TRANSPORT INNOVATION AND AREAL ASSOCIATION IN THE MANAWATU DAIRY INDUSTRY

(The Role of Transport from before 1880 to the Present Day and the Impact of Innovation on the Areal Association between Supplier and Factory and between Factory and Factory)

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by

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PREFACE

For the New Zealand dairy industry, "the principal - one might say the only important disadvantage - was the obstacle of distance...." (Philpott, 1937:11) Although concerned here with the difficulties of overseas transport, (he suggested that time and invention had largely overcome the obstacles of distance) the comment is equally applicable to the difficulties of internal transport. Transport is an important element in dairying but appears to have attracted little attention from researchers. A review of the history of dairying reveals a series of development phases, each of which appears related to transport developments.

The first part of this thesis, then, is an historical review of the period from before 1880 to the present day with particular emphasis upon transport methods and innovations. Emphasis has been given, however, to developments at the factory rather than the farm level. From a consideration of these historical developments, it becomes increasingly evident that each phase has been associated with distinctive patterns of land use and the development of specialised dairying "regions".

The second part, therefore, is an investigation of the changing distribution of dairying activity in the Manawatu. Changes in the distribution of and in the areal associations between suppliers and factories are examined in terms of changes in transport technology. Although transport is not the only variable contributing to change, its importance in contributing to development and change warrants special attention.

This study is concerned primarily with transport developments, particularly with tanker transport, and the effects of these developments on the spatial organisation of dairy factories. Philpott (1937:12) noted, "... there was not a decade which was not crowded with event...." The decades since the 1930's have been equally crowded with event.

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ABBREVIATIONS AND TERMS

Abbreviations

A. & P. Stats.	Before 1921, Statistics of the Dominion of New Zealand (sections referring to agricultural and pastoral production). 1921 to 1954, Agricultural and Pastoral Production Statistics of New Zealand. 1955 to the present day, New Zealand Farm Production. (Note: each of these three series of publications are presented with variations of publishing authority and title.)
A.J.H.R.	Appendices to the Journals of the House of Representatives.
Annual List of Creameries	New Zealand Department of Agriculture, Annual List of Creameries, Factories, Private Dairies, and Packing Houses.
Annual Reports	The Annual Reports, Balance Sheets and Accompanying Accounts of dairy companies only. Annual Reports of other organisations such as the Department of Agriculture and the New Zealand Dairy Board are specifically referred to where used.
C.D.C.	Co-operative Dairy Company.
M.T.S.	See under Terms.
N.Z.F.D.U.	New Zealand Farmers' Dairy Union.
N.Z.O.Y.	New Zealand Official Yearbook(s).

Terms

Cheese Factory	A dairy, the milk supply of which is manufactured into cheese.*

Creamery	A dairy, the milk or cream supply of which is manufactured into butter.* (Note: there is much confusion in the use of this term. It should be used only in regard to butter manufacture, and not, as is often the case, to the skimming of cream from wholemilk at a skimming station.)
"Creamery System"	The practice, whereby wholemilk is received by a skimming station, is separated and the cream sent to a creamery for manufacture into butter. (Note: there are variations to this general pattern. Transport methods were such, that before 1920, the usual radius of supply was two to four miles. If cow densities were low, it was necessary to draw supply for a single creamery from a number of similarly sized collection areas. Suppliers would send their wholemilk to a skimming station and the cream was then sent on to the creamery. Where cow densities were high, however, a creamery could draw sufficient supply from a single collection area about the creamery in which case there was no need for associated skimming stations.)
Collection Centre	Any factory, creamery or skimming station receiving wholemilk or cream either by supplier delivery or by factory collection.
Dual-plant factory	A dairy, manufacturing both butter and cheese.
Dairy factory	A collective term denoting all dairies manufacturing dairy products. Skimming stations are specifically excluded.
M.T.S.	Milk Treatment Station.
Milk Producers' Company	The Manawatu Co-operative Milk Producers' Company Limited. The Milk Producers' Company is concerned with the production and collection of wholemilk for town supply. Wholemilk is collected by a contractor (the tankers are owned by the company) and is delivered to the M.T.S. for treatment and bottling.

Multi-factory company	Any dairy company operating more than one factory for the manufacture of dairy products.
Multi-plant factory	A dairy manufacturing a variety of dairy products.
Packing House	A dairy in which butter manufactured elsewhere is mixed or blended into milled butter.*
Skimming Station	A dairy, the milk supply of which is separated only.*
Tanker (milk tanker)	A collective term denoting any unit or combination of units designed for the transport in bulk of wholemilk and milk by-products.
Tractor trailer	A milk tanker consisting of a tractor unit and a trailer unit which may be towed only by a tractor unit.
Tanker trailer	A unit which may be towed either by a tractor trailer or a conventional truck.

* Definition of term based on Annual List of Creameries, 1906.

PART I AN HISTORICAL REVIEW OF TRANSPORT DEVELOPMENTS IN THE NEW ZEALAND DAIRY INDUSTRY WITH PARTICULAR REFERENCE TO TANKER COLLECTION

CHAPTER ONE

INTRODUCTION

Although many of the observations in this thesis are applicable to dairying anywhere in New Zealand, and some of the examples have been drawn from Taranaki, Waikato and North Auckland, the main area of investigation has been the Manawatu. County and Riding divisions have formed the initial basis for the boundaries of the area to be studied.[1] Consideration of the distribution of suppliers to the Manawatu C.D.C. indicated that some areas should be excluded, particularly areas of forest reserve along the eastern margin of Pohangina, Kairanga and Horowhenua Counties, while the supplier map for the Whangaehu C.D.C. suggested that suppliers along the Whangaehu River towards Mangamahu should be included. The northern limits were demarcated by a combination of County, Riding and Cadastral Map divisions. The area thus defined (fig. 1) comprises 1810.07 square miles and will be referred to as the Manawatu area.[2]

Two main avenues of investigation have been followed, i.e., a) historical and b) statistical. Part I, the historical section, deals with the role and importance of transport in dairying. Emphasis has been given to the phases of development and to the changing relationship between supplier and factory. In Part II, the nature of the changing distribution of dairying is investigated. Variations in the areal association between supplier and factory are discussed in terms of changing transport technology.

As was noted in the preface, the main themes of this study fig. 1

LOCATION

are concerned with the transport of wholemilk and cream from supplier to factory, and with changes in the spatial organisation at the factory level. Inter-factory transport and changes at the farm level, however, form a relatively minor part of the total investigation.

Transport is an essential link between supplier and factory, between factory and port, and between New Zealand and her overseas markets. Obstacles within these flows can be seen to have impeded progress in the dairy industry, while the overcoming of these obstacles by transport innovation has been followed by periods of rapid development and change.

Refrigeration was the first of these major transport innovations. It enabled dairy produce to be shipped to distant markets in larger quantities and with greater success than previously. Refrigeration also facilitated the internal transport of produce from factory to port. The resulting changes in the organisation and scale of dairying, particularly the adoption of the factory system of manufacture, led to rapid development. Inadequacies in internal transport facilities for raw materials, however, were an impediment to progress. The "creamery system" can be seen as partly a response to internal transport limitations under conditions of high external demand.[3]

Motorisation and home separation, transport and transport-modifying innovations comparable in magnitude to refrigeration, eased some of the limitations on internal transport. In response to these innovations the relationships between supplier and factory were modified. The amount of change is indicated in Part II of this thesis by the variations in areal association.

Between 1920 and 1950, dairying became more localised and regional specialisation, evident before 1920, became increasingly apparent. By 1950 the advantages of larger-scale factory operation were evident but developments in this direction were slow. Limited quantities of milk by-products, mainly buttermilk, were being transported in bulk between factories. It was not until the 1960's however, following the lead of the New Zealand Co-operative Dairy Company, that tanker collection of wholemilk (and transport of milk by-products) was adopted on a wide scale. Tanker collection made practicable larger-scale factory operation and facilitated company amalgamation with subsequent closure of uneconomic factories.

These changes may be summarised in terms of the varying relationships between supplier and factory and between factory and factory. Prior to the 1920's, supplier delivery of wholemilk predominated. Motorisation was largely accompanied by a change to factory collection of cream.[4] Limited inter-factory movements of by-products were initiated and the dairy industry became less specialised. Whereas butter and cheese had been the predominant products before the 1920's, during the 1930's and particularly after World War II, casein and dried milk powders gained an important position. In addition, individual factories became less specialised while dual-plant factories, and the production of buttermilk powder and whey butter in creameries, because increasingly common.

The introduction of tanker collection, a third major transport innovation, has resulted in an increase in wholemilk collection with a corresponding decrease in cream collection. Inter-factory movements of wholemilk and milk by-products have also expanded. While some companies continue to specialise in the production of a single commodity (particularly cheese factories) the general pattern is now one of multi-plant factories and multi-factory companies producing a wider range of dairy products.

It is expected, in view of the importance of the transport link between supplier and factory, that changes in transport technology will be associated with changes in supplier - factory relationships. Poor transport facilities are expected to be accompanied by a close areal association between supplier and factory. As transport technology is improved, increasing the potential supply area and often giving rise to greater competition for supply, the areal association is expected to become more tenuous. It is postulated, therefore, that there is an inverse relationship between transport technology and the areal association between supplier and factory. This postulate is the basis for the working hypothesis considered in Part II.

Notes

1 The counties and ridings considered were as follows:
Waitotara County - Brunswick Riding only
Wanganui County - Upokongaro, Kaitoke, Kaikatea, and Purua Ridings, and part of Mangamahu Riding
Rangitikei County - Otakapu, Rangitoto, Pukepapa, Porewa and Rangitira Ridings, and parts of Otaire, Te Kapa, Awarua and Wangaehu Ridings
Pohangina, Kiwitea, Manawatu, Oroua and Kairanga Counties - all ridings
Horowhenua County - Tokomaru Riding only.

2 The Manawatu area as defined must be distinguished from the supply area to the Manawatu C.D.C. although the two correspond closely and for most purposes are taken as the same. Less than one percent of the suppliers to the Manawatu C.D.C. lie outside the Manawatu area, these being either west of Kai Iwi, or in the vicinities of Raetihi and Taihape, or south of Shannon.

3 Differences in cow density must also be considered as important causitive factors in the development of the "creamery system". (See definitions of abbreviations and terms, page ix).

4 Supplier delivery of wholemilk to cheese and casein factories continued in most areas until the adoption of tanker collection although some of these factories did adopt factory collection during the 1920's and 1930's.

CHAPTER TWO

THE PIONEERING PHASE: BEFORE 1882

The lack of adequate transport facilities was the main obstacle to the pioneers. Internal transport was hampered by heavy bush, swift flowing streams, and broad rivers. Roads were confined initially to the major settlements and soon deteriorated to foot tracks. Some rivers, such as the Manawatu, Rangitikei, and Wanganui, provided easy access to inland areas. Where possible the bullock cart, the dray and sled were used but their use was dependent upon the existence of roads, or at least, formed tracks through the bush. Few tracks were metalled and few of the rivers bridged.[1] During the winter months roads became impassable. Inland transport was slow, unreliable, and irregular. In its place, coastal shipping assumed an important role in linking together the small isolated settlements.

Overseas transport was also plagued with difficulties for the transport of dairy products. Sailing ships and the early steam vessels were slow; the sailing time from England was 90 to 100 days, and there were no provisions made for the storing of perishable goods. The passage to and from Sydney, on the other hand, took only a week to ten days, enabling this area to become an accessible, if small, market for New Zealand's butter and cheese.[2]

These difficulties of transport may be extended to include the import of dairy stock. Although possible to ship cattle and other livestock from England, many of New Zealand's early imports were from Australia. In particular, the Durham, a dual purpose breed suitable for milk and meat, the Yorkshire, and Teeswater were imported from New South Wales from the 1820's. (Clark, 1949:240)

An efficient means of preservation was necessary for the successful export of dairy produce. Few of the many attempts made were very successful. Hargreaves (1964:127) reports on experiments with the tinning of butter, preservation in brine, and packaging in kiln-dried oat seeds. Saw-dust was also used as an insulator. (Philpott, 1937:22) The poor quality of the initial product, plus the inherent unsuitability of the methods tried, meant that little cheese, and even less butter, reached the English market fit for human consumption. That these products could be transported with success was demonstrated by the imports of Irish butter and English cheese. This success was largely the result of careful selection and packing. (Philpott, 1937:23) New Zealand cheese gained an early reputation for high quality on the Australian market but butter was "liable to develop all manner of obnoxious flavours during the short voyage across the Tasman Sea." (Scholefield, 1909:143)

The conditions of communication created feelings of isolation among the settlers. Not only were they isolated individually, but their communities were isolated from each other by several days of unreliable travel. A third level of isolation can be observed in terms of the distance from New Zealand to England. Consequent upon isolation was the need for pioneers to be as self sufficient as possible. Their occupations were "very primitive indeed, for the market was limited; the opportunities for trading were few, and the facilities for getting the produce to and from the port [of Foxton] were fewer still." (Buick, 1903:291)

There were no specialised dairy farms in the modern sense; stock management was secondary in importance to the felling, sawing, and selling of timber.[3] Once land had been cleared stock were gradually introduced to increase the settlers' capacity for self sufficiency. Two or three cows provided a family's needs of milk, butter, and cheese. Social organisation could well be compared to Hill's interpretation of the Wairarapa "squatter society". (Hill, 1965:28)[4]

The making of butter and cheese under these conditions of isolation and difficult transport was the domain of the pioneer wife and family. The dairy was an "adjunct of the household". (Lampard, 1963: 57)[5] The technological demands of butter making were minimal; cheese making, however, required additional skills and so was a less common activity in the farm dairy. (Appendix A) Where there was a surplus of butter or cheese, it was traded at the nearest store for goods which could not be produced from the farmer's own resources. Such surpluses were irregular and of indifferent quality.[6] Not only was butter and cheese making a relatively insignificant activity, in terms of the total bush-farm organisation the irregular surplus was often regarded by the pioneer as "pin money" or, at most, an income supplement.

Variations in butter and cheese making skills led to a rudimentary division of labour. Although an individual's reputation may have been based only on the possession of superior cows, better pasturing, or closer attention to cleanliness, those who produced better than average butter or cheese were soon receiving wholemilk from neighbours for processing.[7] From this initial extension of skills came the early factory-type production. Although this was on a small scale, it would have required a sufficient cow density around the place of manufacture. The daily delivery of milk was a considerable disadvantage because of the limited transport facilities.[8] Cream, however, could be delivered two or three times a week, enabling a slightly larger area of lesser cow density to be served by a single manufactory.

The continued growth of population, both in rural areas and in the towns and villages, provided an increasing demand for milk and dairy products. Small farm dairies were not suited to large-scale production, but they formed the basis for the development of the factory system of manufacture. The first known dairy factory in New Zealand was established in 1871 at Springfield, on the Otago Peninsula. (Philpott, 1937: 28) Another factory is reported to have been established at Kaiapoi in 1876. (Hargreaves, 1964:126) There were, however, few factories in New Zealand before 1882.

The first dairy factories in the Manawatu were established from the late 1870's. An early promoter of the Rongotea C.D.C., W. Davis, was making cheese from a "large herd of cows" at Waitohi as early as 1876 (Croucher, 1945:12) and James Skerman is reported to have been making cheese by 1880. (Matheson, 1971:65) W.J. Corpe is also reported to have commenced butter making at Makino, near Feilding, at about the same time. The dairy factory at Karere, near Longburn, was established in 1884, while James Bennett and his family had put in a butter making plant at Te Arakura around 1885. (Croucher, 1947:12)

Two related features partly account for this slow development. Firstly there was a scarcity of capital. Resources were thinly spread both in terms of area and in terms of the diversity of interests to be served. The few capitalists (and contrary to the Wakefield Plan, there were very few) who had money to invest were more likely to seek the higher returns from pastoralism and the export of wool. Secondly there was the problem of surplus disposal. Farm dairies and local stores were faced with internal transport problems, and there were few outlets for surplus products because of the lack of storage provisions on board ships.

Butter presented the greatest difficulties. It was liable to deteriorate quickly if not kept cool. Cream, being less perishable, could be transported longer distances. (Long, 1889:12) Farm surpluses were carried to the local store for sale or barter, the store keeper in turn milling, salting, and blending the butter in an attempt to improve its quality.[9] Even if the butter could be transported to a port, there were no facilities for its preservation while waiting for a ship. Success depended upon the use of good cream, thorough procedures in butter making, rapid transport to the port, and immediate loading on board the ship. And even then there was no guarantee that the butter would arrive at its destination in a satisfactory state.

Cheese was in a more favourable position. Its better keeping qualities (also dependent upon care in manufacture) enabled it to be transported over longer distances. Exports of cheese gained high reputations for quality on both English and Australian markets. Despite these difficulties, considerable quantities of butter and cheese were exported before refrigeration. (Table I) The volume of butter exported to the United Kingdom (almost five times the volume of cheese) is surprising in view of its greater perishability and the poor transport facilities available.

Throughout this pioneering period, the demand for improved quality and increased quantity was provided by a constantly growing

TABLE I DAIRY EXPORTS: 1868 TO 1881

	CHEESE		BUTTER	
	cwts.	percent	cwts.	percent
Australia	21096	84.3	14033	49.9
United Kingdom	2316	9.3	10615	37.8
Pacific Islands	1074	4.3	1473	5.2
Cape Colony	371	1.5	1119	4.0
Other	149	0.6	864	3.1
TOTAL	25006	100.0	28104	100.0

Source: Hargreaves, 1964:127

population and the ever present prospects of tapping the English market. The growth of local markets continued to be served from local production. By 1882 it was technically possible to advance from the marketing of a bush-farm surplus to the production of factory-made butter and cheese. Development was arrested by poor external transport facilities and inadequate internal transport.

