the efficiency of processing or handling wheat at various transhipment points. Clearly this would be naive.

It is possible to include processing and handling costs at transhipment points in the model. This modification makes it possible to study the effects of processing and handling costs on the location of processing facilities.

Processing and handling costs are included in the transhipment model simply by adding these costs to the transport costs of sub-matrices of type 'c' in Table 3.1 For example, to include the cost of South Island milling, MC, it is simply a matter of adding the per unit milling cost mc_j (in the algebraic statement defined as f_j) to the transport cost c_{ij} (in the algebraic statement defined as t_{ij}) in the north-west sub-matrix of Table 3.1 It should be noticed that mc_j is a constant (linear) cost rather than a non-linear function depicting the decreasing costs associated with economies of scale in milling. The transhipment model itself can not take account of non-linear costs. The implication arising from this will be examined later when it will be shown how the affects of non-linear costs can be analysed using iterative solution procedures and heuristic search techniques (see Section 3.4).

Other features of the transhipment model make it possible to examine a number of spatial problems which may be associated with an industry. For instance, it should be noted that capacitated problems can be formulated in the transhipment framework (Hurt and Tramel, 1965). That is, it is possible to place any desired upper demand or supply constraint on processing or transhipment facilities of the model. In the wheat industry problem this would make it possible to represent milling quotas. Similarly, it would be possible to restrict bulk shipping to at least its current 100,000 tonne volume. Leath and Martin (1966) show how it is also possible to place lower bound capacity constraints on processing or transhipment facilities.

Using upper and lower bound constraints, the existing political constraints of the market can be represented and, in fact, the entire market structure of the existing industry can be simulated. It would then be possible to compare the solutions of the capacitated model to those arising when constraints are absent, that is, in the uncapacitated case.

The solution to the transhipment model showing optimal product flows through facilities and between regions is known as the primal solution. Associated with every linear programming problem there is also a dual solution. In solving the primal L.P. problem, the dual L.P. formulation is automatically solved. The optimal values of dual variables show how the objective function would change with a unit change in constraints of the problem. Hence, as Cassidy (1968, p. 57) points out, the dual solution allows the marginal value of additional capacity for constrained activities to be estimated. For example, it would be possible to estimate the value of increasing the milling quota at a Wellington mill by one tonne of wheat. This may be useful information to gauge the marginal opportunity cost which current political constraints impose on the industry. Furthermore, from the dual solution of the problem it would be possible to estimate the price differentials between regions. This may be helpful information for it would show the amount by which wheat and flour prices should vary between regions, that is, it would determine the relative marginal values of wheat and flour grown in, or delivered to different regions. It will be recalled from chapter 3 that in the current market standardised wheat and flour prices are paid throughput New Zealand, and therefore regional price differentials are totally unknown.

Provided product homogeneity is assumed, transhipment formulations are flexible enough to handle a wide range of problems. These include multi-region, multi-plant, multi-stages and even multi-period (Leath and Martin, 1967) programming problems. It should be noted that the homogeneity assumption does not prevent multi-product problems from being formulated in this framework as different products can be expressed in equivalent terms. For the current problem, flour is expressed in wheat equivalents. Since one tonne of wheat produces .78 tonnes of flour, a wheat equivalent tonne of flour is accordingly, .78 of a tonne.

In summary, it can be seen that the solution to the transhipment problem can be used to yield a great deal of information useful in policy analysis. Primarily, the solution will determine optimal product flows among regions. From such a solution it will be possible to determine the efficient pattern of mill and port usage. Regional price differentials can also be obtained and, in the capacitated case, the opportunity cost of milling quotas and transport constraints could be determined. However, the product flows will only be optimal in a restricted sense, that is assuming all costs are linear. Clearly, with economies of scale in milling, shipping and ship loading and unloading, this is unrealistic. Iterative solution procedures used in conjunction with heuristic search rules allow this problem to be overcome.

3.4 Iterative Solution Procedures and Heuristic Search Techniques

The effect of non-linear costs can be analysed in the linear transhipment model by repeatedly solving the linear problem. This can be done by updating the per unit processing costs to reflect the economy of scale that would be achieved given the prescribed throughputs of facilities in the previous solution. Combined with the heuristic procedures of Logan and King (1964), Stammer (1971) or Higham et al (1972) which either encourage, discourage or force processing facilities into or, out of, the model, the solution procedure iterates towards an eventual stable solution.

The solution will indicate the location, number and size of processing (transhipment) facilities which exploit the economies of scale in processing, as well as determining an efficient pattern of transportation for the industry's products. Because the heuristic rules do not provide optimising criteria for selecting among potential facilities, the method does not ensure a global optimum solution. It can only ensure a local optimum solution.[5] Usually many local optima may exist, several of which may be of interest to the policy maker.

The heuristic rules of Logan and King (1964) and Stammer (1971) provide a fixed criteria that can be used to derive a certain local optimum. The Logan and King method eliminates potential facilities if they appear in any solution with zero throughput. These are dropped from further consideration by placing artificially high costs on the use of the facilities. By contrast the Stammer method allows previously excluded facilities to remain at their previous costs so they will not be excluded from further re-evaluations. However, if only allocated a small quantity as a result of re-evaluation, the per unit cost will

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5 A local optimum solution is one that has a lower total cost than would arise from alternative market structures created by making only small changes to the solution. With large changes, economies of scale may be achieved at other facilities. This could result in other local optima solutions. A solution is a global optimum if no alternative solution has a lower total cost.

usually rise in successive iterations as the full scale effects would not be realised. This is likely to eliminate the facility from further consideration. Both these methods passively seek out one local optimum according to predetermined heuristic rules. Only the forcing procedure of Higham et al gives the researcher the option to actively encourage locations into, or force locations out of, the solution. This can be done by either adjusting the unit processing cost or by adjusting the capacity constraints on facilities. In this way the researcher is equipped to actively explore the solution space of the problem. The forcing procedure enables the researcher to seek out alternative local optimum solutions. This allows the researcher to apply other heuristic criteria such as that suggested by Rogers (1978, p. 16-27):

> "if there are two locations present in a stable solution which are 'geographically close', one of them is a good candidate for 'forcing out'."

It also enables the researcher the ability to seek solutions possessing particular qualitative attributes that may be of interest for policy purposes. The possibility of being able to locate several low cost solutions may be particularly helpful.

Although iterative solution procedures and heuristic search techniques help overcome the problems introduced by non-linear costs, a further difficulty is presented. Because of the presence of non-linear costs, and therefore the possibility of several local optima, it is possible that the marginal values given by the dual solution may be difficult to interpret as there will not be a unique set of dual costs. Where all intermediate demand and supply points are uncapacitated, their marginal values will be zero in the dual solution regardless of whether non-linear costs are included in the objective function. However, when non-linear costs are included, an alternative optimum may indicate that increasing throughput at a certain mill would result in substantial reductions in total costs. Therefore, while a marginal change would not create cost savings, large changes may do. In this way, dual costs can not be used to gauge how further changes in market structure may lead to cost savings.

The relative marginal values of wheat and flour at initial supply and final demand regions will be available from the dual solution attained from problems with non-linear costs. These values, however, will not be unique. An alternative local optimum solution and therefore alternative market structure with a similar total cost could produce quite different sets of regional price differentials. This may have important implications if the model was used to suggest what might be fair relative prices for different regions.

3.5 Summary and Conclusions

It has been shown in this chapter how the transhipment model can be used to study multi-region, multi-staged marketing problems. Further, it has been shown how the use of iterative solution techniques which embody heuristic search procedures could be used in conjunction with the transhipment model to study the effects of economies of scale on multi-region, multi-staged marketing problems. It is precisely these types of problems that exist in the wheat and flour industry.

In the next chapter a practical static model of the industry is set up. In chapter 5 results arising from using this model with heuristic search procedures are reported.

CHAPTER 4

THE MODEL -

THE PROGRAMMING MATRIX, DATA AND ASSUMPTIONS

4.1 Introduction

This chapter sets up the programming matrix discussed in the previous chapter. This requires defining the regions of the model and specifying relevant regional demands and supplies, and milling and shipping capacities. In addition, transport charges for wheat and flour shipments and processing and handling costs must be specified.

4.2 Regional Demarcations

New Zealand was partitioned into various regions for the study. Regional boundaries were established according to the areas distinguished by the existing transportation patterns, however, subjective considerations and the availability of data also had a bearing of where these were fixed.

For initial wheat supply from farms, the South Island regions presented in the North-West corner of Table 4.1 were used to define the six production regions for the model. Counties were aggregated into these six general regions partly for statistical convenience, but mostly because of their distances from initial destinations to which wheat is transported.

The location of flour mills in the model were assumed to be the general regions in which mills are currently located; dispatch ports were defined by existing ports and receival ports by their proximity to North Island mills. Final demand regions were considered to correspond to the regional population densities, and, as such conveniently corresponded with the statistical areas used by the New Zealand Department of Statistics (1973). However, because within the Wellington, Canterbury and Otago regions there are more than one supply region, aggregation of these as final demand regions would conceal certain possible trade flows in the model. Accordingly, Wellington was disaggregated into Palmerston North and Wellington; Canterbury was disaggregated according to the flour demands around Timaru, Ashburton and Christchurch; and Otago was separated into Oamaru and remaining Otago. Further, it was considered appropriate to aggregate North Auckland and Auckland, East Coast and Hawkes Bay, Nelson and Marlborough, and Christchurch and Westland, since it was expected that the combined regions would be supplied from the same sources. Hence, in all there are thirteen demand regions. These can be seen as final demand regions presented in the North-West corner of Table 4.1

4.3 Data

Four general types of data were required for the model;

(i) regional supplies of wheat,

(ii) regional demands for flour,

(iii) milling and shipping capacities (for the capacitated problem), and

(iv) regional and inter-regional transport, processing and handling costs.

4.3.1. Regional Supplies

All regional supplies were assumed inelastic. The amounts assigned were considered to be fairly representative of a year of self-sufficiency, and were estimated as follows:

		tonnes
1.	Southland	76,000
2.	Otago (excluding North Otago)	23,000
3.	North Otago	16,000
4.	South Canterbury	50,000
5.	Mid Canterbury	75,000
6.	Remaining Canterbury	50,000

It was assumed that the regional supply quantities are of milling quality wheat.

4.3.2 Regional Final Demands

Like the regional supplies, regional demands were assumed to be inelastic. Estimates of final demands were calculated from the national average flour consumption of 70 kilograms per head (N.Z. Department of Statistics, 1979a). Assuming flour use to be evenly dispersed among the population, the population multiplied by this average was considered to give a reasonable approximation of demand in each area. These final demands for flour were converted to wheat equivalents; these are as follows:

	tonnes
Auckland/North Auckland	85,000
South Bay of Plenty	45,000
East Coast/Hawkes Bay	17,000
Taranaki	4,000
Palmerston North	4,000
Wellington	55,000
Nelson/Marlborough	10,000
Christchurch and Districts/Westland	34,000
Mid Canterbury	2,700
South Canterbury	4,400

	tonnes
North Otago	3,000
Otago (South and Central)	14,000
Southland	9,000
	287,100

4.3.3 Milling and Shipping Capacities

Milling capacities used for the first run of the model were those corresponding to existing regional quota capacities. Borrell (1980, Table 2-5) estimates these as follows:

	tonnes of wheat
Invercargill	9,000
Dunedin	24,000
Oamaru	14,000
Timaru to Temuka	21,000
Ashburton	7,000
Christchurch and Rangiora	53,000
Wellington	20,000
Palmerston North	14,000
Mount Maunganui	30,000
Auckland	100,000

The shipping capacity constraint corresponded to the current restrictions which limit bulk shipping to 100,000 tonnes per annum from the South Island to the North, but these were required in capacitated versions of the model only.

4.3.4 Marketing Costs

Although estimates of costs for the model were drawn from a variety of sources and time periods, appropriate adjustments were made to standardise costs to those applicable as at May 1979. These costs fall into general categories as outlined overleaf.

(i) Transport Costs The constant per unit transport costs between sources and destinations can be seen in Table 4.1. The sub-matrices of the parent matrix designated with a letter A, B, C, etc) define where feasible product flows of the model can occur.

Table 4.1 is similar to Table 3.1 of the previous chapter. The distinguishing feature between these two tables is simply that in the latter, actual, rather than theoretical regions have been specified, and the list of source regions have been re-ordered.

The costs applicable to matrices A and B of Table 4.1 are the Ministry of Transport Area Road Schedule Charges (1979), and the New Zealand Government Railways Class E Rail Rates (1979). Where the inter-regional transfers in matrices A and B involve distances in excess of 150 kilometres, rail rates have been calculated. This has been under-taken to represent Government's 150 kilometre road transport limit. In addition to the rail cost, a consolidator's fee has been included for the service involved in loading rail wagons.

To calculate intra-regional transfer costs of matrices A and B it would have been necessary to calculate an average distance between sources and destinations of each area. Since the New Zealand Wheat Board must calculate this distance to determine the receipts of growers from the Ministry of Transport area road schedules and Class E rail rates, it was possible to compute a weighted average cost from a sampling of the Wheat Board's source documents which detailed this information. Tables 4.2 and 4.3 show respectively matrices A and B. The costs in Tables 4.2 and 4.3 are considered to be the best available estimates of the costs of the transport activities represented in these tables. The same data sources have been used to derive representative transfer costs involved in railing wheat to North Island mills from South Island supply regions. These costs comprise mainly Class E rail rates, but also include farm to rail transport

TABLE 4.2

Average Transport Cost from Farms to South Island Mills Used in Matrix A of Table 4.1

($/tonne wheat)

Farms \ Mills	Southland	Dunedin	Oamaru	Timaru and Temuka	Ashburton	Christchurch and Rangiora
Southland	5	18	25	29	32	36
Otago	18	10	20	24	27	31
North Otago	25	15	2	6	15	19
South Canterbury	29	19	6	4	5	15
Mid Canterbury	32	22	15	5	2	13
Remaining Canterbury	26	24	19	15	13	3

TABLE 4.3

Average Transport Costs from Farms to South Island Ports Used in Matrix B of Table 4.1

($/tonne wheat)

Farms \ Ports	Bluff Bulkship	Dunedin Container	Timaru Bulk	Lyttelton Bulk	Lyttelton Container
Southland	10	20	29	38	38
Otago	20	13	24	33	33
North Otago	27	17	6	21	21
South Canterbury	31	21	3	17	17
Mid Canterbury	34	24	5	14	14
Remaining Canterbury	38	28	15	5	5

TABLE 4.4

Railage from South Island Farms to North Island Mills Used in Matrix C of Table 4.1

($/tonne wheat)

South Island Farms \ North Island Mills	Wellington	Palmerston North	Mount Maunganui	Auckland
Southland	62	70	88	88
Otago	55	64	81	81
North Otago	50	59	76	76
South Canterbury	46	55	72	72
Mid Canterbury	43	52	69	69
Remaining Canterbury	39	48	66	66

TABLE 4.5

Costs of Transporting Wheat to North Island by Container Ship[a] Used in Matrix E of Table 4.1

($/tonne wheat)

South Island Ports \ North Island Mills	Wellington	Palmerston North	Mount Maunganui	Auckland
Dunedin Ro/Ro	50	60	75	78
Lyttelton Ro/Ro	29	39	61	64

[a] It was considered infeasible for other South Island ports to supply directly to North Island ports by container ship.

the apportioning of fixed costs. The fuel cost associated with shipping along any of the nine routes can be treated as a linear cost. These can be included in matrix F of Table 4.1.

Estimates showed that per unit fuel cost along any of the nine routes did not differ by more than one dollar. These costs were very low and are equal to approximately $1.00 per tonne of wheat. These were included in the model through matrix F of Table 4.1.

Matrix G of Table 4.1 comprises area road schedule or Class E rail rates for permissable transport flows from North Island ports to North Island mills. Table 4.6 reports these costs.

The transport cost matrices A - G represent the costs of assembling wheat to mills. The remaining two matrices of Table 4.1 represent the delivery costs of flour from mills.

Rail costs are also applicable for the transport of flour from South Island mills to North Island and also outpost South Island final demand areas. Flour moving in bulk containers is railed at 1.25 times Class E rail rates. In comparison, bagged flour railed by freight forwarders under contract is railed at rates slightly less than Class E rates. However, extra costs are included in delivering bagged flour since flour often must be bulked to facilitate delivery. For this reason, it is reasonable to use the 1.25 times Class E rates to estimate all flour railage costs. Although consolidators' fees for loading and unloading were not obtained for the study, an arbitrary 7 per cent of the Class E rate (5 per cent for loading, 2 per cent unloading) was included to at least take account of this cost. Therefore 1.32 times Class E rates were used to estimate flour railage plus handling costs. However, because flour is expressed as wheat equivalents in the model, the true quantity of flour required by any final destination will be .78 that of the solution. Therefore, it is necessary to calculate a 22 per cent discount on the appropriate rate, which equals 1.03 times Class E rates. Table 4.7 shows the costs used in matrix H of Table 4.1.

The zero costs of Table 4.7 correspond to intra-regional delivery costs of flour. No attempt was made to quantify these. Similarly, no intra-region flour delivery cost is levied on inter-regional flour transfers, only a cost for the inter-regional leg of the journey is charged.

The remaining matrix of Table 4.1 is matrix I which represents the delivery costs of flour from North Island mills to final demand regions. In this matrix, 1.03 times Class E rail rates or area road schedule rates have been used to estimate transport costs to North Island final demand areas. Transfers from North Island mills to South Island final demand regions in matrix J were assumed to be feasible.

Other marketing costs are also required for the model. These relate to the cost functions associated with processing or handling at transhipment points.

(ii) Milling Costs Statistical (econometric) analysis of accounting data was made to establish the nature of the economies of scale experienced in New Zealand milling. Although it can be expected that many factors such as location, age of plant, specialisation and product differentiation, depreciation and other accounting procedures distort the observed scale effects in milling, it is possible to fit a representative function that will show the general relationship between cost of milling and mill size. This could be estimated from accounting data measuring the actual cost of milling for a variety of different sized mills. However, econometric estimation would suggest careful consideration must also be given to any *a priori* expectations

TABLE 4.6

North Island Port to Mill Transport Costs

Used in Matrix G of Table 4.1

($/tonne of wheat equivalent)

North Island Ports \ North Island Mills	Wellington	Palmerston North	Mount Maunganui	Auckland
Wellington	2	12	35	35
Mount Maunganui	35	20	1	10
Auckland	35	30	10	2

TABLE 4.7

Transport Costs from South Island Mills to Final Demand Regions

Used in Matrix H of Table 4.1

($/wheat equivalent tonne flour)

Mills \ Final Demands	Southland	Otago	North Otago	South Canterbury	Mid Canterbury	Remaining Canterbury	Other South Island	Wellington	Palmerston North	Taranaki	East Coast Hawkes Bay	South Bay of Plenty	Auckland
Invercargill	0	19	26	30	33	37	50	63	72	80	90	85	90
Dunedin	19	0	12	16	19	23	39	56	66	73	83	78	83
Oamaru	26	12	0	6	15	20	34	51	61	68	78	73	78
Timaru and Temuka	30	16	6	0	5	15	30	47	57	64	74	69	74
Ashburton	33	19	15	5	0	13	27	44	53	62	72	67	71
Christchurch and Rangiora	37	23	20	15	13	0	23	40	50	59	69	64	64

TABLE 4.8

North Island Mill to Final Demand Transport Costs

Used in Matrix I of Table 4.1

($/wheat equivalent tonne flour)

North Island Final Demand Regions / North Island Mills	Wellington	Palmerston North	Taranaki	East Coast Hawkes Bay	South Bay of Penty	Auckland
Wellington	0	12	17	27	35	35
Palmerston North	12	0	20	17	30	30
Mount Maunganui	35	30	18	20	8	11
Auckland	28	30	16	28	11	0

which may have been established about the production process, and the curve fitted to the data should be consistent with these expectations. For instance, French (1977) notes that milling operations which involve large capital inputs relative to labour inputs are likely to show greater economies of scale; this is the case with flour milling. Other a priori expectations relevant to flour milling may be established from similar studies undertaken elsewhere. Leath and Blakely (1972, p.23) report that some flour mills in the United States have an annual output of 600,000 tonnes of flour. This is equivalent to three times the requirements of the New Zealand population. This might suggest there is no upper limit or internal diseconomy of scale applicable to the New Zealand milling operation, although the combined cost of milling and other activities certainly may create net diseconomies.

A common functional form used to represent decreasing cost functions which do not have an upper limit, is:

$$Y = \alpha X^{\beta} \qquad (1)$$

where Y = processing cost per unit

α = positive constant

β = negative power

X = quantity of product processed.

The function form above was used to estimate the milling cost curve in this study. From point estimates obtained in discussion with flour millers and using the average marketing margin paid for flour at 1 February 1978 (adjusted to 1979 prices) established by the Department of Trade and Industries (1978) (see Appendix I) a set of synthetic data was derived. This was used to obtain a crude estimate of a representative long run average cost curve (scale curve) for milling. This is reported in equation (2).

$$\underline{MC} = 275\,\underline{X}^{-.25497}$$

where $\underline{MC}$ = milling cost per tonne of wheat

$\underline{X}$ = quantity of wheat milled.

Equation (2) was estimated in logarithmic form using ordinary least squares. Because synthetic data were used, the usual statistical tests are not valid.

Although the estimation of this function lacked the statistical rigour required in econometric estimation, at the time, the limitations of the data meant it was the best estimate that could be made. Equation (2) was used to represent milling costs in the model. Subsequent to completing the analysis of the project, data were received from the New Zealand Flour Millers Association (1979). However, the time available did not make it possible to test how sensitive solutions were to the new function estimated using these data.[6]

The nature of per unit milling costs represented by equation (2) can be seen in Figure 4.1.

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6 Using these data a similar equation to (2) was estimated:

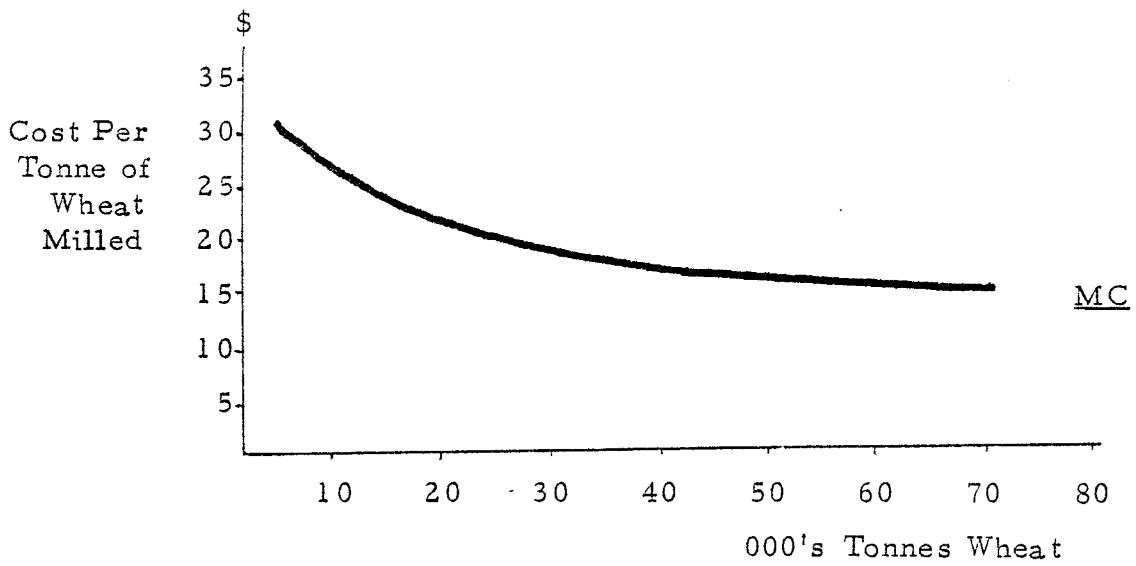
$$MC = 145X^{-.18578}$$

$$\bar{R}^2 = .89$$

Both parameters $\hat{\alpha} = 145$, and $\hat{\beta} = -.18578$ were highly significant. This relationship provided an estimate of milling cost which was approximately 3 per cent higher than of equation (2), at a milling capacity of 15,000 tonnes.

FIGURE 4.1

Shape of Representative Scale Curve for Milling



It can be seen from Figure 4.1 that for a mill with a throughput of 5,000 tonnes of wheat per annum, it would be expected to incur a per tonne milling cost of approximately $31.00. This compares to a cost of approximately $16.00 per tonne of wheat for a mill with a capacity of 70,000 tonnes of wheat per annum.

Equation (2) was used to estimate milling costs in both the capacitated and uncapacitated versions of the model. In the capacitated case where existing mill numbers, sizes and locations were assumed to apply, equation (2) was used to obtain a per unit milling cost for each mill size in each region. A weighted average cost was then calculated from these to estimate an appropriate milling cost for each region of the model. These were then treated as constant costs in the model. This contrasts with the use of the cost function in the uncapacitated version of the model. There the per unit milling cost was able to vary as discussed in section 3.4 of Chapter 3.

The major limitation to using detailed observations from existing mills to obtain a representative cost function, is the danger of generalising from such a curve. For instance, the political restrictions constraining possible rationalisation of the New Zealand flour milling industry may have prevented new, more productive milling equipment from being adopted in this country. Therefore, to extrapolate costs for a future rationalised industry based on what has occurred in the past may be invalid. Nevertheless, despite this limitation and despite the limitation introduced by the crude data used, equation (2) at least allows the model to acknowledge the presence of economies of scale in milling and their effects on the market structure of the industry. If these are significant, it will indicate the value of establishing a more accurate milling cost curve.

(iii) Port Storage and Handling Costs To estimate port storage and handling costs a combination of engineering and accounting data were used. The 1977 amortised construction costs of the Timaru port silos combined with current wharfage and handling costs for South Island ports provided the base from which a non-linear function of the form:

$$PtC = \underline{a} + \underline{b} / Y$$ was calculated,

where $\underline{a}$ = constant wharfage, segregation and cleaning costs,

$\underline{b}$ = fixed cost of amortised inflation adjusted capital, interest and fixed annual operating cost, including rent,

Y = throughput of wheat,

PtC = port costs per tonne of wheat handled. ($/tonne).

Source: Private Transport Company, 1979b)

The same a and b coefficients were used to compute the costs for each South Island port and the coefficients were calculated assuming 6,000 tonnes of storage at each locality. The estimated coefficients are:

$$a = 4,$$
$$\text{and } b = 140,000.$$

For Timaru, which has a current annual throughput of 36,000 tonnes, the equation would suggest port costs equivalent to approximately eight dollars per tonne would be incurred. This appears a good approximation of the costs of wharfage, handling, and other small incidental charges applying for 1979 at Timaru.

The a and b coefficients used to represent costs of unloading and handling through a facility with 6,000 tonnes storage capacity at Mount Maunganui made allowance for higher amortised capital costs in the b cost component of the equation, but allowed a lower a cost component than for South Island ports. Higher amortised capital costs were assumed due to the need for unloading gear. This was considered to be more expensive than loading gear of South Island ports. The lower a cost represented cheaper wharfage rates as indicated in the New Zealand Stevedoring Statistics and also no cost of segregation or cleaning was anticipated. In this situation the coefficients used were:

$$a = 1$$
$$b = 200,000.$$

Because there is currently no facility at Mount Maunganui, this equation could not be validated, but must be assumed to be representative of such a facility.

Cost of port storage facilities at Auckland and Wellington were also required in the model. Here engineering data were used.