Notes

1 The first bridge across the Manawatu River was built in 1875 at the Woodville end of the Gorge. The Fitzherbert Bridge, constructed of wood in 1877, was considered at the time to be "utterly impracticable ... as there are only two planks roughly fastened together connecting it ... at each end, and which absolutely leads nowhere. There is not a foot of road on the Fitzherbert side ... so the bridge might well never have been built for all the good it is to anyone." The approaches were completed in 1878. (Bradfield, 1962:34)

2 For further details regarding early trade the reader should consult Hargreaves, 1964:126-8.

3 Buick reports that even this industry was hampered in its development by the "absence of adequate carriage for the finished product. ... There were no drays or wagons, and on soft muddy tracks, freely besprinkled with stumps, sledges were out of the question." (Buick, 1903:292-3)

4 It should be noted, however, that the spaces between the elements of his diagram are distances, and that the interaction between these elements would be related to the difficulties of transport.

5 Although Lampard was concerned with the development of the Wisconsin dairy industry before 1860, his comments are applicable to New Zealand conditions before 1882. He noted, for instance, "The making of butter and cheese was woman's work, beneath the dignity of the yeoman, and relegated to the kitchen. ... The care and feeding of the few milk animals was likewise a domestic chore, shared by the members of the family, but not deserving much time or effort on the part of the cultivator. ... The dairy industry retained its domestic character, even when it had become a profitable commercial enterprise." (Lampard, 1963:57)

Scholefield (1909:144) comments on the "easy-going housewife whose perquisite the dairy generally was", while Hargreaves (1964:125) considered that the husband was released to attend to the more important duties of clearing the land.

6 Lampard (1963:58), for instance, notes that there was "little system and less science employed at any stage of production...." See also, Hargreaves, 1964:126 and Philpott, 1937:22.

7 "Captain Runciman, of Hautapu, near Cambridge, was ... in 1878 ... making cheese at a small factory on his farm, and in addition to the milk of his own herd was taking in milk from his neighbours." (Philpott, 1937:32)

8 McCallum noted in 1888 that one of the principal causes of failure in the early factory system was the irregularity and insufficiency of supply. "Some of the suppliers will send

their milk at the beginning of the season; but, as the supply diminishes, with a consequent rise in the price of butter, they keep their milk and make butter themselves. How can a factory treated in this way succeed...? - for this is the time when the factory has a chance of making a profit." (McCallum, 1888:6)

9 A writer to the Manawatu Daily Times of 1909 reveals the nature of farmhouse butter in the following terms. "You talk about fourpenny butter! Did you ever see it? Or smell it? Why if you tried to sell the stuff now-a-days you would be had up for selling fermented liquor without a licence - if the Inspector of Nuisances didn't get you first. They used to tie it up in a cloth certainly, because they didn't always have bottles, but the store-keeper had to put it in a can or a keg as soon as he got it and the butter room wasn't the sweetest place in the world even then. ... The buttermilk used to run out through the rag that held it more or less together. The cows were milked in the mud and the cream was, as often as not, put to set under the family bed and butter brought in once a week. Butter! Whew!

"Fourpenny butter was the very nightmare of the store-keeper. ... How he was to turn fourpenny butter into good money was a puzzle. Outside of the very limited local market his only chance was in Sydney, and I know of one pioneer storekeeper who, after filling 100 kegs with the very best of his fourpenny butter and shipping it off to Sydney, proceeded to sit down and wait for the cheque he would get. Instead of a cheque he was called upon to pay 18 pence difference between the sum realised on the 100 kegs and the expenses thereon.

"And mind you, a lot of fourpenny butter that hadn't been considered select enough to go into those kegs was utilised as cart grease or turned out to the pigs. And as often as not the pigs turned up their noses at it." (Quoted by Matheson, 1971:63) See also Lampard, 1963:58.

CHAPTER THREE

RESPONSES TO REFRIGERATION: 1882 TO WORLD WAR I

Experiments in the preservation of meat by freezing were conducted from the 1850's. Early equipment was primitive and liable to breakdowns with the consequent spoilage of the frozen goods. Robertson (1939:11-12) notes two types of preservation. The first, freezing by the evaporation and reabsorbtion of volatile liquids had achieved limited success by 1873, although a trial shipment from Sydney to England failed when machinery broke down. French trials in transporting meat from Buenos Aires to Havre in 1878 were successful but, for some reason, the methods were not developed further. Secondly, attempts were made at chilling mutton and beef for shipment between North America and Europe. Success was again limited.

By the end of the 1870's methods of preservation by refrigeration had been sufficiently developed to enable the shipment of frozen goods between Australasia and Europe. The success of shipments from Australia to England encouraged the New Zealand and Australian Land Company to make a trial shipment of meat from its New Zealand estates. The ship "Dunedin" was fitted out with freezing equipment[1] and stock killed and dressed at the Edendale Estate. Produce was frozen on board the ship between December 1881 and February 1882, and included mutton, beef, lamb, game, poultry, butter and milk, most of which reached England, 90 days later, in good condition. A second shipment involving seven kegs of butter was made from Wellington in 1883. (Philpott, 1937:39) Despite the now obvious possibilities of exporting dairy produce, further progress was delayed by the depression of the 1880's. Robertson noted that "After 1890, however, with the lifting of the depression, and with increasing government supervision and assistance ... dairying went ahead very rapidly, and by 1895 was a flourishing industry." (Robertson, 1939:106) Delays were also encountered in the provision of onshore cool store facilities and in the lack of adequate transport facilities from factory to port.

Coastal and river transport gained an early predominance in the transport of cream, butter and cheese, particularly in areas poorly served by railways or roads.[2] River transport on the Wanganui River served the population from Wanganui to Taumarunui but was discontinued in 1939 after the opening of the Pipiriki road in 1930. (Krenek, 1968:56) The Manawatu and Rangitikei Rivers, on the other hand, were little used for the transport of cream or dairy products; the surrounding areas being better served by road and rail communications. Coastal shipping services were of little importance for the Manawatu area except where Foxton, and later Wanganui, were used for outlets for butter and cheese. Unlike the South Taranaki area, which had neither good port facilities nor rail links to the south, Manawatu was well served by rail both to Wanganui and Wellington by 1882. Thus while Taranaki remained isolated, and tended to specialise in cheese production, the Manawatu was able to develop and specialise in butter manufacture, although cheese making was important in areas of high cow density.

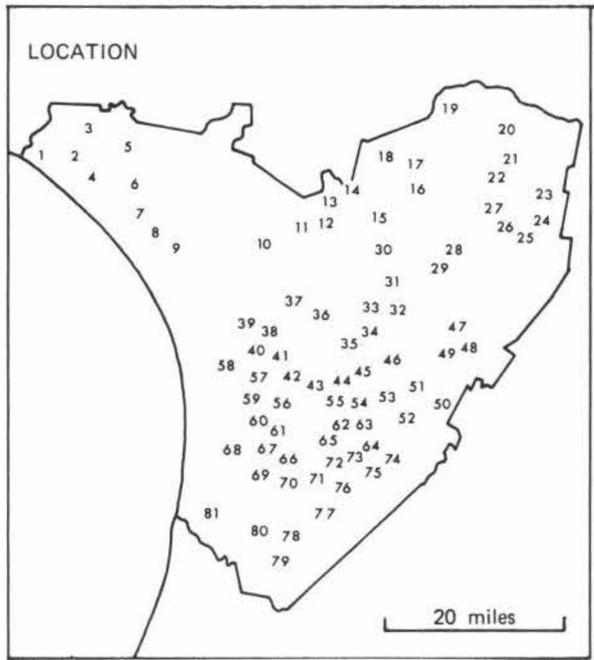
This is not to say, however, that transport difficulties were removed. Prior to the turn of the century, railways were poorly serviced by road networks. Although the railway development brought population to the areas it served, and was responsible for the founding of many small towns, its effect on settlements more than 10 or 15 miles from stations was negligible.

Initially there were no special provisions made for the transport of perishable products, but from about 1890, increasing numbers of iced and ventilated wagons were being provided. (Table II, page 23) By 1914, rail transport had become an important method of cream delivery from skimming station to creamery. The Wanganui Proprietary Dairy Company owned a skimming station at Paraekaretu (Leedstown) and the Waverley Proprietary Dairy Company one at Silverhope, both having their cream railed to their respective creameries. (Little, 1952:12)

The introduction of refrigeration, by enabling distant markets to be served, provided a stimulus for the establishment of cheese and butter making factories. (fig. 2) Existing sources of butter and cheese could not supply the required quantities and their variations in quality placed them at a disadvantage when landed on an overseas market. Factory organisation, on the other hand, produced a (generally) high grade, uniform product which realised a higher premium on the London Market.

Despite the improvement in overseas transport, cheese factories remained hampered in their development by poor internal transport facilities affecting the daily delivery of wholemilk and, to a lesser extent, the delivery of cheese to the ports. These difficulties emphasised the need for high cow densities in the vicinity of the factory and led to the consequent establishment of closely-spaced factories, each with a small number of suppliers. Regional specialisation can be attributed in part to variations both in the difficulty of transport and to cow density. Where transport was difficult but cow density high, such as in South Taranaki, closely-spaced cheese factories tended to predominate. Creameries developed where transport

fig. 2 WHOLEMILK AND CREAM COLLECTION CENTRES, 1908 TO 1971

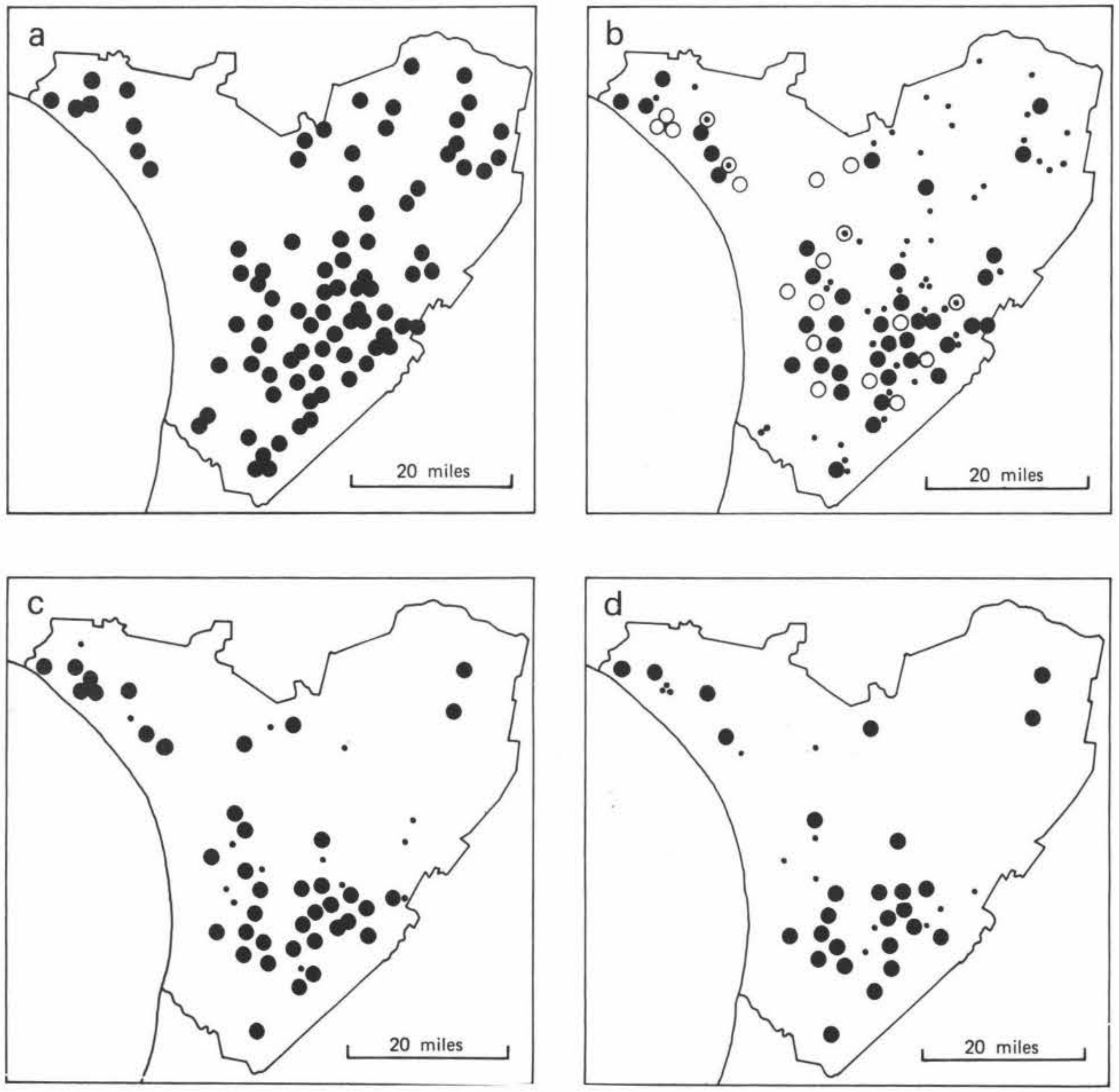


Numbers in parentheses refer to the number of collection centres at each locality.

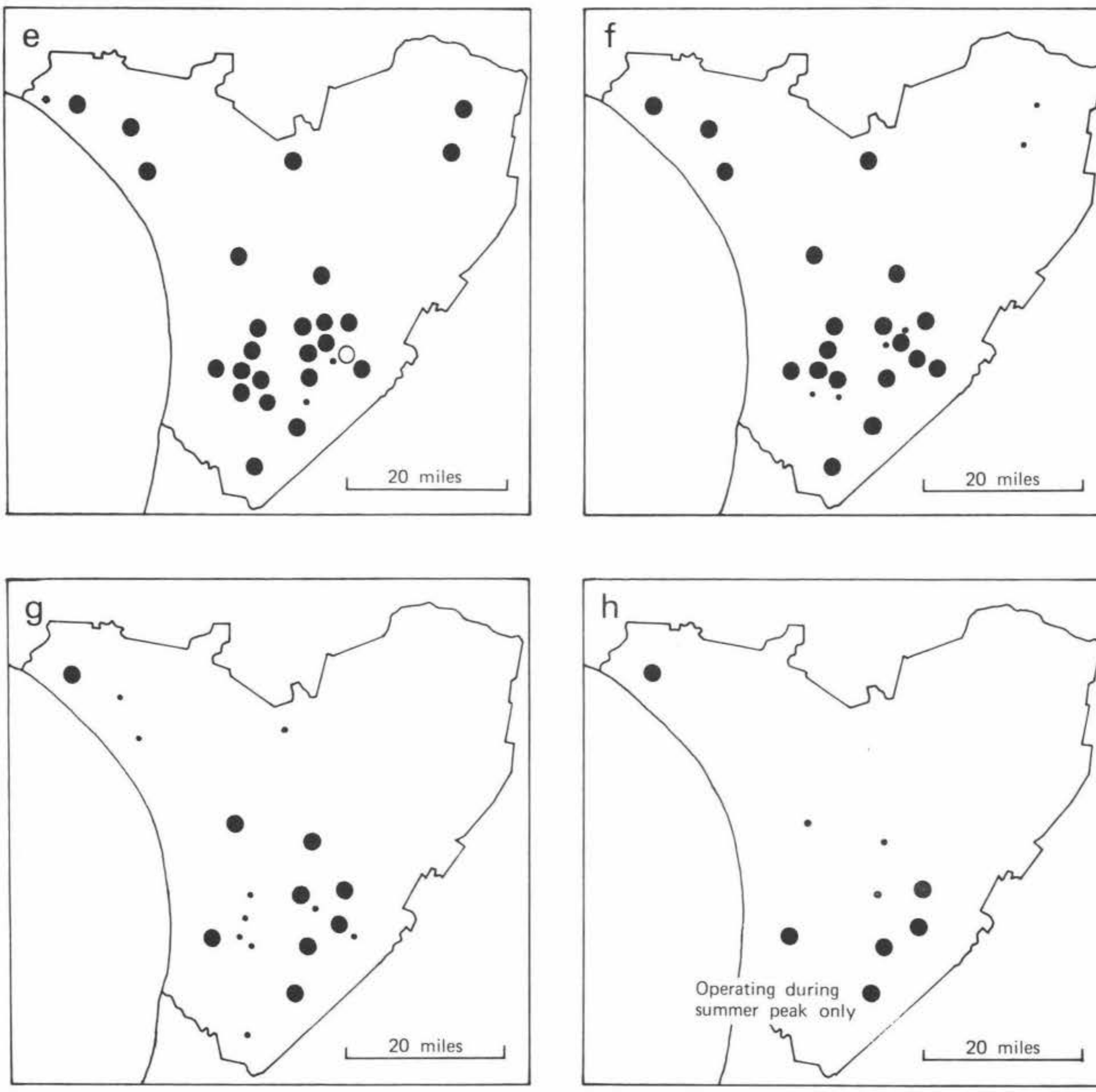
1 Rapanui
2 Westmere (2)
3 Brunswick
4 Wanganui (3)
5 Upokongaro
6 Okoia (2)
7 Marangai
8 Whangaehu (2)
9 Turakina
10 Marton
11 Paraekaretu (Leedstown)
12 Rata
13 Silverhope
14 Hunterville
15 Rewa
16 Pakihikura
17 Sandon Block
18 Mangaonoho
19 Mangaweka
20 Ruahine
21 Rangiwahia
22 Main South Road
23 Table Flat
24 Norsewood Road
25 Utuwai
26 Ridge Road
27 Apiti (2)
28 Kimbolton
29 Kimbolton Road
30 Waituna West
31 Beaconsfield
32 Cheltenham
33 Junction Road
34 Makino
35 Cheltenham (Makino Station)
36 Halcombe
37 Kakariki
38 Bulls
39 Rangitikei (Bulls)
40 Ohakea
41 Sanson (2)
42 Jones Line
43 Awahuri
44 Reliance (Te Arakura)
45 Aorangi (2)
46 Colyton (3)
47 Pohangina
48 Awahou
49 Raumai
50 Ashhurst (3)
51 Hiwinui (2)
52 Whakaronga (3)
53 Bunnythorpe (3)
54 Manawatu Reliance (Rangitikei Line)
55 Awahuri (Kauwhata)
56 Rongotea
57 Makowai
58 Parewanui
59 Carnarvon
60 Kaimaterau
61 Tui (Glen Oroua)
62 Hughes Line
63 Silverleys (Newbury)
64 Palmerston North (3)
65 Kairanga (2)
66 Mangawhata
67 Taikorea
68 Oroua Downs
69 Bainesse
70 Rangiotu
71 Tiakitahuna
72 Kairanga (Longburn)
73 Awapuni
74 Fitzherbert (Aokautere)
75 Fitzherbert West
76 Linton (3)
77 Tokomaru (2)
78 Makerua
79 Shannon
80 Moutoa
81 Foxton (2)