The information was attained from an Auckland company which had contracted engineers to research the possibility of establishing a silo complex at one of Auckland's wharves (Private Transport Company, 1979b). This information revealed that construction costs would be expensive due to piling problems associated with the proposed site. In addition, the demand for port sites in Auckland made rental costs expensive, suggesting more expensive vertical rather than horizontal type silos would be required. From this information, it was calculated that a fixed annual cost of approximately one million dollars would be incurred in operating a receival port storage at Auckland. In addition, a constant stevedoring charge of one dollar per tonne was assumed. Although alternative sites were considered, the Auckland study concluded these would have been located too far from the existing flour mills, and therefore, more expensive road transport would be involved. The model used here does not contain specific mill locations within each general locality. Because the Auckland study abandoned the possibility of alternative sites within Auckland itself, the potential savings of such sites cannot have been great if they would not more than compensate for additional transport charges from more remote sites. Therefore, it might be concluded that siting a port storage and unloading facility at Auckland might be expensive regardless of its specific site.

No information is available on the potential costs of storage at Wellington. Therefore, it was assumed a fixed cost somewhere between the costs at Mount Maunganui and that at Auckland would be appropriate. Since the expensive piling costs were a problem peculiar to Auckland, it was assumed these would not be applicable at Wellington. However, as a main shipping centre, it was considered that demand for port sites would create higher rental and Harbour Board leases than at Mount Maunganui. In light of these considerations, it was anticipated that a fixed annual cost of approximately half a million dollars would be representative of the costs incurred in the receival port storage facility at Wellington. It was expected that wharfage of one dollar per tonne would also be incurred.

All per unit port storage and handling costs have been calculated assuming a fixed sized facility of 6,000 tonnes storage capacity. Although the throughput is allowed to vary, the fact that the facility's capacity is not, means the port cost functions are not strictly long run average cost curves. They are, however, scale curves that experience decreasing per unit costs as throughput increases. Further, the 6,000 tonne storage capacity is assumed not to constrain this throughput. This assumption is considered reasonable, for even if any one port was shown in the solution to handle 150,000 tonnes of wheat per annum, this would mean the 6,000 tonne storage facility would need to turnover its wheat stocks each fortnight (i.e. 150,000/6,000 = 25, and 25 x 2 weeks $\simeq$ 1 year). With efficient shipping, loading and unloading operations as allowed for in the model, this would seem to be practical.

The greatest limitation of the port storage and handling cost equations relate to the adequacy of the data. It has been necessary to estimate port storage and handling costs by making several rather arbitrary assumptions. These could very likely be incorrect and the costs, especially at Mount Maunganui and Wellington, could be quite different to those used here.

(iv) Shipping Costs Large fixed costs and only minor variable costs characterise the economies of bulk shipping. Engineering data obtained from the Shipping Corporation of New Zealand, the Ministry of Transport and two private transport companies all confirmed this fact. It was these data that was used to establish the annual fixed costs of operating a bulk vessel capable of shipping all the North Island requirements of wheat from either the South Island or Australia. This was assumed to be a completely New Zealand operation using a specialised ship not designed for competition for other bulk cargoes on the world market, or in New Zealand. These costs are presented in Appendix 2. Fuel costs of shipping are incorporated in the model through matrix H. Therefore, the cost curve for shipping is formulated as:

$$SC = \alpha / Z$$

where α = fixed cost,

Z = quantity of wheat shipped, (tonnes)

SC = per tonne shipping cost. ($/tonne)

For a 6,000 tonne bulk ship the annual fixed cost was assumed equal to three million dollars, that is α = $3 m (see Appendix 2). Based on the current volume of wheat transported by bulk ship, the shipping cost would equal $30.00 per tonne. Combined with wharfage and handling costs, this is a reasonable estimate of existing costs.

As with the calculations made for port storage and handling costs, the computed shipping cost equation assumes a fixed capacity of 6,000 tonnes. However, because the marginal cost of building larger bulk carriers is only small, it is unlikely that if a different sized ship was required that this would substantially affect per unit shipping costs. Only if a larger ship with spare capacity could be used to transport alternative cargoes could the per unit average cost of shipping be lowered. In Appendix 2 it can be seen that even if a 6,000 tonne bulk ship was required to ship 200,000 tonnes of wheat to the North Island from Sydney each year, there would still be spare days available (i.e. when the ship would not be used). Hence it would appear that a 6,000 tonne vessel places no upper level of the economies of scale in shipping.

4.4 Summary and Conclusions

In this chapter the programming matrix of the model has been defined, the data required for the model presented, and some problems of the model and its assumptions were discussed. Attention must be drawn to the limitations of some of the data used; in particular, the crude estimate required to be made for the milling cost curve and the arbitrary assumptions made to calculate scale curves for two North Island ports. Nevertheless, these estimates allow the theoretical problems identified in chapter two to be embodied in a practical model. Although better estimates for some scale curves would engender greater confidence in the model, the actual estimates made in this chapter do, at least, allow a complete, if not refined, model to be built. The benefit of a complete model is that it allows a representation of the economic forces of the wheat and flour industry, and the effects of these forces on the market structure of the industry can be studied and analysed in a simultaneous and consistent manner. The results of the model simulations which are presented in the next chapter provide an indication of the changes which would take place in a more competitive market situation.

CHAPTER 5

EMPIRICAL RESULTS

5.1 Introduction

This chapter presents and discusses the results obtained from experiments conducted using the model developed in the previous chapter. These results were obtained from several successive runs of the model in which current policy restrictions were relaxed until the model remained constrained only by final demand and initial supply. Heuristic search procedures were applied to investigate the solution space in an effort to discover several low cost unconstrained solutions.

5.2 First Results - The Capacitated Problem

As the starting point of the analysis, the model was run assuming that the existing set of milling quotas were constraining the activities of mills; that the current 100,000 tonne ocean shipment of bulk wheat applied; that the current throughputs at ports were applicable; that imports of Australian wheat were excluded; and that final demand and initial supply (representative of a year of self-sufficiency) were completely inelastic. Appropriately, representative costs of milling, shipping, and port handling charges were calculated and included as constant costs along with other constant transport costs described in the previous chapter. The aim of constraining the model in this fashion was to create a market scenario that resembled the existing market in as many respects as possible.

Not surprisingly, the solution of the capacitated model depicted a market structure similar to that described in Chapter two. While this is an aid in validating this version of the model, a complete validation is not possible as some specific wheat flows cannot be identified with existing statistics. In the solution of the capacitated model these flows can be thought of as the expected, rather than actual flows.

By quantifying expected current flows the solution to the capacitated problem is at least able to give a full and consistent representation of a market structure which is capable of satisfying the demands of the market, given the existing constraints on the industry. This is especially helpful as it allows meaningful dual cost variables to be derived.

It will be recalled from section 3.3 that the optimal values of dual variables show how the objective function would change with a unit change in constraints of the model. For the supply and demand constraints of the model it is possible to impute a relative marginal value of wheat and flour at each source or destination of the model. If it were assumed that a competitive market applied, then these relative marginal values could be assumed to represent competitive regional price differentials, because the forces of arbitrage would ensure minimum transfer costs between regions in the model. Information on the competitive regional price differentials is currently unavailable as standardised prices for wheat and flour are paid throughout New Zealand.

The dual variables for other constraints of the model show the amount by which the total cost would change for changes in milling and shipping constraints. Hence, it is possible to gain an indication of the opportunity cost imposed by current policy constraints and to show how short term changes in the industry's structure might lead to marginal improvements in the market's performance.

To show that the model is reasonably representative of the existing industry it is necessary to validate the model by comparing total marketing costs and trade flows of the model with known marketing costs and trade flows.

5.2.1 Validation - Wheat Flows

Table 5.1 shows the solution obtained from the capacitated problem. This includes the volumes of wheat and flour moving from certain sources to particular destinations and the total supplies from, or receivals at, various regional locations. It can be seen that producing areas supply their local mills. For example, the Southland region supplies the Invercargill mill with 9,000 tonnes of wheat per annum. Two supply regions are also shown to supply South Island ports with wheat for bulk shipping; Southland supplies Bluff with 64,000 tonnes, and South Canterbury supplies Timaru with 36,000 tonnes. All remaining wheat from South Island supply regions moves to North Island mills by rail. For instance, 13,000 tonnes of wheat is railed from Ashburton to Mount Maunganui mill. On the extreme right hand side of Table 5.1 the totals supplied from each production region are tabulated. For example, Southland's total supply is 73,100 tonnes.

Initial destinations in Table 5.1 become secondary, or intermediate supply origins for other marketing stages of the model. For example, South Island mills are seen to supply local final demands with flour; any surplus flour from these mills is seen to be transported mainly to Wellington, but also to other parts of the North Island and northern South Island. The wheat supplied to Bluff and Timaru in the first stage of Table 5.1 can be seen to be transferred to bulk ship in a secondary stage. At a tertiary stage this wheat is transferred to Mount Maunganui and Auckland ports. From there it can

TABLE 5.1

Solution to the Capacitated Problem

000's tonnes

Sources		South Island Mills						South Island Ports						North Island Ports			North Island Mills				Final Demands for Flour (All Regions)														
	Destinations	Invercargill	Dunedin	Oamaru	Timaru and Temuka	Ashburton	Christchurch and Rangiora	Bluff	Dunedin Ro/Ro	Timaru	Lyttelton	Lyttelton Ro/Ro	BULK SHIP	Wellington	Mount Maunganui	Auckland	Wellington	Palmerston North	Mount Maunganui	Auckland	Southland	South and Central Otago	North Otago	South Canterbury	Ashburton	Christchurch Districts and Westland	Nelson and Marlborough	Wellington	Palmerston North	Taranaki	East Coast/ Hawkes Bay	South Bay of Plenty	Auckland and North Auckland	DUMMY DEMAND	TOTAL SUPPLY
Wheat Supply	Southland	9						64																											73.1
	Otago		23																																23
	North Otago			13.1	2.9																														16
	South Canterbury				14					36																									50
	Ashburton				4.1	7											20	13.9	13	17															75
	Remaining South Island						50																												50
South Island Ports Wheat	Bluff												64																						64
	Dunedin Ro/Ro																																		
	Timaru												36																						36
	Lyttelton																																		
	Lyttelton Ro/Ro																																		
Bulk Ship Wheat Supply															17	83																			100
North Island Ports Wheat Supply	Wellington																																		
	Mount Maunganui																		17																17
	Auckland																			83															83
South Island Mills Flour Supply	Invercargill																				9														9
	Dunedin																					14					3	3			3				23
	Oamaru																						3					6.1		4					13.1
	Timaru and Temuka																							4.4				16.6							21
	Ashburton																								2.7			.3	4						7
	Christchurch and Rangiora																									34	7	9							50
North Island Mills Flour Supply	Wellington																											20							20
	Palmerston North																														14				14
	Mount Maunganui																															30			30
	Auckland																															15	85		100
TOTAL DEMAND		9	23	13.1	21	7	50	64		36			100		17	83	20	13.9	30	100	9	14	3	4.4	2.7	34	10	55	4	4	17	45	85		

be seen to move to respective mills in these regions. There it is milled to flour along with other South Island wheat received by rail before eventually being delivered to satisfy North Island demand regions.

The flows of the current solution that could not be validated relate mainly to the rail transfers of wheat from the South Island to North Island mills (20,000, 13,900, 13,000, 17,000 tonnes from Ashburton to, respectively, Wellington, Palmerston North, Mount Maunganui, and Auckland, plus 100 tonnes from Southland to Palmerston North). These transfers are unknown because Wheat Board data only records the aggregate of inter-island wheat flows by container ship (roll on-roll off) and by rail ferry. Therefore the proportion of wheat railed compared to that shipped in containers is unknown. Also intra South Island wheat transfers are not reported by the Wheat Board and cannot be verified. For these reasons, it is not possible to determine how closely the flows of the current solution resemble the actual flows that the Wheat Board would arrange in a year of self-sufficiency, although, it is known for instance, that some container shipping and some rail transfer to North Island mills from Otago does actually occur. It is also known that container shipments via Lyttelton to North Island mills occur, but the current cost minimising model does not include such flows which suggests that they are uneconomical. The model can, however, be validated in terms of the aggregate flows using these two modes of transport. The inter-island rail transfers of wheat shown in Table 5.1 were consistent with the aggregate figures reported by the Wheat Board in years of self-sufficiency.

Other differences between trade flows of Table 5.1 and known actual flows, relate to intra North Island and inter-island flour flows. The total inter-island flour trade of the model is for

46,000 (w.e.) tonnes to be transported from the South to the North Island each year. This is close to the actual flow of approximately 50,000 w.e. tonnes. However, the quantities of flour received at North Island destinations from South Island flour mills in the model are at variance with actual receivals of South Island flour reported by the Wheat Board (Annual Report 1979).

From actual receivals of South Island flour at North Island destinations reported by the Wheat Board (various editions of its Annual Report) it is known that South Island flour is delivered throughout the North Island. In contrast, the model indicates this flour should be used to meet the deficit mainly in the Wellington area and that intra-North Island flour flows satisfy other North Island deficit regions. For instance, 14,000 w.e. tonnes from Palmerston North should go to the East Coast/Hawkes Bay region and 15,000 w.e. tonnes from Auckland to Mount Maunganui.

Despite these discrepancies and uncertainties, the total marketing costs of the solution are close to those of the existing industry. Possibly this is because rail transfer and container shipping costs are not too different (Tables 4.4 and 4.5), and that there is little scope for reducing transport costs by re-organising the flour trade flows in the North Island.

5.2.2 Validation and Marketing Costs

The total marketing cost estimated for the solution was $19.56 m. This comprised $13.0 m freight and handling costs, and $6.56 m. milling costs. This is a close estimate of the total freight and milling costs of the existing industry.

For the year ended 31 January 1979 the Wheat Board paid a total of $12.96 m. for freight. This includes freight on bran and pollard and also $1.3 m. freight on 27,250 tonnes of imported wheat. These costs are not included as freight on equivalent New Zealand wheat. Hence, the actual comparable transport cost may be slightly less than $12.96 m. and therefore further from the estimated cost of the model at $13.0 m. Nevertheless, this divergence is not thought to be significant.

The actual cost of milling is not as readily available as freight costs. The latest available Industry Production Statistics (Department of Statistics, 1977) show the value added by the grain milling industry in the 1975-76 year to be $7.4 m. However, this aggregate includes the value added on bran, pollard and breakfast cereals, and therefore it is not possible to disaggregate the exact cost of flour milling from this statistic. Appendix 1 shows the Department of Trade and Industry calculations for the marketing margin paid to flour mills per tonne of wheat milled from 1 February 1978. Although no longer applicable, this margin would have been equivalent to $24.67 at May 1979. Multiplied by the volume of wheat handled at mills of 287,000 tonnes per annum, a figure of $7 m. would be the derived cost of milling. Again, this is close to the estimated cost of the model at $6.56 m.

The fact that the estimated and actual costs are similar serves to provide a valuable reference point ($19.6 m.) to gauge the changes in market performance which could occur as the structure of the industry is changed in the model. Also, if the marketing costs of the model are a reasonable indication of the true social costs, the solution to the capacitated problem may help identify one of the effects arising from the Government's standardised flour pricing policy.

In chapter two it was shown how the high transport costs of remote localities relative to proximate localities represented an economic disadvantage to the remote region. Also, it was suggested that if a standardised price was paid in each locality regardless of transport or other regional disadvantages, it would lead to a cross-subsidisation from localised to remote regions. Information arising from the solution to the capacitated problem can be used to estimate the current relative levels of cross-subsidisation among flour consumers of different regions and among South Island wheat farmers of different regions. This may be useful information for policy makers.

5.2.3 Consumer Welfare Implications

Although the absolute spatial equilibrium prices for wheat and flour can not be estimated from the existing model[7], regional price differentials are produced. Regional flour price differentials for the capacitated model are presented in Table 5.2. These show the relative locational advantage of various final demand regions in procurring an additional wheat equivalent tonne of flour. These are the relative marginal values of flour in different regions based on extra transfer, handling and processing costs, but excluding production costs of growing wheat. In assuming a competitive market where the forces of arbitrage operate, these values can be assumed to represent regional flour price differentials.

The regional price differentials of Table 5.2 show the relative marginal values of flour at various final demand regions. These are relative to the lowest price region, Otago. For example, the relative marginal value of flour in Southland is $19.00 more than in Otago. This differential represents the relative disadvantage of Southland in procurring an additional wheat equivalent tonne of flour compared to Otago.

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7 These could not be determined on account of the fact that initial production costs (supply responses) for wheat were not included in the model, nor were estimates of demand functions - these were assumed to be completely inelastic also.

TABLE 5.2

Regional Flour Price Differentials
and Consumer Cross-Subsidisation

	$/W.E. Tonne		$/Tonne Flour
	Regional Price Differentials	Consumer Tax[a]	Flour Price
Regions			
Southland	19	32.97	228.72
Otago (South and Central)	0	51.97	204.40
North Otago	5	46.97	210.80
South Canterbury	9	42.97	215.92
Mid Canterbury	12	39.97	219.72
Christchurch (Districts and Westland	16	35.97	224.88
Nelson/Marlborough	39	12.97	254.32
Wellington (Excluding Palmerston North	56	- 4.03	276.08
Palmerston North	65	-13.03	287.60
Taranaki	73	-21.03	297.84
East Coast/Hawkes Bay	83	-31.03	310.64
South Bay of Plenty	74	-22.03	299.12
Auckland/North Auckland	63	-11.03	285.04

Weighted Average of Consumer Price Differential = $51.97.

[a] Negative consumer tax = a consumer subsidy.

The area with the greatest relative disadvantage is the East Coast/Hawkes Bay region. There, the marginal value of flour is $83.00 greater than Otago. It can be seen from Table 5.2 that the regional price differentials do not simply increase with transport distance from the least price region. This is partly a result of the different costs of alternative modes of transport that are used by the Wheat Board along certain routes, and also it is a result of the regional differences of other processing and handling costs.

The existing standardised flour pricing scheme of Government does not reflect the relative regional values of flour. The implications arising from this can be observed by comparing the weighted average of all regional price differentials, $51.97, to the respective price differentials of Table 5.2

The $51.97 value can be used to represent the New Zealand wide cost of distributing the flour. This can be considered to be the standardised price relative to price differentials.[8] It can be seen from Table 5.2 that if this standardised price applied in Otago the price of flour would be $51.97 higher in Otago than under a differential pricing scheme. This implies that under a standardised pricing scheme, Otago consumers pay a tax which is used to subsidise other regions such as Auckland, where the differential price is $63.00 above that of Otago and $11.03 above the standardised price.

Under a standardised pricing scheme, all regions where the flour price differential is below the weighted average would pay more than the marginal value of flour in those regions, by the amount of the consumer taxes shown in Table 5.2. Conversely, those regions

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8 This standardised price is such that the sum of the consumer tax is equivalent to the sum of the subsidy paid to consumers of other regions.

where the marginal value of flour is greater than the weighted average would pay less than the marginal value of flour in those regions, and would enjoy a negative consumer tax or subsidy.

Regardless of the actual level of the standardised flour price relative to the differentials of Table 5.2, the current flour pricing policy of Government insulates the market from the economic forces that the locational disadvantages or price differentials represent. By ignoring these differentials, the standardised flour pricing scheme of Government operates as a discriminatory taxation scheme indirectly affecting the distribution of income. The estimates of taxes and subsidies provided here show the relative (but not necessarily the absolute) level of discrimination caused by ignoring differentials. This may be useful information for policy makers wishing to evaluate the equity of Government's standardised flour pricing policy.

In the current industry it would appear that the standardised flour price is close to the average per unit financial costs of the industry (see Appendix 3). The price for flour effective from 1 February 1979 was $270.00. Table 5.2 presents a list of flour prices which show the marginal values of flour in respective regions if the current standardised flour price were to be modified to reflect regional price differentials.

5.2.4 Producer Welfare Implications

Regional wheat price differentials for the capacitated model are presented in Table 5.3. These show the relative locational advantage of various production regions in supplying an additional tonne of wheat. These are based on extra transfer, handling and processing costs and exclude production costs of growing wheat.

TABLE 5.3

Regional Wheat Price Differentials and Producer Cross-Subsidisation

($/tonne of wheat)

	Regional Price Differential	Producer Tax
Regions		
Southland	0	-14.48
Otago	8	- 6.48
North Otago	17	2.52
South Canterbury	19	4.52
Ashburton	18	3.52
Remaining Canterbury	28	13.52

Weighted average of regional price differentials = 14.48

The regional price differentials of Table 5.3 show that the marginal value of wheat is $28.00 per tonne more in North Canterbury than in Southland. By implication, it is worth paying farmers an extra $28.00 per tonne of wheat in North Canterbury than farmers in Southland. However, under the Government's standardised wheat price scheme, a fixed price is paid to farmers regardless of their proximity. If this standardised price can be represented by the weighted average of price differentials, then estimates of the relative producer tax of farmers in various regions can be calculated.[9] These are also shown in Table 5.3.

9 This representative standardised price is such that the sum of the producer tax (i.e. tax times quantity) is equivalent to the total of the subsidy paid to farmers in other regions.

The producer taxes of Table 5.3 imply that under a standardised pricing scheme North Canterbury farmers are paying a per unit tax of $13.52 to subsidise other regions such as Southland, where the marginal value is $28.00 below that of North Canterbury and $14.48 below the standardised price. Other subsidies can be seen to be paid to Otago farmers and other taxes by farmers in North Otago and northwards.

Again it has been shown how the standardised pricing scheme of Government operates as a discriminatory taxation scheme when price differentials are ignored. This information may be of interest to policy makers concerned with the equity of Government's standardised wheat pricing scheme. However, these figures should be interpreted with caution.

It should be noted that the regional price differentials of Table 5.3 are not competitive equilibrium prices. First of all, production responses to price differentials of Table 5.3 are absent because wheat supplies are assumed to be completely inelastic; this may be unrealistic. If production responses, and therefore supply elasticities, could be included in the model it is likely that these would alter the levels of production in different regions. This could lead to an alternative set of regional price differentials.

Secondly, the price differentials of Table 5.3 and of Table 5.2 are not competitive equilibrium prices because of the many protective Government constraints and controls operating to prevent competition occurring in the industry. For instance, the fact that the throughput of bulk shipping is limited to 100,000 tonnes and that Bluff is restricted to supply 64,000 tonnes of this, may expalin why extra wheat in Southland has less value than wheat in Mid Canterbury. Despite the fact that bulk shipping costs from respective ports of these regions are equivalent, if no more than 64,000 tonnes of wheat can be loaded through Bluff, any extra wheat exported from the region must do so by train to say, the North Island. Compared to the cost of railing wheat to the North Island from Ashburton the cost from Southland may place Southland farmers at a relative disadvantage. Hence, the margin value of wheat in Southland would be expected to be less than that in Ashburton.

As discussed in chapter 4, it is possible to measure the opportunity cost imposed by the constraints of the capacitated model; that is the cost saving forgone by not being able to increase say the loading capacity at Bluff by one unit. This cost could alternatively be interpreted as the marginal value of increasing Bluff's throughput by one unit.

5.2.5 Opportunity Costs of Existing Market Constraints

Table 5.4 presents the opportunity costs imposed by constraints on transhipment activities of the model.

TABLE 5.4

Marginal Opportunity Costs of Constraints

($/wheat equivalent tonne)

Mills		Port		Bulk Ship	
Invercargill	30	Bluff	22	Bulk Ship	0
Dunedin	0	Dunedin Ro-Ro	0		
Oamaru	0	Timaru	8		
Timaru and Temuka	2	Lyttelton	0		
Ashburton	6	Lyttelton Ro-Ro	0		
Christchurch/Rangiora	0	Wellington	0		
Wellington	17	Mount Maunganui	9		
Palmerston North	17	Auckland	8		
Mount Maunganui	0				
Auckland	1				

The figures of Table 5.4 serve as an indication of the marginal value of removing current constraints (or alternatively the marginal opportunity cost currently imposed by these constraints). These values suggest that increased bulk shipping with extra loading at Bluff and Timaru, and unloading at Auckland and Mount Maunganui may lead to cost savings. Also, increased milling in the lower North Island might lead to cost savings, as might the increased milling in Ashburton, and to a less extent, Timaru/Temuka.

Increased milling at Timaru/Temuka might result in a cost saving because flour from these regions supplied to Wellington might save transporting flour from the more remote Dunedin mill to Wellington. However, as with all these marginal values, the ceteris paribus assumption upon which they are based means their relevance will only hold for very small changes. If Wellington milling capacity was increased enough, flour from Timaru and Temuka may no longer be required which could cause the extra output of these mills to have zero marginal value. Alternatively, dropping shipping constraints may decrease the value of wheat at Mount Maunganui mills. Then the marginal value of additional milling capacity might be high compared to its present zero value.

The marginal value of $30.00 at Invercargill mill only applies in a downward direction. That is, a decrease in milling capacity of one tonne at Invercargill would increase costs by $30.00. An increase in milling capacity there would not lead to a cost saving. This is caused by limitations imposed from other constraints.

Despite the uncertainties of interpreting the figures of Table 5.4, the fact the constraints are shown to cause opportunity costs to the existing industry demonstrates that it may be worthwhile to examine the effects of removing constraints in the model.

Further, the fact the economies of scale in milling and shipping are possible, complicates the interpretation of the marginal values of Table 5.4. This occurs because, for instance, each additional unit of milling allows a mill to experience decreasing per unit costs. Only the solution without the current constraints, and where scale effects are represented, can determine exactly which regions and activities of the industry should increase or decrease in the long term. By identifying where short-run costs occur and by studying long-run solutions of an unconstrained industry, it is possible for policy makers to see how to move from the short-run to the most efficient long-run situation.

5.3 Increased Bulk Shipping Capacity

In allowing an unrestricted flow of wheat to be transferred to the North Island by bulk ship, it was also necessary to allow an unrestricted amount of wheat to move through port storage facilities, including the proposed receival port facilities at Auckland, Mount Maunganui and Wellington.[10] Accordingly, capacity constraints were lifted and the shipping and port activities of the model were allowed to handle any quantity of wheat at the cost dictated by their respective long-run average cost curves. The Stammer heuristic search technique was used to analyse the effects of economies of scale in these activities. At this stage no attempt was made to use the force routine of Higham, et. al. (op cit). All other activities of the model were assumed to be constrained as in the first run.

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[10] As discussed in the previous chapter, additional storage was considered necessary to hasten unloading and to provide security of continued supply of wheat to North Island mills.

5.3.1 Solution Number Two

The best solution obtained using the Stammer method, produced a total cost to the industry of $17.7 m.; a saving of $1.87 m. over the solution obtained in the completely capacitated problem. This solution is shown in Table 5.5.

The saving of $1.87 m. arose from the increased economy attained in the transport of an extra 64,000 tonnes of wheat to the North Island by bulk ship. Previously, this had been transported by rail which is a more expensive means of transport.

The extra volume of bulk shipping enabled economies of scale to be exploited in this shipping operation, lowering the cost per tonne from over $35.00 (on 100,000 tonnes of wheat) to $18.00 per tonne (on 164,000 tonnes of wheat). However, part of this benefit was eroded by the additional cost of establishing and running extra unloading and storage facilities at receival ports. The total costs at loading ports did not change significantly, although their relative cost was altered owing to the change in relative volumes handled at each port.

The volumes of wheat handled at ports in the solutions of Table 5.1 and 5.5 are summarised in Table 5.6

It can be seen from Table 5.6 that the increased tonnage of wheat transferred to the North Island by bulk ship is loaded mainly at Timaru. This increased by 61,000 tonnes over the volume in the solution to the capacitated problem. Bluff increased its loading by 3,000 tonnes. The volumes of wheat received at North Island ports increased in accordance with that necessary to fulfill the milling quotas in each region, and replaced the receivals of wheat that had previously arrived by rail.