KEY
- ○ Commenced operations
- ● Operations continuous
- • Ceased operations
- Touching symbols indicate centres at same locality

Source Appendix J



a 1908
b 1909 to 1919
c 1920 to 1929
d 1930 to 1939



e 1940 to 1949
f 1950 to 1959
g 1960 to 1969
h 1970 to 1971

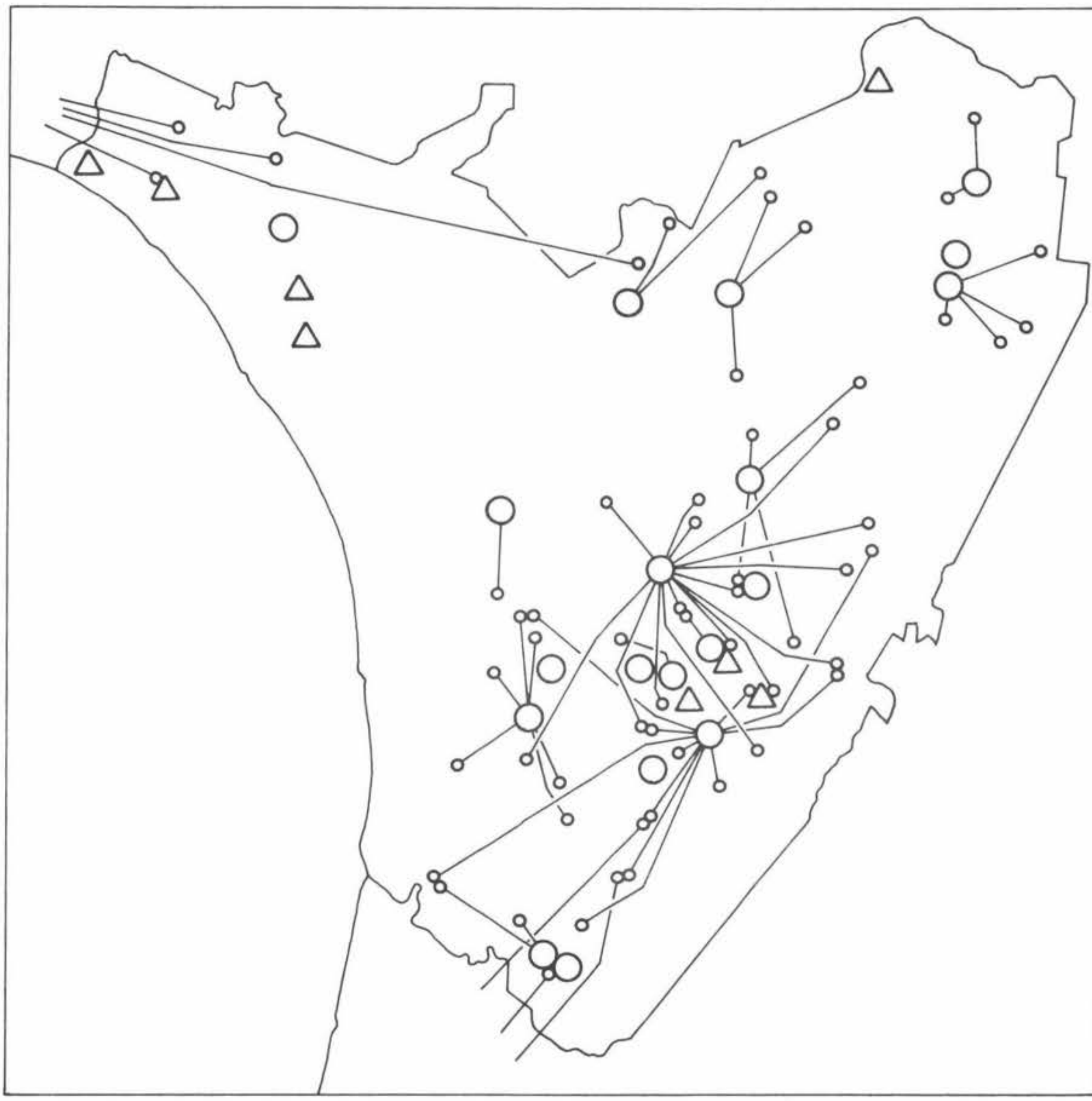
R.E.W.

was less difficult and cow densities lower.

The most striking response to refrigeration was the development of the "creamery system" of butter manufacture. As demand for butter increased, so did the demand for cream. In an effort to tap as wide an area as possible, skimming stations were set up in areas of lower cow density. The skimming stations received wholemilk from the surrounding area and the milk was set aside to gravity separate in large shallow pans. The cream was skimmed off and transported to the creamery. Skimmed milk was returned to suppliers the following day. (fig. 5, page 52) By partly processing the wholemilk in this way, considerable reduction in bulk was achieved. The cream was a less perishable product than wholemilk and could be transported longer distances and less frequently. Thus a single creamery could receive its supply from a much wider area than could a cheese factory. (fig. 3)

For the creameries this was a top heavy structure requiring almost impossible tasks of supervision and high labour inputs.[3] Initially the size of skimming stations was limited by the need for large diameter skimming pans (Lampard, 1963:205), but as mechanical separation was introduced this problem was minimised.

Creamery locations tended to be in the most accessible areas, the manufactured product (butter) being more perishable than cheese and requiring rapid transport to the port cool stores. Skimming stations, however, were located in response to the areas of supply so that the wholemilk could be delivered before it soured. The rapid transport of cream to the creamery was of secondary importance. Nevertheless, creameries soon began demanding special transport facilities for their cream and butter in order to expand their operations. By 1895, iced fig. 3 CHEESE FACTORIES, CREAMERIES, AND SKIMMING STATIONS, 1908



△ CHEESE FACTORIES
○ CREAMERIES
o SKIMMING STATIONS

CREAMERY WITH ASSOCIATED SKIMMING STATION

Notes: 1 Cheese factories and some creameries do not have associated skimming stations
2 Some skimming stations are shown as supplying creameries outside the Manawatu area

Source: Annual List of Creameries, 1908

R.E.W.

trucks were running on the Taranaki-Wellington line "for conveying butter consigned from Taranaki to Wellington for export to Britain." (Philpott, 1937:93) Table II shows the growth of refrigerated, insulated, and ventilated trucks on New Zealand Railways from 1883 to 1904.

TABLE II PROVISION OF SPECIAL REFRIGERATED, INSULATED AND VENTILATED TRUCKS ON NEW ZEALAND RAILWAYS: 1883 TO 1904

Year ending 31 March	Total Rolling Stock	Special Trucks	Percentage
1883	6030	33	0.55
1884	7076	28	0.40
1885	7688	28	0.36
1886	7705	53	0.69
1887	8061	53	0.66
1888	8153	53	0.65
1889	8156	53	0.65
1890	8161	56	0.69
1892	8257	166	2.01
1893	8357	167	2.00
1894	8418	178	2.11
1898	8975	204	2.27
1904	13433	455	3.39

Source: Robertson, 1939:216 (Railway Statements, A.J.H.R.)

In addition to the broad locational aspects, the more specific site requirements gained in importance and led to the development of distinctive landscape characteristics. The sites of cheese factories, creameries and skimming stations were chosen in terms of accessibility to suppliers and the needs for water in the manufacturing processes. They tended to be situated on a cross-roads in both the Taranaki and Manawatu areas. In Taranaki the pattern of roads was influenced by topography. Feeder roads, following the radial streams, were joined by one or two concentric main roads. Factories tended to be sited on the cross-roads which usually corresponded to a bridging point, thus ensuring access to water[4] and giving rise to elongated supply areas. Manawatu supply areas tended to be more circular in response to a lowland plains topography. Riverside locations were less common as artesian water was usually available. Only in peripheral areas do Manawatu supply areas become elongated. The Whangaehu C.D.C. suppliers, for instance, were located along the Whangaehu River, while the Rata C.D.C. suppliers were along the Rangitikei River. Access to rail transport was an important locational factor for some dairy factories, while proximity to a port was important for others.[5]

Competition between creameries for suppliers followed their desire to increase production. It was not unusual to find two or three skimming stations at a single locality with neighbouring farmers supplying different stations. (fig. 3) Rail transport enabled some creameries to obtain their supply from distant skimming stations. The case of Wanganui and Waverley creameries receiving their supply from the Rata area has been mentioned. (page 18) In addition, the Gold Leaf Proprietary Dairy Company, Wellington, received cream from five skimming stations in the Manawatu area in 1907, each of which had competing stations in the same locality. Also at this time, there were three skimming stations in the Colyton area supplying creameries at Cheltenham, Makino and Wellington. This competitive situation was eased for a time as co-operative creameries became established and the proprietary concerns closed down or were taken over by co-operatives. (Appendix B)

The direct effect of refrigeration (which effectively increas-- the overseas demand for butter and cheese) was an increase in dairy factory capacity. This in turn created demands for increased quantity and quality of wholemilk and cream from suppliers and highlighted some of the inadequacies of the "creamery system" and of internal transport. The delivery of wholemilk to the skimming station (and to the cheese factory) was an arduous task, and the return of skimmed milk the subject of much argument. There was no accurate method of equating an individual's supply with the amount of "skim dick" he should receive on the following day. The following description illustrates the point.

> "Horse drawn vehicles jog-trotted and ambled comfortably along the road from Putorino towards the factory [at Rata] with the rural scene placid and every vista offering restful contentment when, out of the blue, came a vehicle in a real hurry, horse flat out dragging its milk laden cart over the bumpy road, with the driver determined that he would be in early to make certain of receiving his full share of skimmed milk." (Little, 1952:43)

Motorisation of transport improved the situation. Although introduced during the First World War, it was not widely adopted until the 1920's.

The early skimming stations returned skimmed milk from the previous day's delivery. Later, with the introduction of mechanical separation at the skimming station or creamery, the "fresh" milk was separated while the supplier waited. Although he was assured of getting a fair measure of "skim dick", the delays for those at the end of the line were considerable.

> "... the cartage of milk to either the factory or the creamery consumed a very large proportion of the farmer's day, even those reasonably close to the factory often not getting back to their farms before mid-day." (Phillips, 1951:8)[6]

It is little wonder that soon after mechanical separation was introduced at the skimming station and creamery level, farmers demanded machinery suitable for their own use. The spread of home separation will be treated in the following chapter.

The demands for increased quantity led to the need for improved milking techniques. Hand milking was slow and demanding of labour. Its continuation was a severe check to herd size and the quantity an individual supplier could supply. Early attempts at machine milking were unsuccessful; they tried to duplicate the human milking action. Later attempts duplicated a calf's suckling action and proved more successful. By 1906 the Department of Agriculture was able to report, "During the past year very considerable progress has been made in perfecting the [milking] machines." (Philpott, 1937:122) Labour shortages during the First World War, and the increasing reticulation of electricity saw most dairy farms in the Manawatu with milking machines by 1920. (Little, 1952:20) (Table IV, page 32)

In 1882 the nature of dairying was such that concentrations of dairy activity corresponded to concentrations of population. Isolated littoral settlements were well served by small numbers of cows in the immediate area. By the close of the period, however, population had expanded considerably, and this had been accompanied by developments in internal transport. Under the stimulus of an accessible export market, dairying had also expanded. It was no longer tied to the local population for a market but was able to specialise in those areas most favourable for dairying. Southland, Taranaki, Manawatu, and the Waikato gained predominance as "dairy regions". This pattern became even more marked after the First World War. The wide dispersal of activity continued, with butter being made on the farm in isolated areas. But this practice became less important as transport improved. Between 1882 and 1914 there are two basic developments which were, in part, the result of refrigeration. It was a period of establishment of factory manufacture (in particular the development of the "creamery system") and a period of rapid expansion into those areas most suited to dairying.

Notes

1 The freezing equipment was installed by the owners of the "Dunedin", and represents a clear declaration of faith in the potential of the new system.

A dry air process was used for freezing the carcases on board and keeping them frozen during the voyage. A contemporary description of the principle was as follows. "Air at the ordinary natural temperature, is compressed to say one-third of its natural bulk by steam power. It is then let into a chamber with walls impervious to heat, (insulated with cork or charcoal). The sudden expansion of the air to its natural bulk again, reduces it to one-third of its former temperature, producing an intense cold within the chamber; and this process being constantly maintained by steam power, the temperature within the chamber is permanently kept down to a point corresponding to the compressure of the air. The carcases of the sheep, ready dressed for sale, are placed in the chamber where they are frozen quite hard and remain entirely unchanged until they are landed in England." (Wakefield, E., 1889, New Zealand of Today, page 129. Quoted by Robertson, 1939:14)

2 The carriage of cream by steamboat in the Bay of Islands was challenged only as roads were extended enabling the economic use of motor vehicles. The Northern Wairoa C.D.C. engaged private steam boats for their cream collection up to 1910, after which it operated its own launches. Between 1929 and 1933 the company disposed of its craft and demolished the associated jetties and wharves. (Megson, 1952:8-9)

3 "With ten creameries besides the main factory to control, the position of Factory Manager was an unenviable one, more particularly so, because during these early times the farmers were not so well educated in these matters of factory routine and in the science of dairying..." (Anon., 1943:6)[6]

4 The Oxford C.D.C. (Taranaki) was located near the Mangatete Stream. The stream broke its banks in 1935 and cut a deep channel through the factory yard. Flood damage was estimated at £780, and four feet of silt was deposited inside the factory. (Thomson, 1965:24-5)

5 The Bay of Islands C.D.C. (Ohaeawai) recommenced operations "alongside the railway line at Moerewa" in 1929 after 28 years at the former site. (Phillips, 1951:11)

Long (1889:12) notes, "There is a plan which, I understand, has been tried in the colony /of New Zealand/, by means of which the cream provided in the country districts is transported to a seaport town for conversion into butter. This appears to me to be a system worthy of extension..."

6 These two quotes indicate a common confusion of terms. Both should read skimming station for "creamery" and creamery for "factory", except for Phillips' second use of the word factory. In this case, both skimming station and creamery are implied. The reader is referred to the definitions of abbreviations and terms.

CHAPTER FOUR

RESPONSES TO MOTORISATION: WORLD WAR I TO 1950

Sailing times between New Zealand and Europe were cut from 40 days in 1900 to 30 days at the end of the Second World War. (Hamilton, 1944:85) Refrigeration techniques were developed both on board ships and at port cool stores. Hamilton was able to write that the former left little to be desired while the latter had increased in efficiency and capacity. The major problems of refrigerated overseas transport had been overcome by the First World War, while between the wars, export methods were elaborated and consolidated.

Internal transport difficulties were largely removed. Road development was followed by the increased use of motor vehicles (Table III) which, in turn, encouraged the building of better roads and the extension of the road network. Supplier factory relationships were subjected to considerable stress and change by these developments, and by the end of the period, inter-factory associations were increasing.

From before the First World War road networks were expanded throughout most of New Zealand. Initially it was the users of horse-drawn vehicles who demanded more and better roads. Although these roads were generally unsurfaced and rough by today's standards, their existence made possible the use of motor vehicles. As motor cars and trucks became more widely used, the demand for roading was further increased. The circularity of this cause and response situation has continued to the present.

Increased use of motor vehicles for commercial transport came in the early 1920's. Registration was introduced in 1924; unfortunately there are no records of vehicle numbers prior to this date.

TABLE III REGISTERED MOTOR TRUCKS: 1925 TO 1930

Year ending 31 August	NEW ZEALAND Under 3 ton	NEW ZEALAND 3 ton & over	NEW ZEALAND Total	TOTAL Wanganui and Wellington West Road Districts[a]
1925	9620	1710	11330	2260
1926	13718	2167	15885	3064
1927	18069	2490	20559	3782
1928	20279	2611	22890	4216
1929	23565	2779	26344	4745
1930	26795	3075	29870	5273

Notes: a Comprising the following counties: Patea, Waitorara, Waimarino, Wanganui, Rangitikei; and Kiwitea, Pohangina, Oroua, Kairanga, Manawatu, Horowhenua, Hutt, Makerua.

Source: New Zealand Official Yearbooks, 1926 to 1931

The use of motor vehicles for cream and wholemilk collection commenced at the same time but was not adopted without difficulty. Competition from horse drawn transport was sufficient to delay the introduction of motor vehicles. The Stratford C.D.C. for instance, accepted a tender of £80 in 1910 for the transport of cream from two skimming stations to the creamery by horse drawn vehicle. A three ton truck of 35 h.p. and a top speed of 16 m.p.h. would have cost the company £850, while a 30 h.p. electric vehicle could have been hired for £9 per h.p. per annum. Despite this competition, the company was using motor vehicles on some of its collection routes by 1917. (Burnard, 1954: 11-12 & 20) Another writer notes:

> "Although the use of motor vehicles spread rapidly, many of the old problems from horse and cart days remained. Main roads were not bad only by comparison with the badness of side roads; the proportion of unused land was even greater than it is today, making the provision of roads and their

maintenance a continuous problem. ... Whereas improvement in roading and the condition of roads was steady, and spasmodically rapid, transport, both in the company's area for cream collection and outside its area for the dispatch of butter was a continual problem." (Phillips, 1951:12)

Despite these difficulties, the spread of motorised transport enabled dairy factories to enlarge their collection areas. Increased speed meant that wholemilk or cream could be carted longer distances before perishing. Collection was speeded up and the truck proved to be "much more economical and efficient." (Little, 1952:44) The eventual provision of all-weather roads resulted in more regular and reliable collection of wholemilk and cream for delivery to the dairy factory. A concomitant development was the change in responsibility for transporting wholemilk and cream. Dairy factories (particularly creameries) became responsible for collection, either by purchasing their own vehicles or by letting contracts for collection. There are a number of reports of school buses, mail delivery vans, and other regular road users being hired for cream collection in more remote areas. This change was not universal. Suppliers to some cheese factories, and some suppliers who were close to their creamery continued to deliver their own milk or cream.

With the increased use of trucks for collection came a decrease in the use of rail transport for the cartage of cream from skimming station to creamery. This transition was partly the result of motor transport being more flexible, and thus suited to short hauls. It was also the result of motor transport (in association with home separation) being able to bypass the skimming station altogether. Rail transport continued to be of importance, however, in longer hauls, transporting butter and cheese from dairy factory to port.

Concurrent with the spread of motorisation was the spread of home separation. (Table IV) Mechanical methods of separating cream from wholemilk were developed during the last decades of the nineteenth century, and hand powered models were available from about 1890. Initially, however, home separation was strongly opposed by the Department of Agriculture and by creamery managers and directors. The Rata C.D.C. decided in 1904 "that no hand separated cream be taken as such a practice was considered detrimental to the quality of the butter made." (Little, 1952:45) The increased use of home separators continued in spite of such opposition and the Rata C.D.C. directors must have revoked their earlier decision around 1910, for by 1914 one half, and by 1919 all, of the company's supply was home separated. (Little, 1952:44) Suppliers pressured their companies to allow home separation and they were also the first to complain about the new system. The Bay of Islands C.D.C. received its first home separated cream at the start of the 1906-07 season and;

> "In November, 1906, the Directors received their first complaint about the cream collection cart arriving too early at the farmer's gate, and two months later received their first recorded complaint regarding short weights of cream and incorrect cream tests." (Phillips, 1951:8-9)[1]

Although the increase in the number of home separators was rapid (Table IV), the method was not universally adopted by creamery suppliers. As late as 1925, the Awahuri C.D.C. creamery was receiving a third of its supply as wholemilk. Croucher notes that the factory was not "equipped to deal with the raw material delivered in different forms, consequently it was extremely difficult to secure a butter of high quality. If progress had to be made, uniformity of supply had to be secured so in the end the company confined its operations to the exclusive use of home separated cream." (Croucher, 1947:26)

TABLE IV MILKING PLANTS AND CREAM SEPARATORS: 1919 to 1950

Year	MILKING PLANTS Wellington Land District	MILKING PLANTS New Zealand	CREAM SEPARATORS Wellington Land District	CREAM SEPARATORS New Zealand
1919	1200	7577	2495	24736
1921	1638	10450	3233	32024
1923	2163	13553	4166	40916
1925	2389	15561	4839	44656
1927	2619	17090	4990	45246
1929	2816	18756	5318	45781
1931	3362	22457	6074	47112
1933	3634	24350	6942	54200
1935	3775	25630	7387	55920
1937	4183	27331	7652	56850
1939	4282	28970	7386	55665
1941	4339a	30878	7443a	54896
1947	-	32596	-	48194
1949	-	34114	-	48451
1950	-	36368	-	54421

Notes: a 1940
- Not Available

Source: A. & P. Stats. for the years given

The prime importance of home separation lies in the reduction of bulk at the farm, thus reducing the volume to be transported. (fig. 5, page 52) This, combined with motorisation, obviated the need for skimming stations. Some became creameries or cheese factories; others were closed. (fig. 2, pages 19 & 20) Overall there were considerable savings in time and in labour requirements.

The use of trucks for collection meant that the potential supply area could be increased. This, in turn, created a demand for increased dairy factory capacity, which when met, created further demands for increased supply. Wholemilk supply is made up of a large number of small units and thus increases gradually. Dairy factory capacity, on the other hand, is made up of a small number of large units. When supply exceeds capacity, factory management must decide either to increase manufacturing capacity or to turn away supply. While the latter decision is rarely made (supplier - factory relationships must be maintained), the former leads to excess factory capacity and the uneconomic use of machinery. Under the "creamery system" this problem was minimised by the overall expansion in the number of dairy factories; the presence of a potential supply was sufficient to justify the erection of a new factory or skimming station. The present period, however, was characterised by the closure of dairy factories and skimming stations and an expansion of the average supply area per factory making it necessary for factories to increase their capacity.

The potentially larger supply area also resulted in increased competition between dairy factories for supply. Overlapping of cream supply areas was general in the Manawatu during the 1930's causing "the adoption of practices that should not exist in a co-operative industry, increased collection costs, and unnecessary wear and tear of roads." (Frazer, 1936:33) Cheese factories tended to overlap less with each other, but were often enveloped by creamery supply areas and consequently suffered from severe competition and often a loss of suppliers. The Executive Commission of Agriculture (Frazer, 1936) noted that much of this competition resulted from the activities of the New Zealand Farmers' Dairy Union which drew its supply from a wide area and competing with all but the most isolated creameries.[2]

For cheese factories, motorised transport meant an easing of the requirements for high cow densities very close to the factory. With trucks, a cheese factory could collect the same volume of milk from a larger area of lesser cow density. Alternatively, the same densly populated area could be served by fewer factories. Relative to creameries, cheese factories remained of small operating size. (Table V and fig. 4) This limitation in size was partly the result of the need for a daily delivery of a relatively large volume of wholemilk. Creameries, on the other hand, were concerned with 90 percent less volume of a product that could be collected infrequently. By the 1950's, however, cheese factories were more widely distributed and of marginally larger operating size than their counterparts of previous decades.

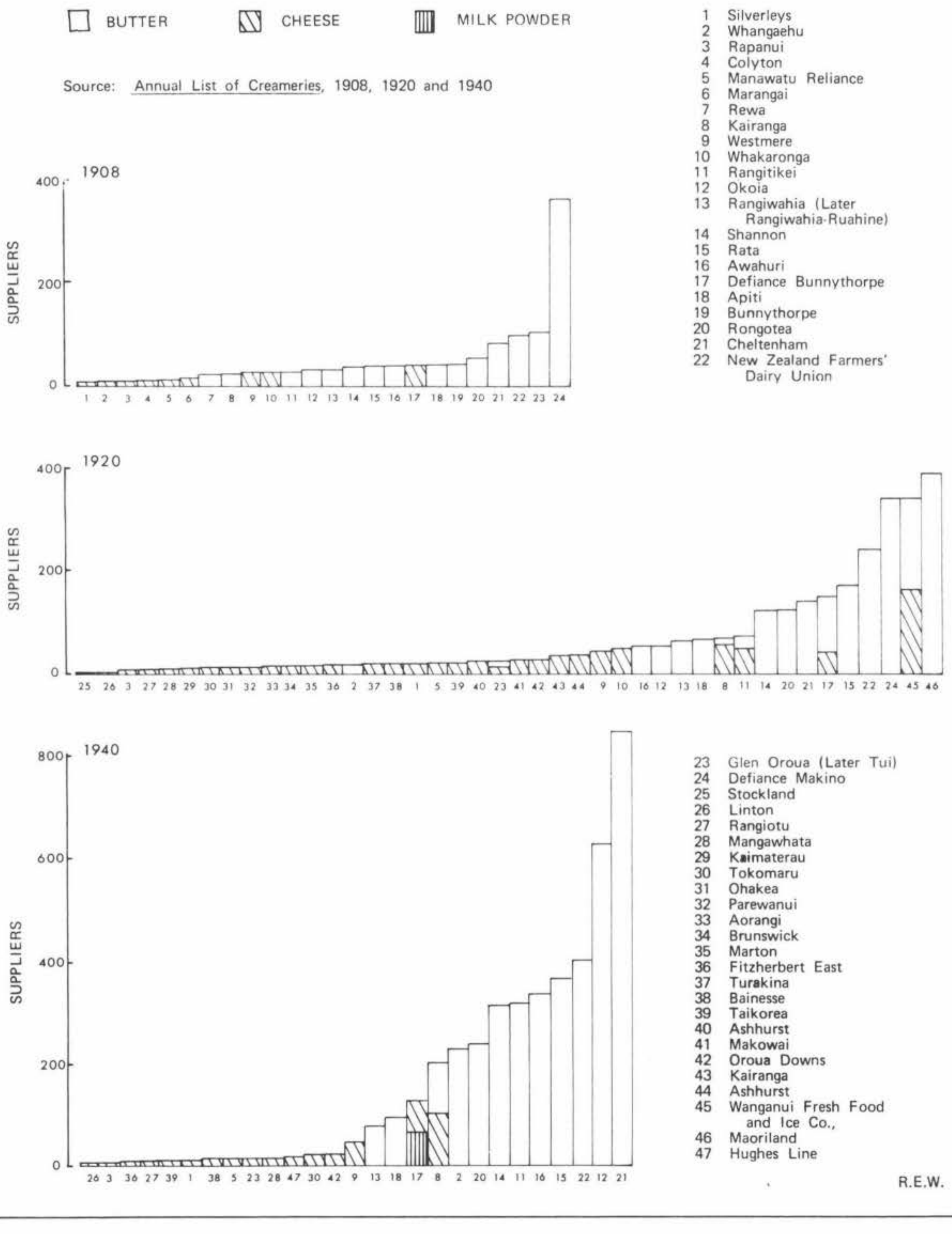
TABLE V SCALE OF FACTORY OPERATION IN NEW ZEALAND: 1905 TO 1949

Year	PRODUCTION PER FACTORY (tons)		SUPPLIERS PER FACTORY	
	Butter	Cheese	Butter	Cheese
1905	108	89	64b	23b
1910	143	122	77	24
1915	181	122	116	23
1920	187	164	157	27
1921d	262	148	273e	36
1923	471	169	243	36
1925	521	214	278	35
1927	527	232	262	38
1929	646	265	286	39
1931	785	282	319	42
1933	976	323	379	40
1935	1042	302	392	39
1937	1235	308	409	39
1939	1203	303	448	38
1941	1337	431	408	41
1943	1220	344	426	49
1945	1307	383	378	37
1948	1267	367	380	39
1949	1494	400	385	39

Notes: b 1906
d Numbers of factories estimated
e Including suppliers to dual plant factories

Source: Appendix H I

fig. 4 DISTRIBUTION OF FACTORIES BY NUMBERS OF SUPPLIERS, WITH TYPE OF PRODUCTION, 1908, 1920, & 1940



For the farmer, motorisation eased him of the responsibility of delivery.[3] Thus the time spent in delivery of wholemilk to, and collection of skimmed milk or whey from the skimming station or cheese factory could be devoted to other activities. Also, the quality of the by-products used on the farm for animal feed was improved; whey from the morning delivery was returned in the afternoon and skimmed milk did not leave the farm. In response to these developments, and as milking machines were adopted, the farmer became able to milk more cows and thus increase his supply. With increased herd size and increased demands for higher milk quality, the farmer's attention was turned to shed design, herd testing, production per cow and per acre, and so on. Specialisation became the essence of progress. Suppliers to cheese factories tended to be more specialised; it being uneconomic to supply wholemilk from a small number of "house cows". Creameries, on the other hand, gained their supply from two levels of dairying activity.

Some creamery suppliers were as specialised as suppliers to cheese factories. Others, however, maintained a few cows to provide for the household's needs. The wholemilk was hand separated (and often the cows were hand milked) and the surplus cream sent to the creamery. The resulting income was of a supplementary nature. The extension of road networks and motorisation meant improved access to previously isolated areas, virtually eliminating farm made butter and cheese for local and domestic use.[4]

Relationships between supplier and dairy factory underwent considerable change with the move from horse drawn, farmer delivery to motorised, factory collection. Daily contact between the farmer and the cheese factory or skimming station was eliminated. In its place came the collection of cans from the farm gate. Grading slips were returned to the farmer in the empty cans (often with a variety of stores from the company's trading department). The continued growth of co-operative dairy factories, however, increased the farmers' involvement with factory operation, and organisation through the elected directors. (Appendix B)

Towards the end of this period the desirability of increased inter-factory association was seen. Demand for other milk products such as casein, lactose, and powdered and condensed milk had increased. Individual factories were not suited to filling this demand. Their small size and the limited quantity of by-products available at each factory for further processing made it uneconomic to introduce new specialised plants. On the other hand, there was no suitable means of transporting these liquid by-products to a central factory for processing. Whey or skimmed milk was either returned to the supplier for use as animal feed, or it was wasted.[5] Despite these limitations, buttermilk was being transported by a tanker from the Cheltenham, Rangitikei (Bulls), and Kairanga (Longburn) dairy factories to the Awahuri factory at Kauwhata for processing into buttermilk powder from 1949. (Little, 1951:34-5) Cream, because of its relatively small volume, was also transported from casein factories to nearby creameries. The need for large numbers of billy cans and the absence of tankers, however, precluded the transport of the larger volumes of whey and skimmed milk to factories for further processing.

Billy cans, varying in capacity from 5 to 20 gallons, were a major disadvantage to be faced by cheese factories and creameries. Their large number, particularly where wholemilk collection was concerned, meant that a large number of trucks had to be available for collection. In addition, the need to collect wholemilk (and to a lesser extent cream) before mid-morning in order to prevent spoilage placed demands on labour which were excessive in relation to the value of the product collected. Congestion at the factory stage was common. A large number of cans had to be handled many times; pick up at the farm gate, rearrangement during the collection run, off loading at the factory, weighing, emptying, washing and, finally, reloading on the truck for return to the supplier. The difficulties involved were related to the number of cans handled rather than to the volume of milk or cream received. The large number of trucks needed resulted in under utilisation of the fleet in the afternoons, leading some companies to undertake general carrying duties in order to offset costs.

The post World War II period was one of rapid development. Depression in the 1930's, followed by war had produced changes in economic organisation and in attitudes to business and trade. Increasing affluence both in New Zealand and overseas provided a rapidly increasing demand for high protein foods. Supply and demand relationships at the supplier - factory level were subjected to increasing stress. This demand for protein rich foods at the consumer level increased the demand for a variety of dairy products and eventually the demand for more wholemilk. Development along these lines was impeded by the difficulties involved in transporting bulk liquids.

Larger organisational and operational units were seen to be more profitable. From the end of the Second World War, mergers between dairy factories took place. This usually involved the closing down of uneconomic factories and the transfer of supply[6] to the major factory. (fig. 2, pages 19 & 20) In other cases, however, dairy factories in the merger continued to operate as branches. Where possible the branch factories specialised in the production of casein, milk powder, and so forth, but again this development was impeded by the absence of bulk transport facilities.

Between World War I and 1950, internal transport was developed and consolidated. Although at the start of this period, motorisation led to increases in potential supply area and an overall expansion of dairying, by the end of the period development was again impeded by transport limitations. Transport, however, is the indispensable link between supplier and dairy factory, between dairy factory and port, and between New Zealand and overseas markets. "It is difficult to over-estimate the part which motor transport has played in the development of the dairy industry. ... It has made possible dairy collection of cream-supplies even in outlying areas, has widened the radius of supply for cheese factories, and made possible larger-scale processing with its attendant e nomies...." (Hamilton, 1944:39)

Notes

1 Difficulties were encountered in the payment for wholemilk and cream. Weighing was unsatisfactory, especially when the unscrupulous watered their milk. The introduction and spread of the Babcock Test (1892) and subsequent payments on the basis of butterfat content was accomplished by the First World War and, to a large extent, solved these problems.

2 Competition and overlapping supply areas, plus the problem of small scale cheese factories moved the Manawatu and West Coast Dairy Companies' Association to call upon the Executive Commission of Agriculture (Frazer, Chairman) and the New Zealand Dairy Board to "make an economic survey of the Association's area, with the object of eliminating overlapping or any other disabilities under which the dairy companies are working, and that special attention be given to the small cheese factories and to the factories manufacturing casein in the area." (Frazer, 1936:3)

3 This movement was not universal. Many farmers were very close to their factories and continued to deliver their own milk, often by tractor and trailer. The practice of self-delivery has been eliminated in most areas, particularly where tanker collection has been introduced.

4 Farm butter is still being made but is now valued for its novelty rather than being a necessary chore of the country housewife.

5 A number of cheese factories operated pig farms as an outlet for whey.

6 In some cases dairy factories were uneconomic because of greatly diminished supply making their continued operation impossible.