TABLE 5.5

Solution Number Two

000's tonnes

Sources	Destinations	South Island Mills: Invercargill	South Island Mills: Dunedin	South Island Mills: Oamaru	South Island Mills: Timaru and Temuka	South Island Mills: Ashburton	South Island Mills: Christchurch and Rangiora	South Island Ports: Bluff	South Island Ports: Dunedin Ro/Ro	South Island Ports: Timaru	South Island Ports: Lyttelton	South Island Ports: Lyttelton Ro/Ro	BULK SHIP	North Island Ports: Wellington	North Island Ports: Mount Maunganui	North Island Ports: Auckland	North Island Mills: Wellington	North Island Mills: Palmerston North	North Island Mills: Mount Maunganui	North Island Mills: Auckland	Final Demands for Flour (All Regions): Southland	South and Central Otago	North Otago	South Canterbury	Ashburton	Christchurch Districts and Westland	Nelson and Marlborough	Wellington	Palmerston North	Taranaki	East Coast/Hawkes Bay	South Bay of Plenty	Auckland and North Auckland	DUMMY DEMAND	TOTAL SUPPLY
Wheat Supply	Southland	9						67																											76
	Otago		20.1																																20.1
	North Otago			14	2																														16
	South Canterbury									50																									50
	Ashburton				19	7	2			47																									75
	Remaining South Island						50																												50
South Island Ports Wheat	Bluff												67																						67
	Dunedin Ro/Ro																																		
	Timaru												97																						97
	Lyttelton																																		
	Lyttelton Ro/Ro																																		
Bulk Ship Wheat Supply														34	30	100																			164
North Island Ports Wheat Supply	Wellington																30	14																	44
	Mount Maunganui																		30																30
	Auckland																			100															100
South Island Mills Flour Supply	Invercargill																				9														9
	Dunedin																					14						3.1			3				20.1
	Oamaru																						3					7		4					14
	Timaru and Temuka																							4.4				16.6							21
	Ashburton																								2.7			.3	4						7
	Christchurch and Rangiora																									34	10	8							52
North Island Mills Flour Supply	Wellington																											20							20
	Palmerston North																														14				14
	Mount Maunganui																															30			30
	Auckland																															15	85		100
TOTAL DEMAND		9	20.1	14	21	7	52	67		97			164	34	30	100	30	14	30	100	9	14	3	4.4	2.7	34	10	55	4	4	17	45	85		

Dropping the shipping and port constraints also caused changes in some intra-South Island wheat and flour trade flows, and inter-island flour trade flows. By comparing Table 5.1 with 5.5 it can be seen, however, that these changes were not great.

TABLE 5.6

Volumes of Wheat Handled at Discharge and Receival Ports

(tonnes of wheat)

	Unconstrained	Constrained
Loading Ports		
Bluff	67,000	64,000
Timaru	97,000	36,000
	164,000	100,000
Unloading Ports		
Wellington	34,000	
Mount Maunganui	30,000	17,000
Auckland	100,000	83,000
	164,000	100,000

The overall reallocations of wheat and flour shipments did not alter the regional flour price differentials. These did not change because flour is delivered to final demand regions from basically the same mills as previously, and the opportunity costs of delivering from alternative regions are also much the same despite changes in the regional wheat price differentials.

5.3.2 Regional Wheat Price Differentials

The set of wheat price differentials of Solution Number Two are given in Table 5.7. The previous differentials are also included for comparison.

TABLE 5.7

Regional Wheat Price Differentials (2)

($/tonne wheat)

Region	Solution No. 2	Capacitated
Southland	5	0
Otago	0	8
North Otago	9	17
South Canterbury	12	19
Ashburton	10	18
Remaining Canterbury	20	28

It is interesting to note that the range of price differentials has decreased from 0-28 to 0-20 in the new solution reflecting the increased efficiency of transporting activities. Also of interest, is the fact that the relative marginal value of wheat in Southland has increased quite notably owing to the increased demand for Southland wheat for bulk shipping.

The differentials of Table 5.7 represent the marginal values of wheat in respective production regions given complete protection from international trade. From Solution Number Two it is possible to obtain the relative marginal value of wheat in Sydney (F.O.B.) assuming production cost in all regions, including Sydney, to be zero.[11]

[11] It will be recalled from chapter 4 that a simple modification of the model would allow Sydney to be included as a potential supply point; Sydney has been included in the matrix from which solution two is derived.

5.3.3 Opportunity Cost of Import Controls

The relative value of wheat supplied from Sydney is $20.00 and therefore it is $20.00 above the marginal value of wheat in Otago. A major reason why this value is high relative to the South Island regions is that the wheat is assumed to be purchased F.O.B. The cost of shipping from Sydney to New Zealand therefore does not include farm to port or loading cost in Australia. This implies that if quantitative controls on imports of Sydney wheat were reduced by one unit, a $20.00 saving in marketing costs could result from importing one tonne of wheat. It should be noted that the marginal value of wheat in Sydney would be expected to decline if extra units were imported.

The $20.00 marginal value of wheat in Sydney (F.O.B.) holds important implications for the relative wheat price in different regions of New Zealand. The implied price differentials of South Island regions set relative to Sydney are presented in Table 5.8.

TABLE 5.8

Regional Wheat Price Differentials

Relative to Sydney

($/tonne wheat)

Region	
Southland	-15
Otago	-20
North Otago	-11
South Canterbury	- 8
Ashburton	-10
Remaining Canterbury	0
Sydney	0

The relative price differentials of Table 5.8 are the amounts by which the price in South Island regions would need to be below the Sydney F.O.B. price to prevent wheat imports entering New Zealand at lower cost. This is assuming an unrestricted entry of Australian wheat and assuming a completely elastic wheat supply in Sydney. The differentials show that Sydney is a highly competitive supply point. For this reason, an experiment was conducted where the model was run in the absence of the quantitative import control. The results of this run showed that if the full 164,000 tonnes of wheat shipped to the North Island in Solution Two were instead procured from Sydney, total industry costs could be reduced to $15.8 m. Compared to Solution Two, this represents an additional saving of $1.9 m.

All wheat delivered to the North Island in the modified model came from Sydney because prices of wheat at Sydney F.O.B. and at South Island regions F.O.R. were assumed equal and fixed.[12] If such a change were to actually occur, however, the price of wheat in South Island regions would decline as farmers sought to compete against Sydney's supply advantage. This would lower the relative marginal value of wheat in Sydney (or perhaps more understandably, lower the relative opportunity cost of <u>not</u> importing wheat from Sydney). At the lower South Island prices, South Island farmers would still be prepared to supply wheat, but probably at reduced quantities. The South Island price and quantity of wheat would continue to decline until the Sydney (F.O.B.) price plus marketing costs to say Auckland was equivalent to the discounted South Island price plus respective marketing costs to Auckland. Under these circumstances Auckland could be supplied from both Sydney and

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12 This is a reasonable assumption based on a ministerial comparison of New Zealand F.O.R. prices and the prices paid for Imported Australian wheat.

South Island regions. Savings in marketing costs would result from the importing of additional wheat from Sydney, while savings in the form of reduced costs of purchasing discounted wheat would result from purchases of New Zealand wheat. In this internationally competitive situation all New Zealand prices would respond to changes in the international wheat price (F.O.B. Australia).

It is not possible to determine full spatial equilibrium prices and quantities from the existing model because respective supply functions of the production regions are not included in the model. Also, because there are non-linear shipping and port costs and, therefore, the possibility of several alternative local optima, it is unlikely that there would be an unique set of spatial equilibrium prices and quantities. Nevertheless, information of the type reported in Table 5.6 may be of interest to policy makers concerned with setting the New Zealand wheat price. This information may be useful for it shows that the total industry costs could be reduced if New Zealand regional (F.O.R.) wheat prices were set according to the marginal value of wheat in these regions relative to the marginal value of wheat F.O.B. in Sydney and therefore made competitive.

Additional competitive forces that could be included in the model are those relating to milling. Currently, milling quotas set by the Wheat Board prevent competition among millers. The marginal opportunity costs of milling quotas given unrestricted transport patterns are available from Solution Two.

5.3.4 Opportunity Cost of Milling Quotas - Shipping Constraints Absent

Table 5.9 presents the marginal opportunity costs of milling quotas for Solution Number Two.

TABLE 5.9

Relative Opportunity Costs

of Milling Quotas (2)

Regions	$/Wheat Equivalent Tonne
Invercargill	17
Dunedin	0
Oamaru	0
Timaru and Temuka	2
Ashburton	6
Christchurch/Rangiora	0
Wellington	13
Palmerston North	12
Mount Maunganui	31
Auckland	18

The marginal opportunity costs of quotas on North Island mills in Table 5.9 suggest that at least small increases in North Island milling capacities would lead to significant reductions in costs. The potential savings are explained by two factors. Firstly, milling is cheaper in the North Island than in the South Island because of the larger mills currently operating in the North Island. Secondly, given that there are no restrictions on transportation in the model, increased milling in the North Island would allow bulk shipments of wheat to be substituted for currently more expensive rail transfers of flour from South Island mills to North Island final demand areas.

A third set of forces not accounted for in the opportunity costs of Table 5.9 are the potential economies of scale in shipping and milling. These represent longer term economic responses.

Marginal measurements only measure small short term changes. As a result, it is possible that the long term value of increasing the Palmerston North milling quota for example, may be negative, while the short term marginal value is $12.00. If the Wellington milling capacity alone was increased instead of both Wellington and Palmerston North,[13] total milling costs for the combined output of both may be less. Therefore increasing milling in Palmerston North may in the longer term prevent Wellington realising its full economy of scale and thus expanding Palmerston North milling would have an opportunity cost in the longer term.

Only by running the model in the absence of milling quotas and allowing milling allocations to adjust according to the estimated long-run average cost curve of this processing operation would it be possible to estimate the importance of these factors.

5.4 Rationalisation and Milling Capacities - Solution Number Three

In the version of the model first used to analyse the rationalisation of milling capacities there were no constraints on milling, shipping, loading or unloading. However, to simplify the analysis imports of Sydney wheat were first restricted to zero and scale effects in milling were assumed absent. This was achieved by retaining milling costs at their previous fixed levels.

Table 5.10 summarises the results of the third solution. From the results to the initial version of this virtually uncapacitated problem it became apparent that substantial cost reductions could be made by further centralising the transport operation of the industry. This resulted from shipping wheat for milling instead of flour to the North Island.

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13 Wellington and Palmerston North are "geographically close".

The minimum cost solution obtained using the Stammer method gave a total cost of $15.44 m. representing a saving of $2.26 m. over Solution Number Two.

The saving of $2.26 m. arose from transporting an additional 46,000 tonnes of wheat to North Island mills by bulk ship. Previously the equivalent flour had been transported to the North Island by rail from South Island mills.

The increased bulk shipping of Solution Three allowed greater economies of scale to be achieved in bulk shipping and at unloading ports. Bulk shipping increased from 164,000 tonnes in Solution Two to 204,000 tonnes in Solution Three. This reduced per unit shipping costs from $18.00 to $15.00. Per unit unloading costs at Wellington reduced from $16.00 on 34,000 tonnes to $10.00 on 53,000 tonnes, and at Mount Maunganui costs reduced from $8.00 on 30,000 tonnes to $2.00 on 151,000 tonnes.

The unloading of Auckland's milling wheat at Mount Maunganui accounts for the higher volume handled at that receival port. As discussed in the previous chapter a port storage and unloading facility at Auckland could be expensive compared to a similar facility at Mount Maunganui. Solution Three indicates that because of the greater economy of scale achieved by unloading the full 151,000 tonnes of wheat at the cheaper facility, the extra cost of transporting wheat to Auckland from Mount Maunganui is preferable to the cost of unloading 85,000 tonnes of wheat at Auckland.

Other cost savings resulting from Solution Three involve milling costs. Regardless of the potential economies of scale, current North Island per unit milling costs are estimated to be less than South Island costs because of the larger average size of mill. If it is assumed that current North Island mills could

TABLE 5.10

Solution Number Three

000's tonnes

Sources	Destinations	South Island Mills: Invercargill	Dunedin	Oamaru	Timaru and Temuka	Ashburton	Christchurch and Rangiora	South Island Ports: Bluff	Dunedin Ro/Ro	Timaru	Lyttelton	Lyttelton Ro/Ro	BULK SHIP	North Island Ports: Wellington	Mount Maunganui	Auckland	North Island Mills: Wellington	Palmerston North	Mount Maunganui	Auckland	Final Demands for Flour (All Regions): Southland	South and Central Otago	North Otago	South Canterbury	Ashburton	Christchurch Districts and Westland	Nelson and Marlborough	Wellington	Palmerston North	Taranaki	East Coast/ Hawkes Bay	South Bay of Plenty	Auckland and North Auckland	DUMMY DEMAND	TOTAL SUPPLY
Wheat Supply	Southland	9						67																											76
	Otago		14					6.1																											20.1
	North Otago			3						13																									16
	South Canterbury									50																									50
	Ashburton				4.4	2.7				67.9																									75
	Remaining South Island						44					6																							50
South Island Ports Wheat	Bluff												73.1																						73.1
	Dunedin Ro/Ro																																		
	Timaru												130.9																						130.9
	Lyttelton																																		
	Lyttelton Ro/Ro																2	4																	6
Bulk Ship Wheat Supply														53	151																				204
North Island Ports Wheat Supply	Wellington																53																		53
	Mount Maunganui																		66	85															151
	Auckland																																		
South Island Mills Flour Supply	Invercargill																				9														9
	Dunedin																					14													14
	Oamaru																						3												3
	Timaru and Temuka																							4.4											4.4
	Ashburton																								2.7										2.7
	Christchurch and Rangiora																									34	10								44
North Island Mills Flour Supply	Wellington																											55							55
	Palmerston North																												4						4
	Mount Maunganui																													4	17	45			66
	Auckland																																85		85
TOTAL DEMAND		9	14	3	4.4	2.7	44	73.1		130.9		6	204	53	151		55	4	66	85	9	14	3	4.4	2.7	34	10	55	4	4	17	45	85		

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expand or contract according to the throughput levels of Table 5.10 without altering their production costs, 46,000 tonnes of wheat could be milled in the North Island more cheaply than in the south.