CHAPTER FIVE

RESPONSES TO TANKER COLLECTION: 1950 TO THE PRESENT DAY

Vehicles which had been developed for the transport of petroleum products and other liquids in bulk were not suited to the transport of perishable liquids such as wholemilk. The increasing demand for larger dairy factories and the more rational utilisation of wholemilk provided an incentive to adapt tankers for wholemilk transport. By 1940, dairy farms in the Bakersfield area of California were being serviced by tankers. (Scott, 1962:59)[1] Tankers were first used in New Zealand by the Wellington City Corporation's Milk Department for the transport of wholemilk from their depot at Rahui to the city treatment station. This service, introduced in 1947, did not involve the tanker collection of wholemilk from suppliers. At about this time also, the New Zealand C.D.C. (Hamilton) was transporting buttermilk between the branches of the company, and Lactose Ltd. was transporting ice cream mix from Manurewa to Auckland. (Purvis, 1956:111) The first use of tankers in the Manawatu has been mentioned in the previous chapter. (page 37)

Tanker collection of wholemilk from suppliers was initiated by the New Zealand C.D.C. at its Waitoa Branch. The scheme was first considered in 1940 "when difficulties associated with manpower and shortage of cans were becoming acute." (Purvis, 1956:111) War conditions and an associated shortage of stainless steel delayed the introduction of tanker collection until the 1949-50 season. Only ten suppliers took part in the pilot scheme, all being within a radius of 1.5 miles.[2] So successful was the pilot scheme that by 1953, all 550 suppliers to the Waitoa factory were on tanker collection. (Morris, 1965:27)

In the Taranaki area, tankers were introduced from 1956, while in the Manawatu area they were operating for wholemilk collection from 1955. (Tables VI & VII) These tables indicate that tanker collection is still not universal. Different requirements for town milk, cheese factories, and creameries have given rise to differential rates of adoption. Town milk suppliers have tended to change to tanker collection most rapidly because of the more stringent demands on quantity and quality.[3] Wholemilk suppliers to cheese, casein and milk powder factories have also changed over rapidly. Further, these two groups of suppliers have tended to adopt tanker collection more quickly than suppliers to creameries. The slower adoption by creamery suppliers is partly the result of the smaller volume of cream to be collected, and partly because cream is supplied by a large number of "part-time" dairy farmers who would find it uneconomic to install the necessary equipment for tanker collection. Where creamery buttermaking is but a part of the total activity of the dairy company, however, the trend towards tanker collection of wholemilk has been more marked. Where both billy cans and wholemilk are collected it is usual to have two collection systems operating. In areas of predominantly cream supply, trucks are used. Isolated wholemilk suppliers may be serviced by a small tanker trailer. Areas of predominantly wholemilk supply are serviced by tankers which have billy can bays for isolated cream supply.

Part of the growth of tanker fleets may be attributed to the increases in inter-factory movements of wholemilk and milk by-products, and associated transport of bulk liquids. Purvis (1959:41) notes the use of tankers for the return of whey to farms, and for the transport of

TABLE VI INTRODUCTION AND SPREAD OF TANKER COLLECTION: TARANAKI

Company and Number of Branches[a]	Products 1967-68 and 1968-69 seasons	Year Tanker Collection Introduced	Year Tanker Collection Universal
Kiwi [12]	Cheese	1956	Not by 1970
Ngaire[b,c]	Cheese	1956	1958
Taranaki [4]	Butter[d], Whey Butter[d], Cheese, Casein[e], Dried Milk Powder[f]	1956	Not by 1970
Whenuakura [2]	Cheese	1956	1969
Cape Egmont	Butter, Whey Butter, Casein, Dried Milk Powder	1958	1960
Clifton	Butter, Casein, Dried Milk Powder	1958	1966
Moa	Butter, Whey Butter, Casein, Dried Milk Powder	1958	Not by 1970
Warea	Cheese	1958	1959
Bell Block [2]	Cheese	1960	1967
Okato & Puniho[b]	Butter, Whey Butter, Cheese[g]	1961	1966
Opunaki[h]	Cheese	1962	1963
Alton	Cheese	1964	Not by 1970

Notes:
- a In addition to the branch listed for the 1968-69 season
- b Dual Plant Factory
- c Registration cancelled 18.11.68
- d At Stratford Branch
- e At Toko Branch
- f At Eltham and Stratford Branches
- g Mainly cheese
- h Closed between 1965 and 1968

Sources: Brooks, 1970:66
Annual List of Creameries, 1968 & 1969

TABLE VII INTRODUCTION AND SPREAD OF TANKER COLLECTION: MANAWATU

Company and Number of Branches[a]	Products 1970-71 Season	Year Tanker Collection Introduced	Number of Tankers as at Dec. '71	Notes
Oroua Downs C.D.C.	Casein	1955	3	Universal by 1971
Glaxo	Dried Milk Powder	1956	4	Universal by 1971
Manawatu C.D.C.[b] [3]	Butter[c], Cheese[d], Casein[e], Dried Milk Powder[f]	1960[g]	36[h]	Not Universal by 1971
Milk Producers' Company	Wholemilk for Town Supply	1963	3	Universal from 1963

Notes: a In addition to the branch listed for the 1970-71 season
b Company formed in 1960
c At Longburn and Rangitikei Branches
d At Westmere Branch
e At Longburn and Tokomaru Branches
f At Longburn Branch and including other milk products
g Awahuri C.D.C. and Kairanga C.D.C. had commenced tanker collection by 1960 with three and one tanker respectively. Shannon-Tokomaru C.D.C. commenced tanker collection in 1961 and Rangitikei C.D.C. in 1963. All became branches of the Manawatu C.D.C. after 1960.
h Including 8 tanker trailers

Source: Company Files and Interviews with Company managers

factory wastes in liquid form for pasture irrigation, water to dairy farms in case of drought, water in case of fire, and (alarmingly) weedicide; these in addition to the more conventional use of tankers for inter-factory transport and collection.

Although tanker collection has simplified collection, transport and delivery operations (Table VIII), it has required the introduction of specialised facilities and techniques. Farmers who supplied wholemilk were required to build roads from their farm gate to the milking shed, install cattle stops, and erect covered vat stands.[4] In addition, they had to modify existing machinery for the delivery of milk into the farm vats. The change from farm separation and cream supply to wholemilk supply required even greater changes in farm organisation. Tankers and farm vats, themselves, represent specialised equipment. The cost of both facilities is met by the dairy company, the latter being hired out to the farmer. Tanker collection necessitated changes in dairy factory layout. The factory stage, where cans were weighed, became obsolete, except where cream continued to be collected, and it has been replaced by special receiving bays designed for the rapid turn-around of tankers. In addition, the dairy factory has had to provide special tanker washing facilities. A summary of the operational techniques of tanker collection compared with those of can collection appears in Table VIII.

The elaborate time and motion studies conducted by Vautier (1956) suggest that considerable savings in time are made at all levels of activity, particularly at the factory.

Tanker collection has, however, disadvantages compared with billy can collection. If a supplier's milk is contaminated there is the possibility of contaminating a whole tanker load. The responsibility for refusing supply has shifted from the qualified grader at the factory stand to the tanker driver. A special course at the Manawatu C.D.C. instructs drivers in assessing milk quality in order to minimise this disadvantage. Efforts to reduce the possibilities of spoilage have led to the introduction of refrigerated farm vats. A side effect of this development has been the introduction of "skip-a-day"[5] collection with consequent economies in travel distance.

TABLE VIII

OPERATIONAL TECHNIQUES:
TANKER AND CAN COLLECTION METHODS COMPARED

	TANKER COLLECTION	CAN COLLECTION
Farm	Coupling milking machinery to farm vat(s). Washing of farm vat after collection	Filling individual cans. Spillage common! Transport of cans to farm gate for collection.
Collection	Inspection of milk in farm vat (a) Coupling of tanker to farm vat. Reading and recording of volume of milk in farm vat. Sampling of milk during transfer from farm vat to tanker. Uncoupling.	Transfer of full cans from roadside stand to truck and return of empty cans to stand.
Transport		Rearrangement of cans to facilitate continued loading during collection round.
Factory	Delivery of records to office. Coupling of tanker to delivery bay inlets and transfer of milk to holding vats. Tanker washing.	Off-loading of cans on to factory stage. Weighing, sampling (a), and recording of supply. Milk poured out of cans and transferred to holding vats. Cans washed and stacked for reloading on to truck.

Notes: (a) An individual's supply may be rejected at this stage

The difficulty of accurate measurement of individual milk volumes has been a cause of dissension. With can collection, a supplier's wholemilk or cream was weighed in the can, tare deducted, and butterfat content calculated. With tanker collection, however, supply volume is measured by reference to a graduated sight tube attached to each vat. (This tube, incidently, is a major source of bacterial contamination. The milk in the tube is exposed to higher temperatures and the tube is difficult to clean thoroughly.) A variety of factors may interfere with the accurate measurement of supply. Attempts to attach a constant flow meter between the farm vat and the tanker have not met required standards of accuracy as yet. An associated problem is the taking of a representative sample of milk for grading purposes. Tanker drivers must ensure that the milk is sufficiently agitated and that the drip sample is taken over the whole of the time the milk is being transferred.

Milk tankers, and other heavy road vehicles, while usually not exceeding Class III road limits, have imposed additional strain on existing road surfaces.[6] Although most tankers have been in the 1500 to 1800 gallon range, the number of units of over 2000 gallons capacity has increased. (Table IX) The Levin C.D.C. owns a tanker of 5000 gallons capacity which is larger than any in the Manawatu area. This vehicle, however, is restricted to the roads it can traverse and is used for inter-factory transport rather than wholemilk collection.

Despite these disadvantages, tanker collection has resulted in substantial economies at both the farm and factory level, although in terms of actual collection costs, there has been an increase. (Table X) The initial capital costs have been high. Lepine (1968:102) has shown that the costs to the farmer and the dairy factory for installations range from $880 to $1150 and $260 to $2916 respectively. In addition,

TABLE IX MANAWATU COMPANIES' MILK TANKERS: 1970-71 SEASON

Tanker size (gallons)	NUMBERS OF UNITS Tractor Trailer	Trailer	Total Capacity of Units (gallons)	AVERAGE ALL-UP WEIGHT OF UNITS (lbs.) Tractor Trailer	Trailer
2200	7	0	15400	39574	0
2150	12	0	25800	38704	0
2100	2	0	4200	-	0
2000	3	3	12000	37681	29879
1800	9	2	19800	33881	26734
1700	1	0	1700	34849a	0
1600	3	2	8000	-	24499
1500	3	0	4500	31740a	0
800	0	1	800	0	11963a

Notes: a Figure for one unit only - not an average
- Figures not available

Source: Manawatu C.D.C. and Interviews. These figures are based mainly on the Manawatu C.D.C.'s fleet of 38 units. The weight of milk has been taken as 10.33333 lbs. per gallon.

the dairy factory must meet the cost of tankers and their associated equipment (in excess of $15000 per unit) and of factory alterations; the building of tanker bays and the installation of receiving vats, and so on. The maintenance cost of all facilities, however, has been low compared to the costs associated with billy can maintenance. Vehicle repairs have remained consistent with the type of vehicle used and in some instances they have been reduced.[7] Farm vats require only thorough washing after the milk has been collected. Cans, on the other hand, needed regular retinning to prevent rust, and, when stored, had to be carefully greased. Purvis (1959:45) calculated that for 1600 20-gallon cans, the annual cost of repair and replacement would be approximately $1700, compared with an estimated $50 to service farm vats for the same number of suppliers.

TABLE X TOTAL COLLECTION COSTS (CENTS PER POUND BUTTERFAT) 1951–52 TO 1970–71

A COMPANIES FORMING MANAWATU CO-OP DAIRY CO.
B MANAWATU CO–OP. DAIRY CO.
C OROUA DOWNS CO–OP. DAIRY CO.

	1951–52	52–53	53–54	54–55	55–56	56–57	57–58	58–59	59–60	60–61	61–62	62–63	63–64	64–65	65–66	66–67	67–68	68–69	69–70	70–71
A Tokomaru	–	–	–	–	–	–	1.04	1.28a	0.75	1.06	1.04	1.05	1.03	1.10	1.20	1.22	2.93b			
Shannon	0.32	0.32	0.37	0.42	0.41	0.49	0.48	0.49a												
Westmere	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	– b				
Taihape	1.11	1.11	1.08	1.31	1.57	1.39	1.18	1.39	1.07	1.79	0.88	0.75	0.89	0.87	0.92	1.15b				
Okoia	0.73	0.72	0.77	0.86	0.87	1.07	1.02	0.96	0.96	1.09	1.09	1.36	1.49	1.20	0.96b					
Raetihi	0.76	0.73	0.81	–	1.04	1.11	1.09	0.92	0.76	0.77	1.24	1.24	0.67	0.69b						
Cheltenham	0.49	0.54	0.75	0.87	0.70	0.78	0.89	0.82	0.82	0.83	0.82	0.82	0.80	0.88b						
Apiti	0.53	0.46	0.74	0.81	0.63	0.86c														
Rangitikei	0.42	0.41	0.42	0.49	0.43	0.46	0.45	0.52	0.52	0.47	0.57	0.49	0.64b							
Whangaehu	0.42	0.43	0.56	0.57	0.61	0.59	0.56	0.59	0.60	0.64	0.64	0.57	0.54b							
Rata	0.72	0.76	0.82	0.97	1.01	0.99d	0.91	1.00	1.09	1.15	1.07	1.07	1.17b							
Mangawhata	–	–	–	–	–	–	–	–	–	– b										
Kairanga(e)	0.18	0.25	0.29	0.31	0.35	0.34	0.39	0.37	0.38b											
Rongotea	0.36	0.38	0.37	0.43	0.35a	0.34	0.35	0.35	0.41f											
Taikorea	–	–	–	–	– a															
Awahuri	0.31	0.30	0.31	0.38	0.36	0.35	0.58	0.83	0.87f											
AVERAGE (1)	0.49	0.49	0.55	0.60	0.66	0.70	0.76	0.80	0.76	0.85	0.95	0.94	0.87	0.95	1.03	1.19				
B Manawatu										0.63	0.82	0.81	0.70	0.92	1.10	1.26	1.45	1.57	1.96	2.06
AVERAGE (2)										0.82	0.91	0.91	0.88	0.94	1.05	1.21	2.48			
C Oroua Downs	–	–	–	–	–	–	–	–	–	–	–	–	– g	–	–	–	0.94	0.87	0.95	0.85
AVERAGE (3)																	1.77	1.22	1.46	1.46

Notes:
– Figures not stated in Annual Reports
a Amalgamated
b Amalgamated with Manawatu
c Amalgamated with Cheltenham
d Rangiwahia-Ruahine amalgamated with Rata
e Including Fitzherbert Branch (Cheese)
f Amalgamated to form Manawatu
g Tui (Glen Oroua) amalgamated with Oroua Downs
(1) Companies eventually to amalgamate with, but excluding, Manawatu - not applicable after 1966–67
(2) Including Manawatu - not applicable 1951–52 to 1959–60, and 1968–69 to 1970–71
(3) Overall average - same as (1) 1951–52 to 1959–60, and as (2) 1960–61 to 1965–66

Source: Annual Reports, 1951–52 to 1970–71

Tankers have kept collection costs at a low level. It can be shown from Table XI that cream collection costs have increased more rapidly than wholemilk collection costs. This economy has resulted from the increased capacity of tanker units over trucks. A tanker "can pick up 1500 gallons of milk per trip. A flat-top with cans can pick up at the most 1200 gallons. ... Therefore, four tankers could do the work of five flat-tops in picking up 6000 gallons. As a result of being able to introduce improvements in organisation of pickup ... one [town milk] producer company has been able to pick up 125,000 gallons more milk in 11,000 less miles than with the use of flat-tops." (Purvis, 1959:45) With the use of larger capacity tankers and tanker trailers, flexibility is increased and even greater economies may be gained. A further economy results from the reduction of unused capacity. Cans were often not filled to capacity thus reducing the effective load transported by flat-top vehicles. Tankers can continue to collect milk until they have reached their capacity.

The effects of tanker collection on company organisation and operation have been considerable and are primarily related to the return to wholemilk collection. (fig. 5) The previous pattern of wholemilk delivery to cheese and casein factories (in some cases wholemilk collection was involved), and cream collection by creameries has been replaced in most areas with wholemilk collection by tankers. Cream collection continues only in the more isolated areas or where a supplier's production is too small to warrant the installation of farm vats. Increases in the volume of milk and cream collected is well illustrated in Table XII. The total weight of wholemilk and cream collected increased from 187.1 million pounds during the 1960-61 season to 479.63 million pounds during the 1970-71 season. Astbury (1969) and Brooks (1970) have argued that

TABLE XI WHOLEMILK AND CREAM COLLECTION COSTS (CENTS PER POUND BUTTERFAT) COMPARED 1957–58 TO 1970–71 (1)

A WHOLEMILK COLLECTION COSTS

	1957–58	1958–59	1959–60	1960–61	1961–62	1962–63	1963–64	1964–65	1965–66	1966–67	1967–68	1968–69	1969–70	1970–71
Shannon–Tokomaru			1.21	1.64	1.43	1.21	1.00	1.00	0.94	0.88	2.18b			
Rangitikei							1.17b							
Awahuri	0.80	1.39	1.14f											
Manawatu				0.63	0.86	0.81	0.55	0.97	1.00	1.08	1.30	1.30	1.74	1.86

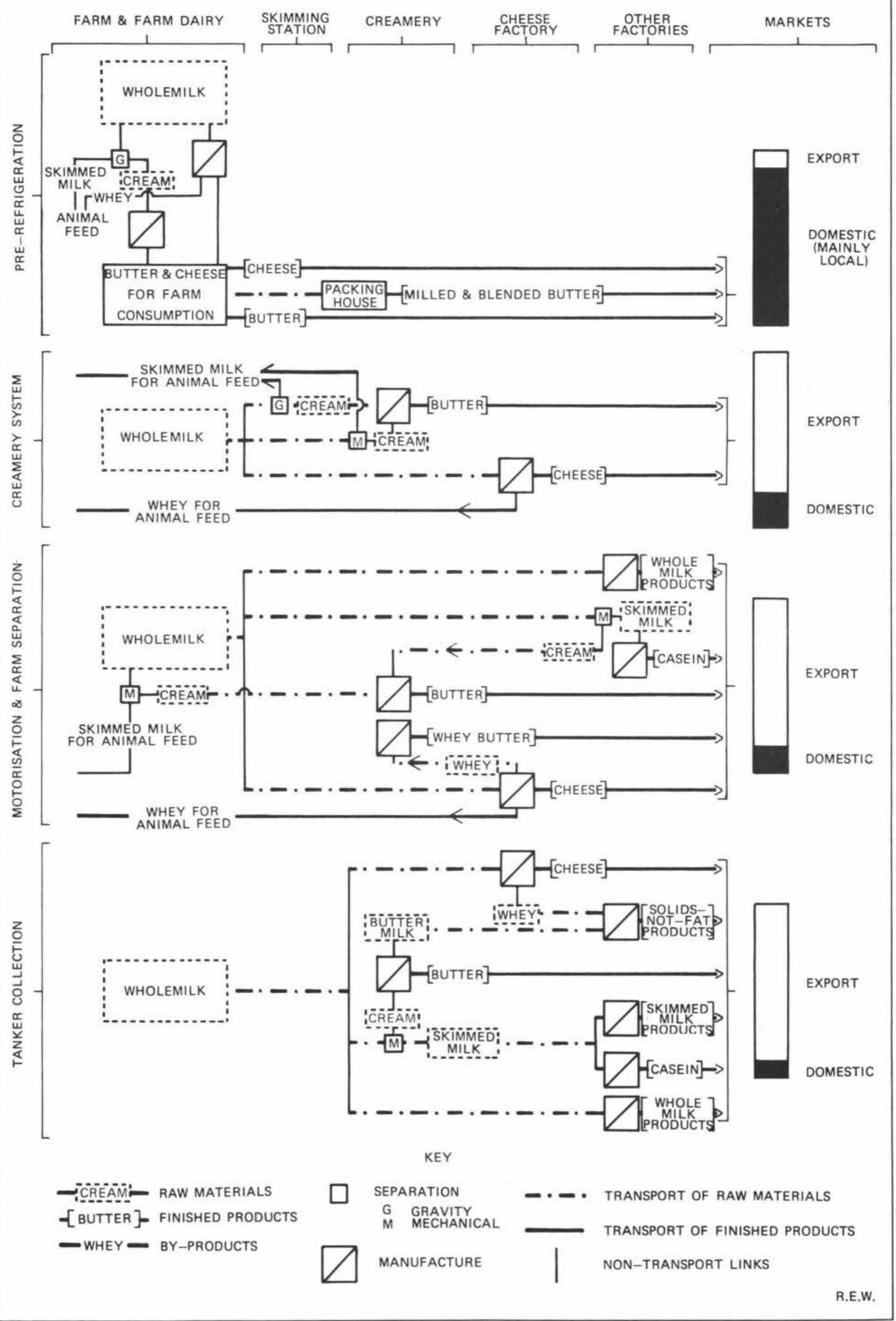
B CREAM COLLECTION COSTS

	1957–58	1958–59	1959–60	1960–61	1961–62	1962–63	1963–64	1964–65	1965–66	1966–67	1967–68	1968–69	1969–70	1970–71
Shannon–Tokomaru			0.62	0.70	0.74	0.91	1.05	1.24	2.23	3.63	10.71b			
Rangitikei							0.57b							
Awahuri	0.50	0.57	0.71f											
Manawatu				0.64	0.79	0.82	0.89	0.88	1.26	1.60	1.85	2.46	2.76	2.69

Notes: (1) Figures stated only where factory collecting both milk and cream
b Amalgamated with Manawatu
f Amalgamated with Rongotea to form Manawatu

Source: Annual Reports, 1957–58 to 1970–71.

fig. 5 CHANGING TRANSPORT LINKS IN DAIRYING



Notes to Table XII:

a It has been assumed that the area served by 11 companies in 1960-61 is essentially the same as that served by 1 company in 1970-71. Thus the 11 companies selected are those that have amalgamated with the Manawatu C.D.C.

b Manawatu, Shannon-Tokomaru, Westmere, Taihape, Okoia, Raetihi, Cheltenham, Rangitikei, Whangaehu, Rata, and Mangawhata

c As for 'b' except Mangawhata (amalgamated with Manawatu)

d As for 'c' except Rangitikei, Whangaehu, and Rata (amalgamated with Manawatu)

e As for 'd' except Raetihi and Cheltenham (amalgamated with Manawatu)

f Manawatu C.D.C. only

Source: Annual Reports, 1960-61 to 1970-71

TABLE XII

VOLUMES OF WHOLEMILK AND CREAM COLLECTED BY MANAWATU COMPANIES: 1960-61 TO 1970-71[a]

	1960-61[b]	1962-63[c]	1964-65[d]	1966-67[e]	1968-69[f]	1970-71[f]
WHOLEMILK COLLECTION						
Suppliers	259	481	577	663	739	670
Million lbs. Wholemilk Received	144.69	161.66	233.84	377.39	408.31	468.53
Million lbs. Butterfat in Milk Received	6.65	7.37	10.77	17.62	18.85	16.87
CREAM COLLECTION						
Suppliers	1515	1230	834	492	322	233
Million lbs. Cream Received	42.41	35.26	31.47	17.64	13.24	11.10
Million lbs. Butterfat in Cream Received	12.06	14.21	12.74	7.26	5.58	4.72
TOTAL COLLECTION						
Suppliers	1774	1711	1411	1155	1061	893
Million lbs. Butterfat in Milk and Cream Received	18.71	21.58	23.51	24.88	24.43	21.59

the introduction of tanker collection has reduced the obstacle of distance. This is true only insofar as larger volumes of wholemilk can be transported over long distances with relative ease and economy. The increased volumes to be transported, and the use of large tankers which may be limited by road and bridge conditions are obstacle increasing features.

The availability of wholemilk and milk by-products has resulted in manufacturing changes and a rationalisation of production. Prior to tanker collection, individual dairy factories were concerned primarily with the production of a single product. There were only a small number of dual-plant or multi-plant factories in operation. Tanker collection has facilitated the development of two new forms of dairy factory organisation; a "Waikato type" (multi-factory) and a "Manawatu type" (multi-plant).

The New Zealand C.D.C. in the Waikato presents a pattern of specialised factories under a single company organisation. Inter-factory movement of liquid by-products assembles a sufficient quantity of a by-product at a given point to warrant further processing. By comparison, inter-factory movements in the Manawatu are negligible because of the concentration of production at a single multi-plant factory. The Manawatu C.D.C. receives wholemilk at its Longburn Branch where butter, casein, milk powder, lactalbumin, milk biscuits, and other products are manufactured. Although cream is received daily from the Oroua Downs C.D.C. (casein production) and a permanent arrangement exists with the Milk Producers' Company to receive their excess wholemilk, inter-factory movements in the Manawatu are irregular and seasonal. The Tokomaru Branch (casein production) of the Manawatu C.D.C. sends cream to Longburn and wholemilk is diverted between the three branches of the company if the need arises. Similarly, wholemilk and milk by-products are occasionally diverted between neighbouring companies in the Manawatu area on an irregular basis.

The ability to transport by-products between dairy factories and to divert wholemilk from one factory to another has resulted in increased flexibility of operation. In interviews with the manager of the Glaxo milk powder factory (Bunnythorpe), the need to operate the factory economically was stressed. He suggested that it was better to operate the tanker fleet less economically if this enabled the factory plant to operate without interruption. The cost of shutting down the plant with the consequent loss of partly processed milk was greater than the losses involved in operating tankers at less than full capacity or increasing their mileage. Multi-plant factories (and multi-factory companies) are better able to accomodate market demand than are single product companies by relatively simple diversions of milk flow within the factory or between factories.

The scale of dairy factory operation in New Zealand has changed markedly since the introduction of tanker collection. (Table XIII and fig. 6) The reduction in the number of suppliers per factory is indicative of increased productivity at the farm level. (Table XV, page 63) Total butterfat supplied per dairy factory in New Zealand in 1951 was 4.2 million pounds, compared with 5.1 million pounds in 1960 and 8.8 million pounds in 1969, a total increase of 110 percent. Over the same period, butter production increased by 137 percent, and cheese production by 134 percent, indicating that, in addition to the greater scale of operation, wholemilk utilisation has become more efficient. This assumption is further supported when it is considered that the use of wholemilk for products other than butter and cheese has also increased over this period.

TABLE XIII SCALE OF FACTORY OPERATION IN NEW ZEALAND: 1950 TO 1969

Year	PRODUCTION PER FACTORY (tons)		SUPPLIERS PER FACTORY	
	Butter	Cheese	Butter	Cheese
1950	1523	440	390	39
1951	1649	467	392	38
1952	1685	446	387	34
1953	1757	493	369	31
1954	1629	484	364	36
1955	1696	485	352	35
1956	1855	510	337	35
1958	2041	570	338	34
1959	2123	514	320	34
1960	2059	568	307	37
1961	2107	633	292	36
1962	2162	683	286	39
1963	2269	681	278	37
1964	2485	654	243	34
1965	2653	811	229	34
1968	3139	1145h	213	39i
1969	3610	1029h	204	39i

Notes: h Excluding dual-plant factories
i Excluding suppliers to dual-plant factories

Source: Appendix H I

In the Manawatu area there has been a reduction in the number of dairy factories operating from 23 in 1950-51 to five in 1970-71. (Of these, two are branches of the Manawatu C.D.C.) (Table XIV) It should be noted in Table XIV that of the two "other factories" operating in the Manawatu in 1950-51, one was a dual-plant factory and the other concerned with milk powder and casein production. The five dairy factories operating in 1970-71 are concerned with a variety of products. (fig. 6) The dominance of the Manawatu C.D.C. in terms of butterfat collected is a recent feature of dairying in the Manawatu resulting from amalgamations since 1960. (fig. 7)

TABLE XIV SCALE OF FACTORY OPERATION IN THE MANAWATU: 1950-51 TO 1970-71

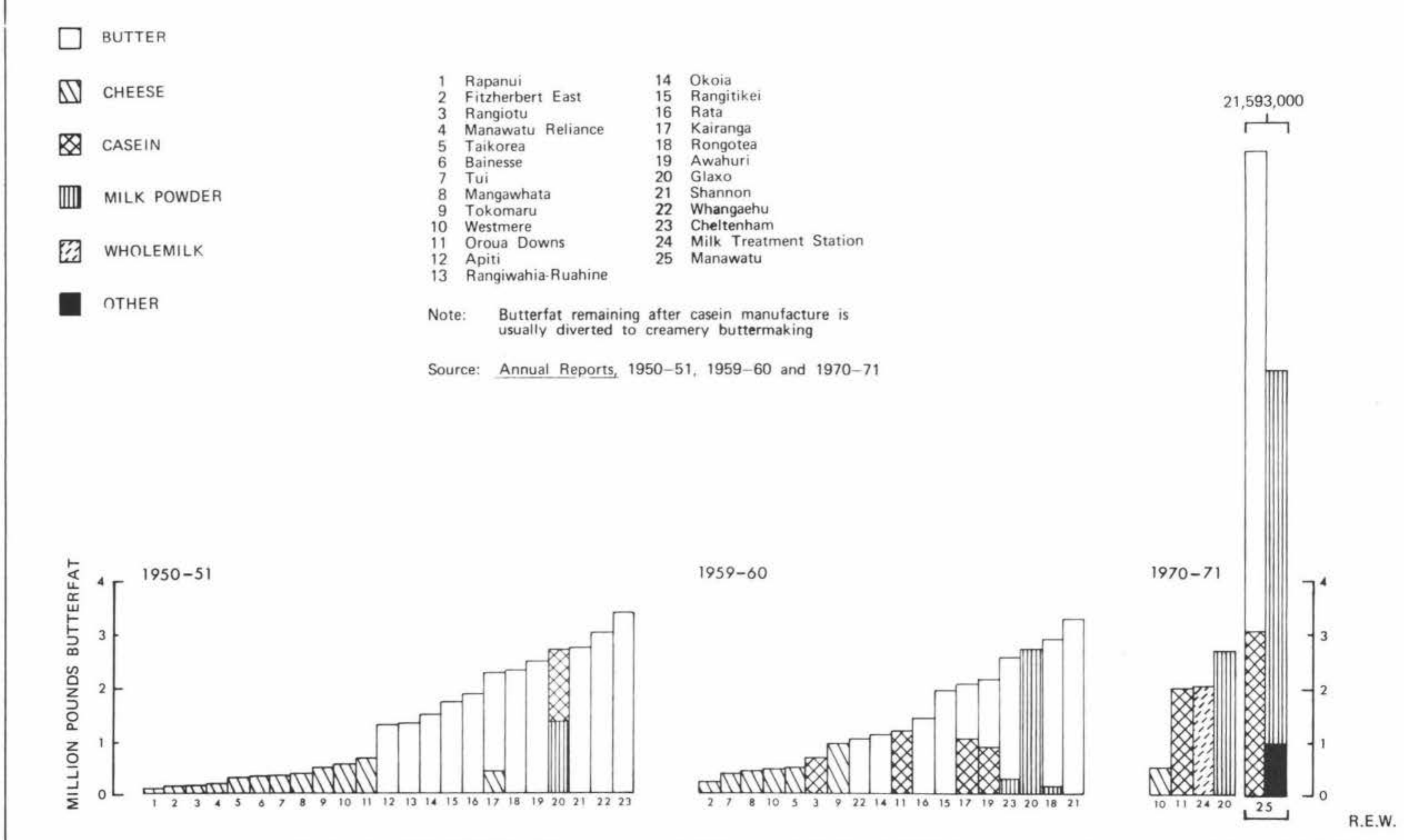
	1950-51	1959-60	1970-71
CREAMERIES	10	5	0
Suppliers per creamery	274	197	0
Million lbs. butterfat per creamery	2.16	1.75	0
CHEESE FACTORIES	11	6	1
Suppliers per cheese factory	20	26	a
Million lbs. butterfat per cheese factory	0.32	0.47	0.54
CASEIN FACTORIES	0	2	1
Suppliers per casein factory	0	64	56
Million lbs. butterfat per casein factory	0	0.89	2.01
OTHER FACTORIES b	2c	5c	3
Suppliers per factory	281	201	202
Million lbs. butterfat per factory	3.56	2.45	12.76
TOTAL ALL FACTORIES	23	19	5
Suppliers per factory	153	120	144
Million lbs. butterfat per factory	1.40	1.35	8.16

Notes: a Included in 'other factories'
b Namely, dual-plant, dried milk powder, and wholemilk for town supply
c Excluding Milk Treatment Station for which figures are not available

Source: Annual Reports, 1950-51, 1959-60, and 1970-71

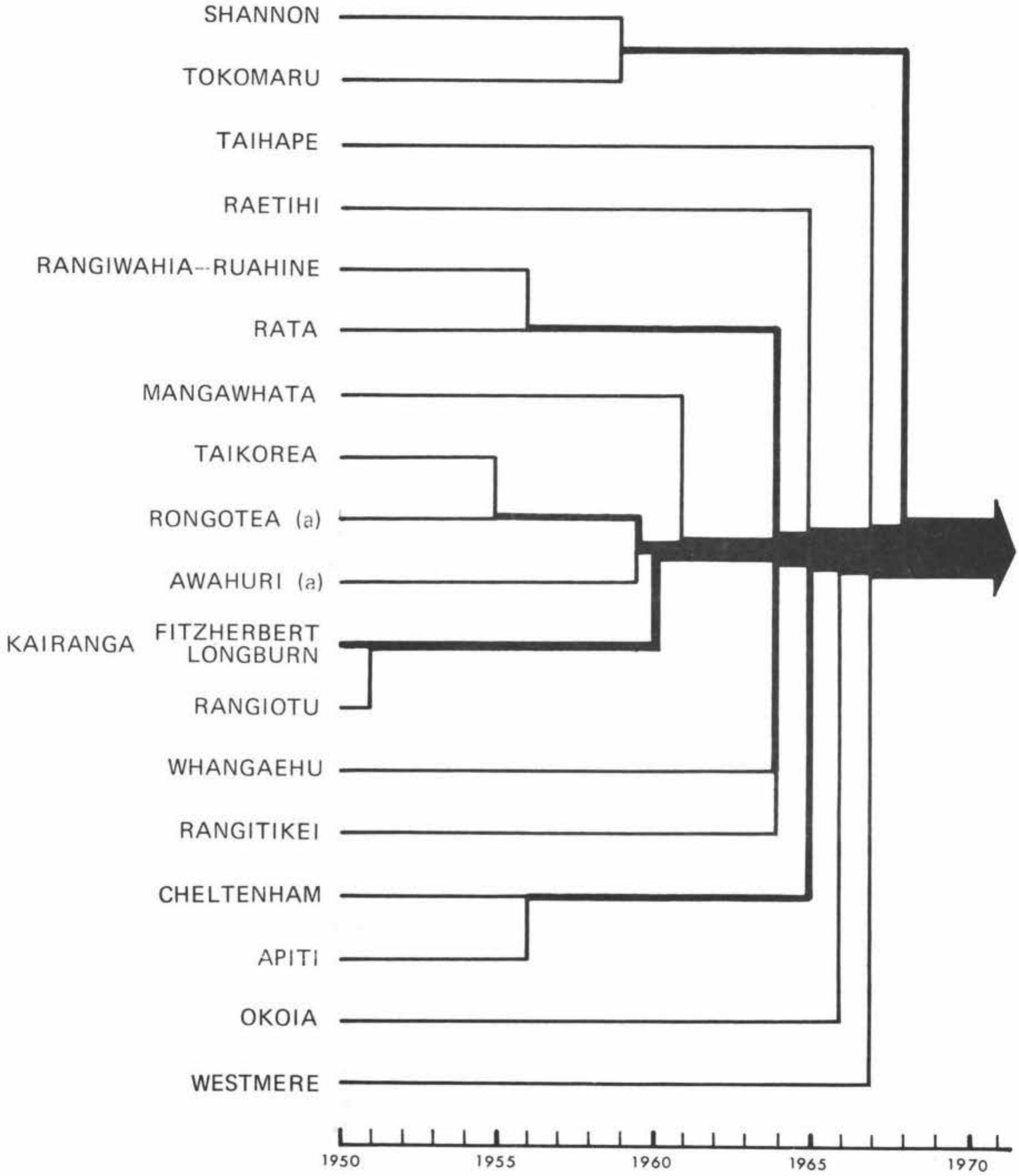
In addition to the changes at the factory level, there have been changes in company organisation. Before tanker collection, the transport of large volumes of wholemilk over long distances was uneconomic and impracticable. As a result, companies tended to be small and had few contacts with other companies. Tanker collection and transport, however, encouraged inter-factory contacts and ultimately made company amalgamation a practicable and viable proposition.

fig.6 DISTRIBUTION OF FACTORIES BY POUNDS OF BUTTERFAT COLLECTED, WITH TYPE OF PRODUCTION, 1950-51, 1959-60, & 1970-71



The course of amalgamations as far as the Manawatu C.D.C. is concerned (fig. 7) shows a notable increase in activity from 1960 to 1968, during which time, 13 companies were absorbed by the Manawatu C.D.C. The absence of amalgamations since 1968 has been the result of an apparent desire by the Manawatu C.D.C. to consolidate its position and undertake internal development following the lack of amalgamation opportunities available. Glaxo milk powder factory is a private company and is unlikely to favour amalgamation, while the Milk Producers' Company has specialised requirements which could not easily be taken over by a dairy factory complex.[8] Oroua Downs C.D.C., the remaining dairy company in the Manawatu area, appears unlikely to amalgamate at the present time; while casein prices remain at high levels and while the supply area can be maintained close to the factory, amalgamation is likely to be resisted by shareholders who are fearful of possible lower returns.