From Table 5.10 it can be seen that the expansion of the Wellington milling quota to 55,000 tonnes per annum and of the Mount Maunganui quota to 66,000 tonnes has resulted in both islands being self-sufficient in the milling of flour. Many regions are also self-sufficient in flour production. In the South Island the only intra-island regional transfer of flour is for 10,000 tonnes to be transported to the Nelson/Marlborough district. In the North Island intra-island regional transfers from Mount Maunganui occur. All other regions of the model are self-sufficient in flour production.

The new market structure of Table 5.10 would cause changes in both the regional flour and wheat price differentials.

5.4.1 Regional Flour Price Differentials

The final demand regional flour price differentials of Solution Three are presented in Table 5.11. The previous differentials have been included for comparison.

From Table 5.11 it can be seen that the relative marginal values of flour have declined in most final demand regions in moving from Solution Two to Solution Three. The overall range of values can be seen to have declined from $0-$83.00 per wheat equivalent tonne down to $0-$51.00 (East Coast/Hawkes Bay). The only regions where the relative marginal values of flour would increase are in North Otago and South Canterbury. These increases can be explained by a complex chain of changing demands for wheat

TABLE 5.11

Regional Flour Price Differentials

(Solution Three)

($/wheat equivalent tonne)

Regions	Solution No.		Regions	Solution No.	
	3	2		3	2
Southland	7	19	Wellington (Excluding Palmerston North	39	56
Dunedin and Districts	0	0	Palmerston North	50	65
North Otago	10	5	Taranaki	49	73
South Canterbury	12	9	East Cost/Hawkes Bay	51	83
Mid Canterbury	11	12	South Bay of Plenty	39	74
Christchurch/Districts and Westland)	13	16	Auckland/North Auckland	36	63
Nelson/Marlborough	36	39			

and flour but are also a result of an increased demand for wheat required for bulk shipping from these regions. It might be concluded that milling quotas, by lowering the demand for wheat in these regions in Solution Two, served to give these regions an artificially lower relative disadvantage in procurring their extra tonne of flour (compared to Otago).[14] In contrast, all other regions, except for Otago, experienced artificially high locational disadvantages in Solution Two (relative to Otago) due to milling quotas.

Table 5.11 shows that the quotas caused marginal values of flour production to be most distorted in the North Island. In the South Bay of Plenty region the locational disadvantage can be seen to decline from $74.00 per tonne with quotas down to $39.00 without quotas. The range of South Island regional wheat price differentials also narrowed.

5.4.2 Regional Wheat Price Differentials

Table 5.12 shows the new set of regional wheat price differentials for Solution Number Three. The previous differentials are included for comparison.

The relative marginal values of South Island regions increase in Table 5.12 as a result of increased demand for wheat at the ports to which these regions supply. The increased demand is a result of the additional 46,000 tonnes transported by bulkship.

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14 It must be remembered these regional advantages and disadvantages are concealed by the standardised flour price in the current market.

TABLE 5.12

Regional Wheat Price Differentials

($/tonne wheat)

Region	Solution No.	
	3	2
Southland	10	5
Otago	0	0
North Otago	14	9
South Canterbury	17	12
Ashburton	15	10
Remaining Canterbury	17	20
Sydney	22	20

The decline in the relative marginal value of wheat in Mid and North Canterbury is a result of the relatively high cost of transporting 6,000 tonnes of surplus wheat from this region. Previously the milling quota of this region had created artificially high local demands for wheat which meant that 2,000 tonnes of wheat were actually imported into the region.

The increased marginal values of wheat in South Island regions supplying to either Timaru or Bluff are the cause of the increase in the marginal value of wheat in Sydney. These increased values of wheat in South Island regions represent an additional cost of not importing wheat from Sydney. By dropping the import constraint to estimate the net cost saving of forcing New Zealand prices to be competitive with Sydney prices, total industry costs were reduced to $12.7 m. This represents an additional cost saving of \$2.7 m. over Solution Three. As discussed previously, although dropping this constraint is valid for calculating this specific piece of information on costs, the model can not determine what might be a rational market structure because the model does not embody production costs of growing wheat in different regions. Consequently, it is not possible to calculate the long run proportions of Sydney and South Island wheat that should be supplied to the North Island. For the same reason it is not possible to calculate useful dual information from such a model.

5.5 Rationalisation and Scale Economies of Milling

Because of the limited information that can be attained when the import constraint of the model is dropped, this was reintroduced to the model to study the effects of non-linear milling costs.

The introduction of non-linear milling costs to the model meant that several, if not many, local optima solutions might exist. Although previously non-linear shipping and port handling costs were introduced these did not create any apparent alternative optima problems.[15] To take account of the problems introduced by non-linear milling costs, the Stammer method was used in conjunction with the forcing technique of Higham, et. al. This made it possible to examine several low cost solutions.

From the several low cost solutions generated using this version of the model, it became apparent that further cost reductions could be obtained by centralising the milling operations of the industry. This highlights the dispersed and fragmented structure of the current industry.

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[15] One exception was the possibility of loading enough Ashburton wheat through Lyttelton to achieve sufficient economies of scale in bulk loading there. This may have allowed 6,000 tonnes of wheat otherwise shipped in containers to be shipped by more economical bulk ship. This was not tested, but nor was 6,000 tonnes of wheat considered significant.

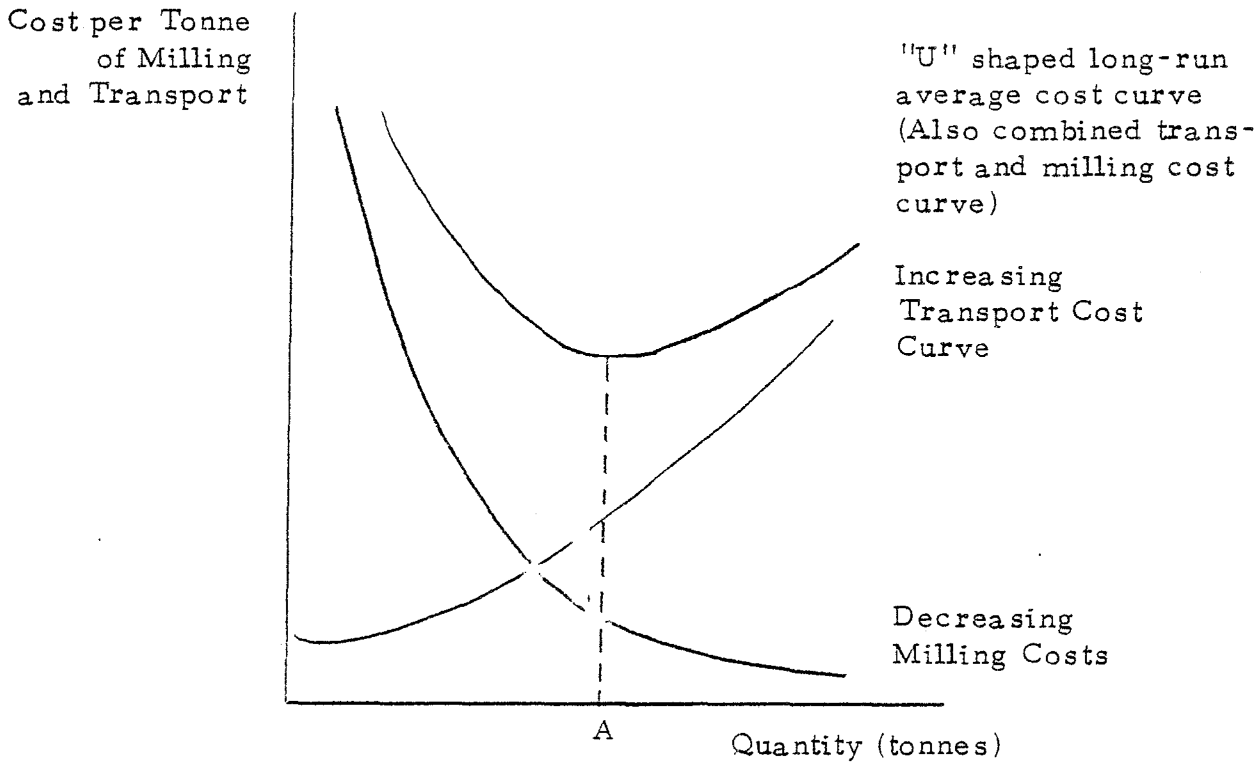
5.5.1 Number of Mills in Each Region

Only if the long-run average cost curve of an activity has a minimum, indicating a maximum size beyond which internal production diseconomies of scale occur, will the duplication of facilities in any locality lead to a saving in total costs. Such a diseconomy can be seen to occur at point A on the "U" shaped LRAC curve of Figure 5.1 but as discussed previously, it is assumed in this study that internal diseconomies do not occur in milling. Instead a continuously decreasing LRAC curve is assumed. This is shown in Figure 5.1 as the "decreasing milling cost curve". Because of the nature of this curve, milling costs can always be reduced in a region by milling in the largest possible mill, rather than in several mills all with higher per unit milling costs. Accordingly, the current version of the model assumed only one mill should be present in any region.

The inter-regional case is not so simple. The addition of transport and handling costs create external diseconomies for a mill. The "U" shaped LRAC curve of Figure 5.1 shows that diseconomies will occur once increasing per unit transport costs are greater than decreasing per unit milling costs past point A. Transport cost will increase for instance when extra flour produced to achieve milling economies must be delivered to points further from the place of milling. For this reason, the rational number, size, and location of mills in New Zealand as a whole, can only be determined by carefully analysing the trade-off between lower milling costs and increasing assembly and distribution transport costs which result from centralisation.

FIGURE 5.1

Maximum Size of Mill According to Shape of LRAC Curve



5.5.2 Solution Number Four

The best solution obtained using the Stammer method produces a total cost of $13.8 m. This represents a saving of $1.64 m. over Solution Number Three. Solution Number Four is presented in Table 5.13.

Solution Four suggests there should only be a total of six mills in New Zealand. These should be located close to the major pockets of human population. In Auckland and in Invercargill these mills should only fulfill the flour demand in their respective regions.

TABLE 5.13

Solution Number Four

000's tonnes

Sources	Destinations	South Island Mills: Invercargill	Dunedin	Oamaru	Timaru and Temuka	Ashburton	Christchurch and Rangiora	South Island Ports: Bluff	Dunedin Ro/Ro	Timaru	Lyttelton	Lyttelton Ro/Ro	BULK SHIP	North Island Ports: Wellington	Mount Maunganui	Auckland	North Island Mills: Wellington	Palmerston North	Mount Maunganui	Auckland	Final Demands for Flour (All Regions): Southland	Otago South and Central	North Otago	South Canterbury	Ashburton	Christchurch Districts and Westland	Nelson and Marlborough	Wellington	Palmerston North	Taranaki	East Coast/ Hawkes Bay	South Bay of Plenty	Auckland and North Auckland	DUMMY DEMAND	TOTAL SUPPLY
Wheat Supply	Southland	9						67																											76
	Otago		18.1					2																											20.1
	North Otago									16																									16
	South Canterbury									50																									50
	Ashburton									75																									75
	Remaining South Island						50																												50
South Island Ports Wheat	Bluff												69																						69
	Dunedin Ro/Ro																																		
	Timaru												141																						141
	Lyttelton																																		
	Lyttelton Ro/Ro																																		
Bulk Ship Wheat Supply														59	151																				210
North Island Ports Wheat Supply	Wellington																59																		59
	Mount Maunganui																		66	85															151
	Auckland																																		
South Island Mills Flour Supply	Invercargill																				9														9
	Dunedin																					14	3	1.1											18.1
	Oamaru																																		
	Timaru and Temuka																																		
	Ashburton																																		
	Christchurch and Rangiora																							3.3	2.7	34	10								50
North Island Mills Flour Supply	Wellington																											55	4						59
	Palmerston North																																		
	Mount Maunganui																													4	17	45			66
	Auckland																																85		85
TOTAL DEMAND		9	18.1				50	69		141			210	59	151		59		66	85	9	14	3	4.4	2.7	34	10	55	4	4	17	45	85		

Other mills should supply flour to regions without mills. Dunedin should supply its own region, North Otago, and part of South Canterbury's demand; Christchurch should supply all remaining South Island demands including 3,300 tonnes to South Canterbury.[16] In the North Island it can be seen that Wellington should supply itself and Palmerston North, and Mount Maunganui should supply the remaining North Island regions apart from Auckland.

Other structural changes occurring as a result of centralised milling are for different volumes to be handled at ports. Table 5.14 shows the respective volumes handled in Solutions Three and Four.

TABLE 5.14

Tonnes of Wheat Handled at Ports

(000's tonnes of wheat)

Port	Solution Number	
	4	3
Bluff	69	73.1
Timaru	141	130.9
Lyttelton Ro-Ro	0	6.0
Wellington	59	53.0
Mount Maunganui	151	151.0

The opportunity to load an additional 10,000 tonnes of wheat at Timaru would arise because of the lack of mills between Dunedin and Christchurch. The wheat milled to flour for these regions would come from wheat in North Canterbury and Otago. This would

16 Christchurch does not supply the full 4,400 tonnes of flour required in South Canterbury, because to do so would require importing wheat to Christchurch from other regions.

eliminate North Canterbury's previous 6,000 tonne surplus and Wellington would receive an additional 6,000 tonnes by bulk ship instead of by Ro-Ro container shipments from Lyttelton. Hence, bulk shipping would increase to 6,000 tonnes which is too small a change to effect the economy of scale of bulk shipping.

The effects of these small changes in demand for wheat in South Island regions were not enough to affect the relative marginal values of wheat in respective production regions. However, the relative marginal values of flour in respective final demand regions did change.

5.5.3 Regional Flour Price Differentials

Table 5.15 shows the new set of regional flour price differentials for Solution Four. Those of the previous solution have been included for purposes of comparison.