The growth of larger dairy companies has brought changes in the personal relationships between suppliers and factory management and changes in the nature of the decision-making process. Although companies retain their co-operative status, there has been a move towards a more formal, less personal, structure. Closer relationships existed between supplier and management before tanker collection. Dairy companies were smaller and employed a small staff which was often known on a personal basis by a large number of supplier shareholders. Staff were generally unspecialised, each having a number of duties within the factory. Truck drivers doubled as factory hands and the factory manager undertook clerical duties in addition to the supervision of production. The large dairy company has a much larger and more sophisticated administrative staff.[9] The number of drivers has increased, as has the fig. 7 AMALGAMATIONS, 1950 TO 1971 (MANAWATU CO–OPERATIVE DAIRY CO.)



(a) Parent Companies

Source: Annual list of Creameries, 1950 to 1969
Annual Reports, 1950–51 to 1970–71

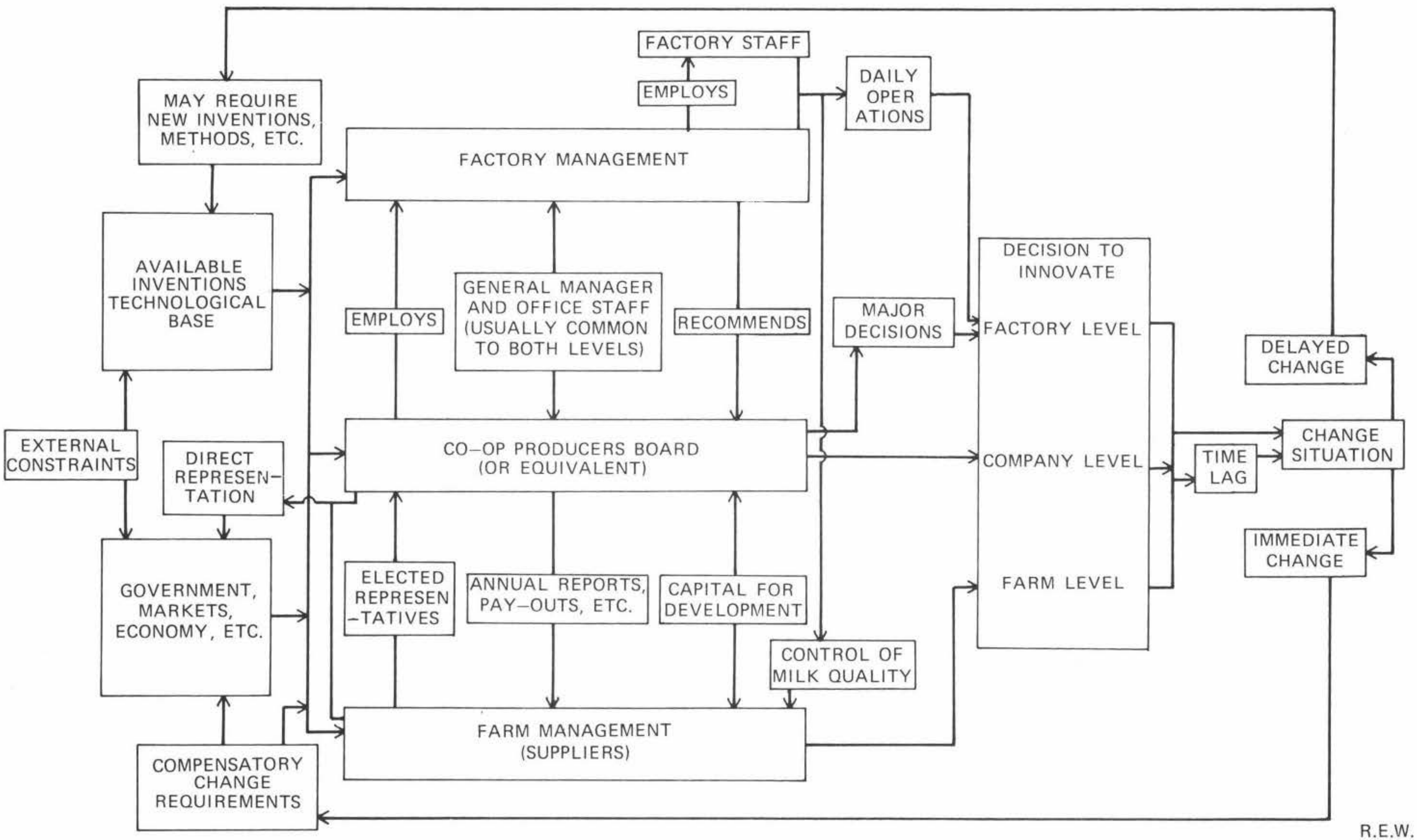
R.E.W.

need for specialised engineering and maintenance staff. With the increases in automated butter and cheese making, general factory hands as a group have declined while there has been an increase in the number of technicians responsible for testing the product at all stages of manufacture.

With a more formal structure, major decisions of company policy are made by the board of directors rather than the factory manager. Although managers have always been responsible to a board of directors, their responsibilities now involve daily factory operation, production, and marketing, rather than company policy making. (fig. 8) This change has implications for factory - supplier relationships. With smaller companies, suppliers could influence factory management by direct personal contact with the manager. Such a link is less common under the present structure; suppliers can influence company policy only through their elected board. In addition, there has been an increase in the number of non-supplier or dry shareholders. This development is not surprising in view of the increased capital needs for dairy factory development.

Farm operation has been no less affected by tanker collection. The adoption of wholemilk supply has led to a decline in the availability of skimmed milk and other by-products for animal feed (fig. 5) with a consequent decline in pig rearing on dairy farms.[10] Dairy farming has tended to become more specialised and less flexible. The facilities and higher investment level required for tanker collection deters the farmer from changing his supply from wholemilk to cream, and from one company to another depending on the payouts offered. Accompanying this specialisation has been an increase in herd sizes and a decrease in the number of suppliers. (Table XV) Although a number of small-fig. 8

DECISION-MAKING AND INNOVATION IN THE CO–OP. DAIRY INDUSTRY



scale suppliers remain (mainly cream suppliers), the trend evident in table XV is towards increasing dairy farm productivity.

TABLE XV SCALE OF DAIRY FARM OPERATION IN NEW ZEALAND: 1951 TO 1969

Year	Suppliers	Cows in Milk per Supplier	Butterfat per Supplier[a]
1951	51139	37.1	9660
1952	50721	37.6	9878
1953	47090	40.8	11125
1954	48077	41.6	10338
1955	45196	43.2	10975
1956	43097	46.2b	12298
1958	40258	48.9	13861
1959	38501	50.2	14467
1960	37061	50.9c	14760
1961	34543	55.8	16125
1962	33143	59.4	16746
1963	31427	63.5	18042
1964	27233	73.8	21665
1965	25265	80.4	24659
1968	19353	115.3	32915
1969	17906	126.6	36362

Notes: a In pounds per annum
b Estimated
c Figures refer to holdings over 1 acre before, and over 10 acres from 1960

Source: A. & P. Stats. for years given

The complex interplay between supply and demand has continued. The emphasis on quality has increased, encouraging farmers to adopt improved methods of shed hygiene and install vat refrigeration. Quantity demands have encouraged larger herd sizes and the development of increased milking capacity. Increased scale of dairy factory operation has led to changes in financial relationships. (fig. 8) With small co-operative companies, suppliers were able to provide sufficient capital for factory development. With the present large dairy companies, however, this has not been possible. In fact, the reverse case may apply with the dairy company providing capital for farm development by the installation of farm vats and associated cooling equipment.

The move from a large number of small-scale companies to the present small number of larger dairy companies has had significant repercussions on the spatial arrangements of suppliers and on dairy factories, and on the spatial relationships between these two elements of the dairy industry. These aspects will form the subject matter of the following section.

Notes

1 The situation was unlike that in New Zealand. Tankers collected from a small number of highly productive town milk suppliers. Scott (1960:59) noted that milk "was collected over a diverse area with subsequent hauls of 120 miles in air temperatures of 100°F or more. The designers of the scheme expected to reduce collection costs and improve milk quality...." He continues, "Generally equipment is costly by New Zealand standards, but it should be remembered that the system was developed for town milk requirements."

2 "Eight 'dead' miles were traversed and milk was collected for seven miles before returning five miles to the factory. A total of 1063 gallons was collected, (the observation was made in mid-January when the flush of the season was past but milk yield was still good)." (Vautier, 1956:117)

3 Town milk suppliers must guarantee to supply a minimum daily quantity of milk throughout the year. Further, if the butterfat and solids-not-fat content falls below a specified level, the supplier is penalised. Premiums may be gained, however, for chilled milk and the use of accredited sheds.

4 Road access should not be less than 12 feet wide and have a loop close to the farm vat stand of 60 feet in diameter. The approaches to cattle stops should be straight and level to prevent loss of traction. Vat stands should be lined to assist cleanliness, be well drained, and protect the vats and their contents from sunlight and the entry of birds and domestic animals. (McFetridge, 1959:49-51)

5 "Skip-a-day" collection is a term used to describe the practice of collecting from suppliers with adequate vat capacity and chilling facilities once every two days.

6 One county engineer who was interviewed expressed the opinion that the increase in heavy traffic (including milk tankers) over the past decade was the main reason for recent increases in road maintenance and construction costs. He suggested that 10 years ago a seal would have been laid over three to four inches of consolidated metal. Today, however, a foundation of 10 to 12 inches is necessary. While milk tankers are not the only heavy vehicles using the roads, their frequency of operation undoubtedly contributes to road deterioration.

7 An interview with a past transport manager of the Manawatu C.D.C. revealed that tyre wear was less on tankers than on trucks. (Also Purvis, 1959:45) The reason given was that loads are more evenly distributed. Any improvements in road surfaces were considered to have been offset by increases in off-road travel; that is, travel over farm access tracks.

8 Recent suggestions concerning the use of reconstituted milk for town and city consumption may change this situation. It is envisaged that reconstituted milk would be made available during the winter, fresh wholemilk being supplied in the summer flush. The likely place for milk reconstitution could be the dairy factory, thus obviating the need for milk treatment stations. Such a move would be facilitated by the already high standards of hygiene practiced in most farm dairies and in the dairy factories. The assumption of town milk supply by dairy factories is, however, likely to be strongly resisted by town milk suppliers and their companies.

9 Pro-amalgamation shareholders claimed that the duplication of office staff would be eliminated by amalgamation. It is probably true that duplication has been eliminated, but a much larger staff is now necessary to operate the amalgamated dairy company. (See also Rowlands, 1970:163)

10 Some dairy companies, faced with problems of waste and by-product disposal, established company piggeries. This development has, however, lost momentum as the nutritional value of wastes has declined with the increasing utilisation of wholemilk.

PART II AREAL DISTRIBUTION OF SUPPLIERS AND FACTORIES AND THE RELATIONSHIPS BETWEEN SUPPLIER AND FACTORY AND BETWEEN FACTORY AND FACTORY

CHAPTER SIX

INTRODUCTION AND ASSUMPTIONS

This section is a development of the working hypothesis that changes in the spatial relationships between supplier and factory, and between factory and factory are inversely related to changes in transport technology. While no attempt has been made to specify which is the dependent variable, the intuitive assumption throughout is that spatial relationships are partly dependent on transport. Transport technology includes variables such as the type of vehicle, road conditions, and topography and may be regarded as the ability of technology to overcome the obstacles created by these variables. A second related assumption is that the relationships that exist between factories are strongly influenced by the distribution of suppliers. Where suppliers are densly distributed and factories are close together, the opportunities for interaction between factories will be greatest.

Spatial relationships will be considered in terms of three methods of analysis, a) the distribution of suppliers by area and by distance from the factory, b) nearest neighbour analysis, and c) centrality analysis.[1] Each of these methods has advantages and limitations which will be discussed later. The two basic relationships (supplier - factory and factory - factory) have important transport elements. Transport constitutes an essential link between supplier and factory with the cartage of wholemilk and cream. The assembling of by-products for further processing gives transport importance in the inter-factory link. Together, these links have important ramifications for the development of the dairy industry in the Manawatu area and in

New Zealand. The analysis of these spatial relationships has been conducted under the following assumptions which define the boundaries of the problem.

It has been assumed that a rational economic system exists, and that dairy companies are striving for acceptable profit levels by innovations[2] which make adjustments to changing economic conditions. Schumpeter (1939) and Estey (1956) have noted that the entrepreneur who initiates an innovation receives the greatest return, but that as others adopt the innovation, the profit margin is reduced. It would appear that this situation provides an incentive for continuing innovation and so gives rise to a succession of innovations.[3] It has been suggested in previous chapters that refrigeration, motorisation, home separation, and tanker collection are major innovations. They were rapidly adopted by the dairy industry and each gave rise to successive waves of adjustment and development. "Progress ... proceeds by jerks and rushes. ... In every span of historic time it is easy to locate the ignition of the process and to associate it with certain industries and, within these industries, with certain firms, from which the disturbances spread over the system." (Schumpeter, 1939:102)

The present study has been focused on a theme of transport change within the dairy industry. It has been necessary to assume, therefore, that all other variables in the industry are constant. Although an unrealistic assumption, it facilitates the examination and discussion of the main theme. It should be noted, however, that where these variables are influenced by, or influence, transport, they are given fuller consideration. Home separation, for instance, has a strong transport component although it is not, in itself, a transport or transport-motivated innovation. It is further assumed that transport innovation has its initial impact on dairy factories. The consideration of farm effects is minimised in this study.

Transport changes have been considered in terms of the obstacle of distance. This in turn, has been divided into volume and physical distance. An implicit assumption is that the obstacle of distance is positively related to both the distance to be travelled and to the volume to be transported. This assumption is moderated by such variables as road conditions, volume of supply per unit area and vehicle capacity. Distance has been measured both by road-miles and air-miles (Appendix C), while the volume to be collected has been measured by pounds of butterfat collected and by supplier numbers. Where the latter measure is used it has been assumed that an average quantity is received from all suppliers. Where large numbers of small-scale suppliers exist, and where the level of technology is low, such as during the first decades of this century, it is likely that each had a similar production volume. The change to smaller numbers of larger-scale suppliers has, however, resulted in greater variation in production volume.[4]

The time factor is relevant to the discussion of transport change. It has been assumed that the obstacle of distance is reduced if the same volume of wholemilk is collected (or distance covered) in less time, or a greater volume is collected (or distance covered) in the same time. From the farmer's and factory manager's view points, the time saved by more efficient systems of collection can be used for alternative purposes. Although time in this sense has not been measured, its importance as a motivation for innovation has not been ignored.

In more specific terms, the obstacle of distance may be reduced or increased by transport change. The case of transport changes having no effect on the obstacle of distance is considered unlikely. The previous chapters have outlined the historical sequence of transport innovations. Refrigeration lifted the constraints on the export and internal long-distance transport of manufactured dairy products. Continued limitations on the internal transport of raw materials were a contributing factor in the development of the "creamery system". Motorisation and improved road conditions further reduced the obstacle of distance. Coupled with home separation, this innovation enabled collection of wholemilk and cream from larger areas than previously. Handling of larger quantities of wholemilk was simplified, and the reliability and regularity of transport was improved. Nevertheless, there were restrictions. Motor vehicles were confined to formed roads and where these did not exist, horse-drawn transport persisted. Tanker collection, the most recent transport innovation, has led to overall reductions in the obstacle of distance in spite of increased volumes of wholemilk being carted and the increased distances being travelled. Obstacles have been reduced by savings in collection time, improved ability to deliver fresh wholemilk to the dairy factory, and greater flexibility of operations.

The two following chapters are an attempt to specify the changes in spatial organisation of suppliers and factories in order to demonstrate the effects of changes in transport technology.

Brief review of assumptions.

1. The spatial relationships between supplier and dairy factory and between factory and factory are inversely related to, and partly dependent upon, changes in transport technology.