The increases in the relative marginal values of flour in some South Island regions, namely Southland, North Otago and South Canterbury, are explained by the lower milling costs achieved in Dunedin and Christchurch, and the transport costs from these mills to other South Island regions. Attention should be drawn to the fact that these values say nothing about the absolute value of flour. They simply show the locational disadvantage of final demand regions in procurring their extra tonnes of flour relative to Otago. Therefore, if the marginal value of Otago flour drops, the relative disadvantage of some regions may increase.

The regions whose relative disadvantage decreases most as a result of milling scale economies are Christchurch and Nelson/ Marlborough. By centralising milling in Christchurch, this allows this region to exploit its full locational advantage. This advantage lies in its proximity to a large pocket of demand and allows this milling location to substantially reduce its milling costs. This relative advantage can be seen to spill over into the Christchurch and Nelson/Marlborough final demand regions.

TABLE 5.15

Regional Flour Price Differentials (4)

($/wheat equivalent tonne)

Regions	Solution No. 4	Solution No. 3
Southland	9	7
Dunedin and Districts	0	0
North Otago	12	10
South Canterbury	16	12
Ashburton	14	11
Christchurch (Districts and Westland)	1	13
Nelson/Marlborough	24	36
Wellington (Excluding Palmerston North)	35	39
Palmerston North	47	50
Taranaki	44	49
East Coast/Hawkes Bay	46	51
South Bay of Plenty	34	39
Auckland/Northland	34	36

The reduction in milling costs in the North Island are not as great. Hence the spillover advantages are also not as marked and therefore the decline in the relative disadvantages of North Island final demand regions are not as great as that in Christchurch.

The regional flour price differentials of Table 5.15 are those resulting from one local optimum solution to the current problem. Alternative local optima may have different sets of regional flour price differentials. It is possible that an alternative market structure could produce a solution with similar or reduced total costs. It may be recalled from discussion in chapter three that a knowledge of marginal opportunity costs or marginal value products is not sufficient to determine which possible changes in market structure might lead to solutions of reduced costs, but that instead some other rules might be useful to identify possible areas of improvement in the model's solution. One such rule is:

> if there are two locations present in a stable solution, which are "geographically close", one of them is a good candidate for "forcing out".

In Solution Four, Auckland and Mount Maunganui could be considered to be two locations which are "geographically close". For this reason it was decided to force Auckland from the solution and generate an alternative local optimum solution.

5.5.4 Solution Number Five - Auckland Milling Forced Out

Solution Five differs from Solution Four in that the entire northern North Island flour is milled at, and supplied from, Mount Maunganui instead of both Mount Maunganui and Auckland. This gives a solution with only two mills in the North Island and three in the South. This change results in a reduction of total marketing costs by $0.2 m.

While centralisation of the milling operation at Mount Maunganui resulted in higher transport costs of a more specialised product, flour, instead of wheat from Mount Maunganui to Auckland, the extra economies of scale resultingfrom increased milling at Mount Maunganui more than compensated for the increased transport costs. Table 5.16 shows the magnitude of these costs for Solution Four and Five; the difference between the costs of these solutions is also shown.

TABLE 5.16

Marketing Cost Comparison - Solution Four/Solution Five

($m.)

	Total North Island Milling Costs	Total North Island Port to Mill Transport Costs	Total North Island Flour Delivery Costs	Totals[17]
Solution No. 4	3.334	1.034	.82	5.188
Solution No. 5	2.966	.296	1.755	4.99
Change	- .368	- .765	+ .935	- .198

In Table 5.16 it can be seen that flour delivery costs increase by $.17 m more than the wheat assembly costs decrease (i.e. $.935 m. - $.765 m. = $.17 m.), however, the centralisation of milling at Mount Maunganui rather than at Mount Maunganui and Auckland more than compensates for this increase where the greater economy of scale in milling reduces costs by $.368 m. Hence the $.198 m. reduction in costs (rounded = $.2 m.).

The effect that the overall reductions have on the regional flour price differentials are shown in Table 5.17.

17 Total North Island unloading, milling and transport costs included costs associated with Wellington, which remain constant.

TABLE 5.17

Regional Flour Price Differentials[18]

($/wheat equivalent tonne)

Regions	Solution No.	
	5	4
Taranaki	41	44
East Coast/Hawkes Bay	43	46
South Bay of Plenty	31	34
Auckland/Northland	34	34

It is interesting to note that closing down all milling in Auckland would be of no advantage to Auckland consumers as there would be no change in the marginal value of flour in that region. It is thought that the additional cost of transporting flour rather than wheat to Auckland is just compensated for by decreased milling costs. The other three North Island regions of Table 5.17 benefit by decreased milling costs without incurring increased transportation costs.

The decreased cost resulting from centralising at Mount Maunganui, rather than at both Mount Maunganui and Auckland, does not mean centralisation at Auckland could not also provide a good solution.

Although previously it was shown to be uneconomical to unload 85,000 tonnes at Auckland when this could instrad by unloaded at Mount Maunganui and transported to Auckland at a lesser cost, if 150,000 tonnes were unloaded at Auckland the additional economies of scale involved with unloading may make this a favourable location for centralised milling. The increased economy of scale in unloading

[18] Price differentials in all other regions did not change, and all differentials are set relative to Otago.

would not result in lower unloading costs than at Mount Maunganui, however, there would be a decrease in the total transport bill which may off-set this cost. The cost of transporting 85,000 tonnes of flour (W.E.) from Mount Maunganui to Auckland would be avoided and whilst an extra cost of delivering flour from Auckland to the South Bay of Plenty region would be incurred, this would not be excessive since the average cost of delivering flour from Mount Maunganui to the South Bay of Plenty region is only $3.00 less than from Auckland. The average cost of flour deliveries to the East Coast/Hawkes Bay area is $8.00 greater from Auckland than Mount Maunganui in the model, and to Taranaki $4.00 cheaper.

Accordingly, Mount Maunganui was forced from the solution to analyse the effects of a centralised milling operation at Auckland.

5.5.5 Solution Number Six - Mount Maunganui Milling Forced Out

Solution Six differs from Solution Five in that the entire northern North Island flour is milled at and supplied from Auckland instead of Mount Maunganui. Also, all wheat is assumed to be unloaded at Auckland instead of Mount Maunganui. This solution results in the increase of total marketing costs by $.385 m.

The magnitudes of the various marketing costs of Solutions Five and Six, and the difference between these are shown in Table 5.18. It can be seen that the saving in total flour delivery costs arising from Solution Six compared to those costs of Solution Five are not enough to compensate for the increased total unloading and wharf to mill transport costs.

While the overall increase in costs of $.385 m. is not a large increase it is interesting to note that the new set of marketing costs results in considerably different relative price differentials. These are shown in Table 5.19.

TABLE 5.18

Marketing Cost Comparison - Solution Five/Solution Six[19]

($m)

	Total North Island Unloading Costs	Total North Island Milling Costs	North Island Port to Mill Costs	Total North Island Flour Delivery Costs	Total Costs
Solution No. 5	1.043	2.966	.269	1.755	6.033
Solution No. 6	1.949	2.966	.42	1.083	6.418
Change	+ .906	0	+.151	- .672	+ .385

TABLE 5.19

Regional Flour Price Differentials (6)[20]

($/wheat equivalent tonne)

Regions	Solution No.	
	6	5
Taranaki	46	41
East Coast/Hawkes Bay	58	43
South Bay of Plenty	41	31
Auckland/Northland	30	34

[19] See note of Table 5.16.

[20] See notes of Table 5.17.

The comparative figures in Table 5.19 demonstrate that the relative disadvantages of final demand regions in procurring their extra flour supplies can be sensitive to relatively small changes in the total marketing costs between different low cost solutions. This may hold important implications for those policy makers concerned with the equity of Government's flour pricing policy. The high sensitivity of these regional price differentials raises important questions as to what might be "fair" regional flour price differentials to reflect the relative disadvantages of regions.

The relatively small differences in the total costs of Solutions Four, Five, and Six suggest that the question of mill location in the northern North Island may be highly sensitive. In light of the uncertainties surrounding some of the data used in this analysis, a closer, more rigorous study on the comparative costs of these regions might need to be undertaken before concluding which was the most favoured site.

The problem of mill size in the southern North Island is another problem that bears sensitive solutions. This can be seen from Solution Number Seven.

5.5.6 Solution Number Seven - Increased Milling at Wellington

Among the several solutions generated from the iterative solution procedure involved in deriving Solution Six, it was noticed that a second solution with a total cost of $14.0425 m. had arisen. This cost is only $50,000 greater than Solution Six. Solution Seven differs from Solution Six by the amounts milled at the two North Island mills.

In Solution Seven the final demand requirements of the East Coast/Hawkes Bay region are supplied from Wellington instead of

Auckland as is the case in Solution Six. This resulted in Wellington milling 76,000 tonnes (an increase of 17,000 tonnes) and Auckland 134,000 tonnes (a decrease of 17,000 tonnes). This gives an indication of how sensitive the size of mill in the northern North Island and in Wellington is to relatively small changes in total costs. That is, for a .4 per cent change in total costs, there is an 11.26 per cent change in the milling capacity needed in Auckland and a 28.8 per cent change in that of Wellington.

5.5.7 Solution Number Eight - Invercargill Mill Forced Out

Only one test was undertaken to measure the sensitivity of mill size in South Island regions. This involved forcing Invercargill mill from the solution.

Solution Eight was similar to Solution Five. However, in Solution Eight the Dunedin mill supplied its own region and that of Southland. This decreased the total demand for wheat in Southland and increased demand in Otago exhausting supplies in that region. As a result it became feasible to mill flour in Oamaru to supply North Otago and part of the South Canterbury demand. This change, however, increased total costs by \$.092 m.

It is possible that other alternative low cost solutions could be found which would provide further information for policy purposes by increasing the range of optional solutions to the industry's problem. With a range of solutions, policy makers could use other criteria to evaluate what might be the best rational market structure. For instance, it may be a secondary objective of policy makers to promote industry in a particular location for regional development reasons. This may make the decision of mill location and size in the northern North Island more clear cut. However, rather than simply generating a range of solutions, it may be more worthwhile using the model to generate specific solutions to solve specific problems of policy makers.

It should be remembered the model is only a simplistic representation of the industry and market. Once general principles of industry rationalisation have been identified from the simplistic analysis, policy makers may wish to examine the implications of these general principles when considering other more complex issues and problems of the industry.

In light of the general principles identified by the model, policy makers may wish to determine the extra total cost of perhaps moving a certain amount of milling capacity to the North Island from the South, subject to retaining some milling in each locality currently milling wheat to flour. This may be done to initiate the closing down of older and smaller units.

Specific problems of the type suggested above could be solved using the model. However, without a knowledge of the specific, secondary objectives of policy makers, it is not known what other alternative solutions it would be useful to generate to study further issues of mill location, number and size.

5.6 Summary and Conclusions

In this chapter it has been shown how the market performance of the New Zealand wheat and flour industry might change in response to different market structures. More specifically, this involved examining the market performance of the existing industry compared to an industry unrestrained by current protective and insulating constraints.

By examining the performance of the existing industry it was possible to estimate the regional price differentials for wheat and flour. Under the Government's current wheat and flour pricing policy this information is not available from the market place as prices are standardised throughout New Zealand. Further, standardised pricing results in cross-subsidisation among flour consumers of different regions and also among farmers of different regions. From respective price differentials, estimates of the relative levels of such subsidisation were calculated. These suggested that the current pricing policies of Government resulted in significant income transfers from South Island flour consumers to North Island flour consumers and from South Island wheat farmers north of Oamaru to South Island wheat farmers south of Oamaru.

It was also possible from the model of the existing industry to gain an indication of the opportunity costs imposed by current shipping and milling constraints. These were shown to be high and, as such, were seen to be evidence that substantial savings might arise from lifting these constraints. Accordingly, shipping constraints and milling quotas were relaxed. Also, transport and processing costs were adjusted to take account of the potential economies of scale possible in an uncapacitated industry.

From the several low cost solutions generated with the less constrained versions of the model, it became apparent that substantial cost reductions could be made by centralising both the transport and milling operations of the industry. This contrasts markedly with the fragmented and dispersed market structure of the existing industry.

The results of the modified models would suggest that there should be no inter-island trade in flour and that an additional 46,000 w.e. tonnes of flour should be milled in the North Island with an equivalent reduction to be made in the South Island. Under this situation, 210,000 tonnes of wheat would be required in the North Island per year. The results showed that substantial saving could be made by transporting this full tonnage by bulk ship. It was shown that this would eliminate alternative expensive modes of transport, namely rail ferry and Ro-Ro container shipments of wheat and flour, and allow greater economies of scale in bulk shipping. The results also showed that potential economies of scale could be exploited in the milling operation.

To take full opportunity of scale economies it was shown that at most only one mill per region was required. In allowing centralisation of milling between regions it was further shown that as few as five mills would be all that were required in a rationalised industry. This would require one mill of between 135,000 and 150,000 tonnes in the northern North Island, preferably at Mount Maunganui, one of between 55,000 and 75,000 tonnes in Wellington, another of 50,000 tonnes in Christchurch, 18,000 in Dunedin, and 9,000 in Invercargill. As a result of the location of mills in the North Island appropriate amounts of wheat would need to be unloaded from bulk ship at Mount Maunganui and Wellington. In the South Island, results showed that in a year of self-sufficiency, 70,000 tonnes of wheat should be loaded to bulk ship at Bluff and 140,000 tonnes at Timaru. (To facilitate loading and unloading, and to provide additional buffer stock storage at the four ports involved, it had been assumed that 6,000 tonne port storage facilities were available.)

From the modified models it was also possible to measure the marginal value of wheat in Sydney relative to wheat at farms in South Island regions. This value was shown to be high and suggested that if F.O.R. prices for wheat in the South Island were to compete with the Sydney F.O.B. price, further substantial reductions in total costs could be made. However, because supply functions of respective regions were not included in the model it was not possible to give any indication what proportions of wheat should be supplied from respective sources under a free-trade situation with Australia.

The model used to generate the results presented in this chapter is only a simplistic representation of the structural problems in the wheat and flour industry. For this reason the results can only be interpreted as showing the general principles of industry rationalisation.

CHAPTER 6

LIMITATIONS, IMPLICATIONS AND EXTENSIONS OF THE MODEL

6.1 Introduction

The results presented in the previous chapter have shown that the model developed in this study has considerable potential to aid in the analysis of problems in the wheat and flour industry. It is important however, to realise that there are limitations to the model and the extent to which it can be used for policy analysis. This chapter describes the major limitations to the model and the implications of the current results.

6.2 Limitations of the Model

6.2.1 Assumptions About Wheat Supply

In the model the long-run wheat supply functions for the South Island production regions were assumed to be of constant quality, completely inelastic and representative of a year of self-sufficiency. Although this is clearly an unrealistic representation of supply, this does not severely limit the interpretation of results.

Because in the low cost solutions all wheat arriving in the North Island is received from bulk ship, the structure of the model is such that once wheat is loaded aboard ship, per unit marketing costs thereafter are independent of the source of the wheat. Therefore, the rationalised structure of milling in the North Island is independent of the sources from which its milling grade wheat is derived. The implication of this is that the market structure of the industry in the North Island shown in the low cost colutions, would be unaffected by changes in supply, assuming both islands remain self-sufficient in the production of flour. This is important for it suggests that in years of domestic shortfall, the need to import Australian wheat would not affect what might be a rational market and industrial structure in the North Island.

In the South Island it is possible that a mill in one or more of the regions between Dunedin and Christchurch may be viable if the uncertainties of supply were acknowledged in the model. McCarthy et. al. (1971) outline how it would be possible to test the stability of plant locations to changes in regional production. Also Higham et. al. show that heuristic search procedures could be used for this purpose. Although this would be a logical extension of the study, it is unlikely that South Island milling allocations would alter significantly if the model had been tested with the actual levels of regional production achieved in the recent years. The only major implication arising from the simplistic assumptions about the wheat supply would appear to be that spatial equilibrium prices and quantities can not be determined directly from the model. However, if estimates of long-run regional supply functions were available there are iterative-reactive programming techniques which could allow the incorporation of supply functions in the model. This would be a worthwhile extension of the model and would provide valuable information for policy makers concerned with New Zealand wheat pricing.

6.2.2 Assumptions About Final Demand

Despite the wide disparities between the regional flour price differentials of the South and North Islands, the assumed, completely inelastic, demand for flour is not seen as a serious limitation of the model. Even if regional price differentials were reflected in the flour price, the significant decline in the South Island price could not be expected to create a significant change in the local consumption of flour. A more serious limitation may have arisen from assuming that the industry produces only one product, a single quality flour.

As Borrell (1980, Figure 2.1) shows, wheat is used to produce a range of products. The demands for these products require mills to produce several lines of flour and also bran and pollard to stock-foods. Ignoring the fact that there are different flours may be to ignore an essential economic force of the market. It may involve considerable expense to shut down the rollers at a mill to clean machinery and change over to a different line of flour. Larger production runs may be cheaper, emphasising the need for either flour storage facilities or for specialised mills. Large mills could produce flour for bread baking while smaller mills could produce flours for biscuits, cakes and household uses. No attempt has been made in this study to take account of the implications the production of alternative types of flour might have upon the location, number or size of mills. Different qualities of wheat available in different supply regions may be more suitable as supply posts for a mill that might specialise in, say, household flours. This may hold implications as where best to locate such a mill.

The demand for bran and pollard by stockfood manufacturers similarly may hold implications for the location, number and size of mills. No attempt has been made to identify any such implication.

6.2.3 Importation of Australian Flour

Another factor which may hold implications for rationalising mills is the possibility of importing flour from Australia.

A paper from the Flour Millers' Council of Australia dated 8 May 1979 suggests that if substantial orders were placed, Australian flour could be purchased for $206.00 per tonne net, free alongside ship, packed in 50 kilo jutes. This could mean Australian flour might be competitive with North Island milled flour, although quality differentials and the cost of shipping would have to be considered to evaluate the economic viability of this alternative. No consideration has been given to this factor in the study. If this alternative was viable it is possible that Sydney could supply North Island final demand areas rather than North Island flour mills.

6.2.4 Coastal Shipments of Flour

The fact that it was assumed feasible to use a specialised bulk ship for wheat raises two important questions.

(i) Would it be feasible to use a specialised ship to transport the equivalent flour and what implications might this create, and

(ii) would it be feasible to backload flour from North Island mills aboard the specialised bulk ship and what implications might this hold?

Solutions to these problems are not given in this study. However, if estimates of the costs of such proposals were available these could be easily incorporated in the model.

6.2.5 The Dynamics of Shipping and Storage

Borrell (1980, Chapter 3) discusses the trade-off between lower per unit costs of bulk shipping by larger vessels on occasional voyages[21] and the increased per unit capital cost of building larger

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21 Assuming it was possible to charter large bulk ships currently serving the Australian export trade. These could be chartered on a monthly basis.

and perhaps more numerous storage facilities necessary to facilitate intermittent shipping. The static model does not allow the size of ship or the size of storage facilities to vary. There are assumed to be fixed in actual size, although their throughputs are able to vary.

It is possible that the static model could be used to determine annual trade flows which could then be used as inputs to a dynamic model. The dynamic model could then be used to show how annual trade flows should be scheduled throughout the year, what size of ship or ships would need to be chartered, and what might be the maximum size of storage facility required at any one location.

The exclusion of dynamic effects in the model of this study is seen more as an opportunity to extend the problem rather than a limitation of the model, although it is possible that economies of scale associated with the dynamic problem may have implications for the degree of centralisation of milling in the North Island and for the centralisation of port loading and unloading facilities.

6.2.6 Uncertainties of the Data

In presenting the data of the model in chapter four, attention was drawn to the limitation of some of that data. In particular, the crude estimate required for the milling cost curve and the arbitrary assumptions made to calculate scale cost curves for two North Island ports. The implications arising from the uncertain data are that the specific characteristics of any low cost solution must be treated with caution, and that only general principles concerning issues of market structure can be identified.

For a more rigorous analysis, more accurate data would be needed. It is likely that the Wheat Board would have much of the data needed for these purposes and the model could easily be re-estimated using new data.

Another method that could be used to overcome the uncertainties of the data used would be to conduct sensitivity testing. This could be conducted by changing the parameters of the various cost curves of the transport costs in a systematic fashion in successive runs of the model. Hence it would be possible to identify how the solution might change over a range and combination of alternative transport and cost curves. Although this might reduce the uncertainties as to what might be a suitable market structure, one limitation would be the many possible combinations of curves that could be tested.

6.3 Implications of Model Results

The results of the model show how changes in market structure could lead to a lowering of total industry costs. They do not show how market conduct should or would change given the type of structural changes required. However, some interesting implications regarding market conduct do arise from the solutions of the model.

In the model it is assumed that the market conduct is that of a perfectly competitive industry. Hence the objective function of the model seeks to minimise total costs. However, the market structure suggested by the low cost solutions of the model is not necessarily consistent with a perfectly competitive industry. For instance, each mill of the solution has a potential spatial monopoly. For this reason, the removal of those constraints representing Government controls in the model does not necessarily imply that the abolition of controls in the industry will lead to a rationalised market structure where costs are minimised.

When a competitive structure does not apply, the findings of the type of market model used in this study only established a market structure norm that estimates the near maximum economic surplus (gain or saving) that could be obtained, but says nothing of the market conduct required to achieve this economic surplus. Cassidy and Kilminster (1975) give an example of how a similar market model to that used in this study has been incorrectly interpreted and the policy recommendation arising from the solutions of that model are partly invalid. The problem arose because it was assumed that competitive conduct would prevail despite the fact that an imperfectly competitive market structure was suggested by the model. To overcome such problems it is necessary to interpret results in light of the economic theory relating to imperfect competition. The implication arises: how does the theory of market conduct and imperfect competition relate to the normative market structure derived by the model of this study.

The low cost solutions of the study suggest a need for integration, co-ordination and for bargaining power. These all arise from the fact that the market structure of the solutions indicates the need for centralisation. A consequence of this would be that monopoly powers could emerge in the milling and transport sectors. While these centralised organisations might be capable of integrating and co-ordinating the market, the theory of countervailing power, however, might suggest that because of the atomistic farm structure at the beginning of the marketing chain, and also that of bakeries and consumers at the other end, the interest of farmers and bakeries may only be protected by the presence of one independent organisation with strong bargaining power. An alternative would be to have three separate groups forming countervailing forces against the monopolies.

An obvious extension of this study would be to attempt to consider this problem but it must be kept in mind that the model only provides solutions showing the results of long term structural changes. Therefore in answering the questions above, consideration must be given as to what conduct would be necessary to bring about restructuring in the transition phase and how best to achieve such conduct.

The second half of the Government wheat and flour marketing policy discussed in chapter two involved the Government fixed wheat and flour prices and the margins paid to millers. Even though competitive spatial equilibrium prices were used in the model to identify where other cost savings might be made in the industry, it does not necessarily imply that price setting conduct should be that of a free market. It is possible that if the market could be structured with appropriately countervailing groups, the pricing conduct of the industry could perhaps be left to free market forces to determine spatial equilibrium prices. However, complications introduced by fluctuating world commodity prices and equity considerations may mean prices are best set by Government. In this case the results of the model showing regional price differentials can be thought of as useful supplementary information that policy makers consider in making their decisions. An obvious extension of the model might be to try and tie up spatial aspects of pricing to the other pricing problems of the industry.

In conclusion, it must be stated that the results of this study only establish a market norm; they only show what could be possible, they do not specify what policy measures are required to achieve such a norm. In this way the results provide an indication of the direction for the industry and, therefore implications for the Government's wheat and flour marketing policy.

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APPENDICES

APPENDIX 1

<u>Average Flour Price Paid to Millers from 1 February 1978</u>

<u>Calculated by Department of Trade and Industry</u>

(Source: New Zealand Flour Millers' Association, 1979).

	$ tonne
Wheat Cost, 135 x 1.287	173.75
Conversion Cost, i.e. 78% extraction	22.40
Standard Profit Margin	5.06
	201.21

Revenue from the sale of Bran and Pollard by-produced is thought to pay for the commission and discount made to the Wheat Board for the sale of flour.

The milling margin is therefore:

$ tonne
22.40
5.06
27.46

In wheat equivalents, this is 27.46/1.28 = $21.45 per tonne. Allowing for 15 per cent inflation between February 1978 and May 1979, $21.45 x 1.15 = $24.67.

Although it is not known whether the Department of Trade and Industry used the average size of mill to calculate this average margin, it is useful to note that the average size of mill handles approximately 14,000 tonnes of wheat per annum.

APPENDIX 2

Fixed Annual Charges for 6,000 Tonne Bulk Ship

		$m
Capital $10 m./15 years		.7
Interest 12 per cent		1.2
Operating Cost		1.1
		3.0
Annual Operating Cost		
Salaries and Wages	$m	$m
Master	.03	
3 Deck Officers	.075	
2 Engineers	.075	
7 Seamen	.140	
Medic	.02	
Cook and Steward	.04	
	.37	
Superannuation	.04	
	.41	.41
Crew Support (travel, medical, compo)		.07
Victualling		.035
Deck Stores		.015
Engine Stores		.020
Repairs and Maintenance		.3
Insurance ($10 m. x .01)		.1
Management		.1
Port Expenses (30 x 3,000)		.09
		1.14

(Source: Two Private Transport Companies and Ministry of Transport).

To charter a similar vessel on the World spot market for one year would cost $1.9 m. - this excludes fuel and port charges. (New Zealand Shipping Corporation Figures, 1979).

Operating Days Using 6,000 Tonne Bulk Ship

Routes		Sea Miles	Days @ 14 m.p.h.
Bluff	- Wellington	455	1.3
	Mount Maunganui	865	2.6
	Auckland	950	2.8
Timaru	- Wellington	260	.8
	Mount Maunganui	672	2.0
	Auckland	756	2.3
Sydney	- Wellington	1,300	3.9
	Mount Maunganui	1,325	4.0
	Auckland	1,264	3.8

Assuming the most time demanding possibility

200,000 tonnes Sydney - Mount Maunganui
200,000/6,000 = 33 trips

Days for return journey to North Island	- 8
Days for loading/unloading	- 2
	10

33 trips @ 10 days = 330 days

A larger ship could be purchased to allow a greater number of free days. The extra capital cost would not be great.

APPENDIX 3

Standardised Flour Price and Average Financial Cost of the Industry

Marketing costs for the industry were approximately $20 m. for 1978. These were incurred in producing approximately 290,000 wheat equivalent tonnes of flour (see section 5.2.2). Therefore, the average marketing cost per (W.E.) tonne = $20 m./.29

= $68.97.

Converting to flour $68.97 x 1.28 = $88.28 per tonne

For the year ended 31 January 1979, the average cost per tonne for wheat including storage and brokerage paid by the Wheat Board was:

$35,532,925/292,755 tonnes = $124.79/tonne.

(Source: New Zealand Wheat Board 13th Annual Report).

Allowing for 15 per cent inflation to adjust to 1979 prices

$124.79 x 1.15 = $143.51.

Converting from wheat to flour

$143.51 x 1.28 = $183.69.

Adding the marketing cost component

$183.69 + $88.28 = $271.97.

This cost is close to the price charged for flour in bulk and sacks throughout New Zealand effective from 16 February 1979; this was $270.00 per tonne.

(Source: New Zealand Wheat Board, 1979).

Although the financial costs of the industry are close to the price charged for flour, this does not necessarily mean the price charged is close to the social cost of the industry. For instance, by preventing imports of Australian wheat and flour, this may impose an opportunity cost on consumers; that is, it might result in flour being more expensive than it otherwise could be. This would represent an additional social cost of the industry.

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