2. These relationships are strongly influenced by the distribution and density of suppliers.

3. A rational economic system exists with dairy factories striving for acceptable profit levels.

4. All aspects of the dairy industry, excluding transport technology, are assumed to be constant.

5. The obstacle of distance is positively related to the distance travelled and to volume transported.

6. Where numbers of suppliers are used to measure supply volume, it is assumed that an average supply volume is produced by each supplier.

Notes

1 It would appear at first sight that the "Transportation Problem" is a relevant analytical technique for this thesis. Preliminary investigations indicated that its relevancy was marginal in terms of the relationships being investigated. Cox (1952:228) notes, "The objective function of the problem is to minimise the total cost or total distance travelled." Garrison (1968) notes the use of linear programming in defining hinterland boundaries. In order to have advanced the discussion of the effects of tanker collection on the various relationships within the dairy industry, a number of time periods would have to be analysed. Unfortunately, only the present season (1970-71) provided sufficient data for such an analysis. While it was possible to generalise the location of suppliers to a factory location and use this as the basis for centrality measures, such manipulation could not be conducted for either the boundary problem or the transportation problem.

2 "Innovations are to be distinguished from inventions. Invention is the discovery of scientific novelties. Innovation is carrying these inventions into actual performance, or, in common terms, 'exploiting' them. Invention is probably much less fluctuating than innovation. It is innovation that is subject to cycles, not invention." (Estey, 1956:145)

3 This is not to be mistaken for the innovation waves discussed by Hagerstrand. Hagerstrand was concerned with waves of acceptance. Here we are concerned with successions of innovations where one major innovation necessitates continued supporting developments.

4 An examination of the production records for the Manawatu C.D.C. showed a daily variation in wholemilk collected per supplier from less than 1500 lbs. to over 5000 lbs.

CHAPTER SEVEN

THE DISTRIBUTION OF SUPPLIERS AND FACTORIES (Non-continuous distance distribution patterns and nearest neighbour analysis.)

Although any comment on the distribution of suppliers must be qualified by severe data limitations (Appendix D), a number of general observations may be made using what data is available. Supplier maps are generally not available for any time before 1960, and only for the current season are detailed maps available covering the whole of the Manawatu area. Such maps could, however, be constructed from lists of shareholders. Unfortunately these lists are incomplete with respect to the area being considered and in terms of time. Further, the task of locating each supplier is made difficult by the lack of adequate records of land ownership. With respect to dairy factory sites a similar, but less restricting, comment may be made. In only a few cases is the exact factory site known; for most an approximation to a small locality must be made.

Prior to c.1920 the obstacles of distance were considerable. Roads were often impassable, transport methods were slow and unreliable, and relatively large volumes of wholemilk had to be transported. The associated spatial pattern was one where suppliers were in close proximity to the cheese factory, creamery or skimming station which received their wholemilk. The supply radius was probably some two to four miles, that is, about an hour's travel time by horse and dray. Considerable variation must be allowed for as road conditions and suppliers' willingness to travel longer distances would have increased the distance between some suppliers and the dairy factory.

Nearest neighbour analysis conducted by Brooks (1970) in the Taranaki area, and undertaken for this study, suggests that a two to four mile radius is a realistic figure. (Table XVI) These figures represent the average distance between nearest neighbouring dairy factories and skimming stations. The average distance between second and third nearest neighbours (all of which could have been competing for supply) would be greater. If the average size of the supply area (Tables XX & XXI, pages 80 & 81) is used to calculate an average radius of supply, figures ranging from 1.96 miles (Taranaki) to 4.43 miles (South Taranaki) may be observed. The values for the Manawatu area fall between these two extremes.

TABLE XVI AVERAGE DISTANCE TO NEAREST NEIGHBOUR: TARANAKI AND MANAWATU COMPARED

Area	Year	Average Distance to Nearest Neighbour (miles)
Taranaki - all factories and skimming stations	1909	2.014
South Taranaki	1909	2.609
Manawatu	1908	1.820
Manawatu	1920	2.590

Source: Brooks, 1970:3, and Table XX

Between 1920 and 1950 the supplier distribution patterns changed markedly. Although the average distance between nearest neighbours increased only slightly, the average radius of supply for the Manawatu dairy factories increased considerably. (Table XXI, page 81) In addition there was a change in the quantity of supply. Whereas in 1908 suppliers produced only small quantities of mainly wholemilk, by

1950 the individual's supply was much greater, and both wholemilk and cream were being delivered to, or collected by, dairy factories. Similarly, there had been a change from a large number of small-scale factories to a smaller number of larger-scale factories. (Tables V & XIII, pages 34 & 56; and figs. 4 & 6, pages 35 & 58)

A more detailed description is possible for supplier distribution since 1950. In terms of distribution by distance from the dairy factory, there has been a slight change towards greater dispersion of supply. Vautier (1956) showed that for 20 factories (unidentified) during the 1949-50 season, 60 percent of butterfat collected came from within 20 percent (9 miles) of total distance from the factories. Similar figures for the Manawatu C.D.C.'s wholemilk collection in 1970 show 60 percent of butterfat coming from within 23 percent (16 miles) of total distance from the factory. (Table XVII) It would appear from this evidence that the distance to the furthest supplier has increased and that there is a reduction in the supply density close to the dairy factory. Nearest neighbour analysis supports this conclusion by indicating a continued increase in the average distance to the nearest neighbouring factory. The averages for area, radius of supply area, and number of suppliers have also increased, indicating larger supply areas and increased distances to the furthest supplier.

A comparison of factory supply areas is possible with only a limited number of examples.[1] (Table XVIII) It is evident that, in terms of the base area used for calculation, there is a marked agglomeration of suppliers about each factory. Of more importance, however, are the differences in the value of the nearest neighbour statistic 'R'. With the exception of the Manawatu C.D.C. supply area

TABLE XVII PERCENTAGE DISTRIBUTION OF SUPPLY AND SUPPLIERS BY PERCENTAGE OF TOTAL DISTANCE FROM FACTORY

% of Total Distance from Factory	% of Supply 1949-50 (a)	% of Supply 1970 (b)	% of Suppliers 1970 (c)
5	11.5	5.0	2.0
10	30.0	15.0	5.0
15	46.0	31.5	13.8
20	60.0	53.4	32.5
25	69.7	63.5	50.0
30	76.0	71.2	60.4
35	81.0	76.0	67.0
40	84.9	79.8	70.8
45	87.7	83.0	74.0
50	90.2	86.0	77.0
55	92.7	88.5	80.3
60	95.0	91.0	83.6
65	97.2	93.8	86.8
70	98.0	94.5	90.2
75	98.1	95.8	93.4
80	98.3	97.0	95.9
85	98.5	98.0	97.8
90	99.1	99.0	98.9
95	99.6	99.5	99.5
100	100.0	100.0	100.0

Notes: a Vautier's figures based on supply over the 1949-50 season

b Figure based on the butterfat supplied to the Manawatu C.D.C. on 15.11.70

c Figure based on Manawatu C.D.C. suppliers as at 17.12.70

Source: Vautier, 1956:135
Running sheets and supplier maps from Manawatu C.D.C.

in 1970, all dairy factories appear to have similarly agglomerated supply areas suggesting similar densities of suppliers around each factory.

TABLE XVIII SUPPLIER DISTRIBUTION PATTERNS BY NEAREST NEIGHBOUR ANALYSIS[a]: 1960 TO 1970[b]

Factory and Year	Number of Suppliers	Average Distance Between Nearest Neighbours (yds)	Sq. miles per Supplier[c]	'R'[d]
Awahuri 1960	152	863	11.91	0.2843
Glaxo 1964	144	661	12.57	0.2119
Whangaehu 1964	96	720	18.75	0.1885
Rata 1967	146	741	12.40	0.2393
Glaxo 1970	94	810	19.26	0.2096
M.T.S. 1970	77	1030	23.51	0.2414
Oroua Downs 1970	56	823	32.32	0.1645
Manawatu 1970				
Wholemilk	636	983	2.85	0.4710
Cream	251	1741	7.18	0.7382

Notes: a See Appendix E for derivation of measure, and Appendix G for computational procedures
b Selection of years based on the availability of supplier maps
c Density figure and subsequent calculation of 'R' based on a total area of 1810.07 sq. miles
d The use of a large base area deflates the 'R' value for all supplier patterns except Manawatu. The Manawatu C.D.C. suppliers are spread over most of the total area.

Source: Supplier maps

If the assumption is made that for any given year, the supply area for each factory is the average supply area for all factories, a set of values which are more realistic in terms of the value of 'R' may be obtained. (Table XIX) This assumption, however, tends to inflate the supply area for cheese factories and deflate the area for creameries, which, in turn, deflates 'R' for cheese factories and inflates 'R' for creameries. The figures obtained in this way indicate a degree of randomness much closer to the spatial patterns of the factories. (Table XX) Oroua Downs C.D.C. and Glaxo **milk powder factory** (both for 1970), however, show marked agglomeration.[2]

TABLE XIX SUPPLIER DISTRIBUTION PATTERNS BY NEAREST NEIGHBOUR ANALYSIS WITH ALTERED AREA BASE[a]: 1960 TO 1970[b]

Factory and Year	Area Base (sq. miles)[c]	Square miles per Supplier	'R'
Awahuri 1960	95.3	0.63	1.2385
Glaxo 1964	129.3	0.90	0.7926
Whangaehu 1964	129.3	1.35	0.7050
Rata 1967	164.6	1.13	0.7930
Glaxo 1970	226.2	2.41	0.5934
M.T.S. 1970	226.2	2.94	0.6829
Oroua Downs 1970	226.2	4.04	0.4653

Notes: a Area base altered under the assumption that the supply area for each factory is the average factory supply area as calculated in Table XX
b Selection of years based on the availability of supplier maps
c From Table XX

Source: Supplier maps

Dairy factory distribution may be more easily compared using nearest neighbour techniques. (Appendix E) Table XX indicates a marked trend from 1908 to 1970. The early period (1908 to 1920) is characterised by an agglomeration of factory activity with large numbers of closely-spaced factories. From 1920 to the late 1960's, however, factory distribution tended towards randomness, while from 1970 (including two possible projections) the factories have become agglomerated once again. In contrast with the early period, however, a small number of closely-spaced factories have given rise to this later period of agglomeration. Brooks' (1970) findings for Taranaki (Table XXI) show similar changes. The total areas are similar (1848 sq. miles for Taranaki and 1810 sq. miles for Manawatu) allowing direct comparison. Brooks' 'R' value for 1969, however, was based on an area of 1487 sq. miles. The reworked values, based on the larger area are given in the table in parentheses.

TABLE XX

MANAWATU FACTORY DISTRIBUTION PATTERNS BY NEAREST NEIGHBOUR ANALYSIS: 1908 TO 1971, WITH TWO PROJECTED FIGURES

Year	Average Distance Between Nearest Neighbours (miles)	Average Size of Supply Area (sq. miles)[a]	Average Radius of Supply Area (miles)	'R'
1908	1.82	21.3	2.6	0.7894
1920	2.59	34.8	3.3	0.8784
1940	3.96	67.0	4.6	0.9681
1950	4.52	75.4	4.9	1.0408
1951-52[b]	4.73	82.3	5.1	1.0427
1953-54	4.57	78.7	5.0	1.0312
1955	4.40	75.4	4.9	1.0144
1956	4.70	78.7	5.0	1.0602
1957	4.62	86.2	5.2	0.9948
1958-59	4.71	90.5	5.4	0.9895
1960	5.00	95.3	5.5	1.0259
1961-63	5.27	100.6	5.7	1.0516
1964	5.46	129.3	6.4	0.9607
1965	6.09	150.8	6.9	0.9913
1966-67	6.29	164.6	7.2	0.9809
1968	6.35	181.0	7.6	0.9455
1969	6.43	201.1	8.0	0.9073
1970	6.66	226.2	8.5	0.8856
1971	5.40	301.7	9.8	0.6216
(1)	6.35	452.5	12.0	0.5970
(2)	4.62	603.5	13.9	0.3762

Notes: a Density figure and subsequent calculations of 'R' based on a total area of 1810.07 sq. miles

b Grouped years indicate no change during period

(1) Assumes closure of Westmere and Tokomaru Branches of the Manawatu C.D.C.

(2) Assumes amalgamation and/or closure of the Oroua Downs C.D.C.

Source: <u>Annual List of Creameries</u>, 1908 to 1969
Annual Reports, 1969 to 1971

TABLE XXI

TARANAKI FACTORY DISTRIBUTION PATTERNS BY NEAREST NEIGHBOUR ANALYSIS: 1909, 1949 AND 1969

	Number of Factories	Average Distance Between Nearest Neighbours (miles)	Average Size of Supply Area (sq. miles)	Average Radius of Supply Area (miles)	'R'
Factories and Skimming Stations 1909	153	2.01	12.07	1.96	1.203
South Taranaki 1909	30	2.61	61.60	4.43	0.665
Factories 1940	112	2.65	16.50	2.29	1.274
Factories 1960	40	3.55	37.17	3.15	1.164
((Factories 1969	40	3.55	46.20	3.83	1.045))[a]

Note: a Figures in parentheses use same area base as figures for 1909 and 1949

Source: Brooks, 1970:3. (Average radius of supply area and figures in parentheses calculated from Brooks' figures.)

The technique of nearest neighbour analysis, while providing a useful measure of broad change, does not throw any light on the relationship between supplier and dairy factory. Factory - factory relationships are partly summarised by the assignation of a single value for each year. These values are, however, dependent upon the choice of base area. The analysis is inadequate where linear patterns are evident; in such circumstances 'R' usually approaches unity indicating a random pattern. This is clearly a problem in the Manawatu area where dairy factories and suppliers are located along roads. It would appear that the use of the term "random" is misleading in this regard. King (1962:6) notes, "... the concept of randomness ... might well be disregarded, except for the fact that the value R=1 is a convenient and useful origin from which to measure the tendencies towards an aggregation or uniform spacing...."

It may be concluded that nearest neighbour analysis, while providing a useful basis for further investigation, is not robust enough to stand modification. Its inability to discern important geographic patterns, and the likelihood of bias due to area selection are serious disadvantages. In terms of this study, nearest neighbour analysis does not provide sufficient information for an analysis of relationships in the dairy industry. While this is in part the result of insufficient data, the method of analysis does not lend itself to overcoming these insufficiencies. For these reasons, an investigation was made into the use of the gravity model. This led to the development of centrality measures which largely enabled data limitations to be overcome and the analysis of inter-relationships to be furthered. The development, results and interpretations of centrality analysis are presented in the following chapter.

Notes

1 Supplier maps were obtained for Awahuri C.D.C., 1960, Whangaehu C.D.C. and Glaxo milk powder factory, 1964, and Rata C.D.C., 1965. A map for Rangitikei C.D.C. proved to be incomplete and was not used. Maps for Manawatu C.D.C., Oroua Downs C.D.C., Glaxo milk powder factory and the Milk Producers' Company were constructed for December, 1970 from maps and supplier lists held by the companies concerned.

2 Figures for the Manawatu C.D.C. have been omitted as suppliers to this company are spread over most of the area being considered.

CHAPTER EIGHT

AREAL ASSOCIATION BETWEEN SUPPLIERS AND FACTORIES

(Centrality Analysis)

The application of central tendency measures arose out of the inadequacies of nearest neighbour analysis and its inability to specify fully the inter-relationships between supplier and dairy factory. Of the three measures used (see Appendix F for the derivation of potential, and median and mean centres), potential was selected for further manipulation in order to show supplier - factory relationships more clearly. The median and mean centres have served to elaborate the general patterns indicated by potential analysis.

Potential is an expression of population per unit distance and is, therefore, little affected by extremes within the population. In this study it is expressed as suppliers or factories per mile and is termed "supplier potential" or "factory potential". Although potential is not a true measure of population density, the research of others, notably Stewart and Warntz, indicates that the peak value of potential is an adequate approximation of maximum density.[1] Measures of potential have been variously interpreted as "the intensity of the possibility of interaction" (Carrothers, 1956:96), as the degree of accessibility to a given point (Harris, 1954:321), and as the "hub of socio-economic activity" (Neft, 1966:35). For the purposes of this study, potential is interpreted in terms of its substitution for supplier density. The expressions of interaction have important implications for the inter-relationships between factories. Relationships between supplier potential and factory potential are conditioned by the degree of accessibility between suppliers and dairy factories. This is not to suggest that all interpretations of potential are equally applicable. Rather, the various aspects of the inter-relationship problem may best be considered in terms of the several related interpretations of the potential model.

The median centre possesses the important property that its minimum value is the point of minimum aggregate travel distance. That is, all suppliers could be assembled at the median centre with the minimum total travel. As such, the median centre may be considered as a theoretical optimal location point for a factory.[2] The minimum value of the mean centre, on the other hand, has little intrinsic value. A high sensitivity to changes in the location and distribution of suppliers, however, endows this measure with its most useful property for this study by enabling changes over time to be readily summarised.

An important property of each of the three measures is that they are areally continuous. As such they may be plotted as iso-lines to give a continuous map surface. It is usual to treat potential in this manner as, as has been noted, potential gives an approximation of population density.

The utilisation of centrality measures overcomes the disadvantage of bias associated with area selection. These measures are independent of the area chosen for study. The central points of each measure usually lie within the area being studied. Neft (1966) notes that while the peak of potential must always lie within the area, median and mean centres may lie outside certain odd-shaped areas. This feature presents no problem for the present study.

Against these advantages are problems in applying centrality measures to the available data. The primary level of generalisation arises in placing data within a grid to facilitate calculation. A grid of 5000 yards was used, giving an area for each cell of 8.07 square miles. The central point of each cell was taken as the location point of all items within that cell. While detailed locations of each item could have been used (the additional time for calculation would have been considerable), this level of generalisation was considered acceptable.

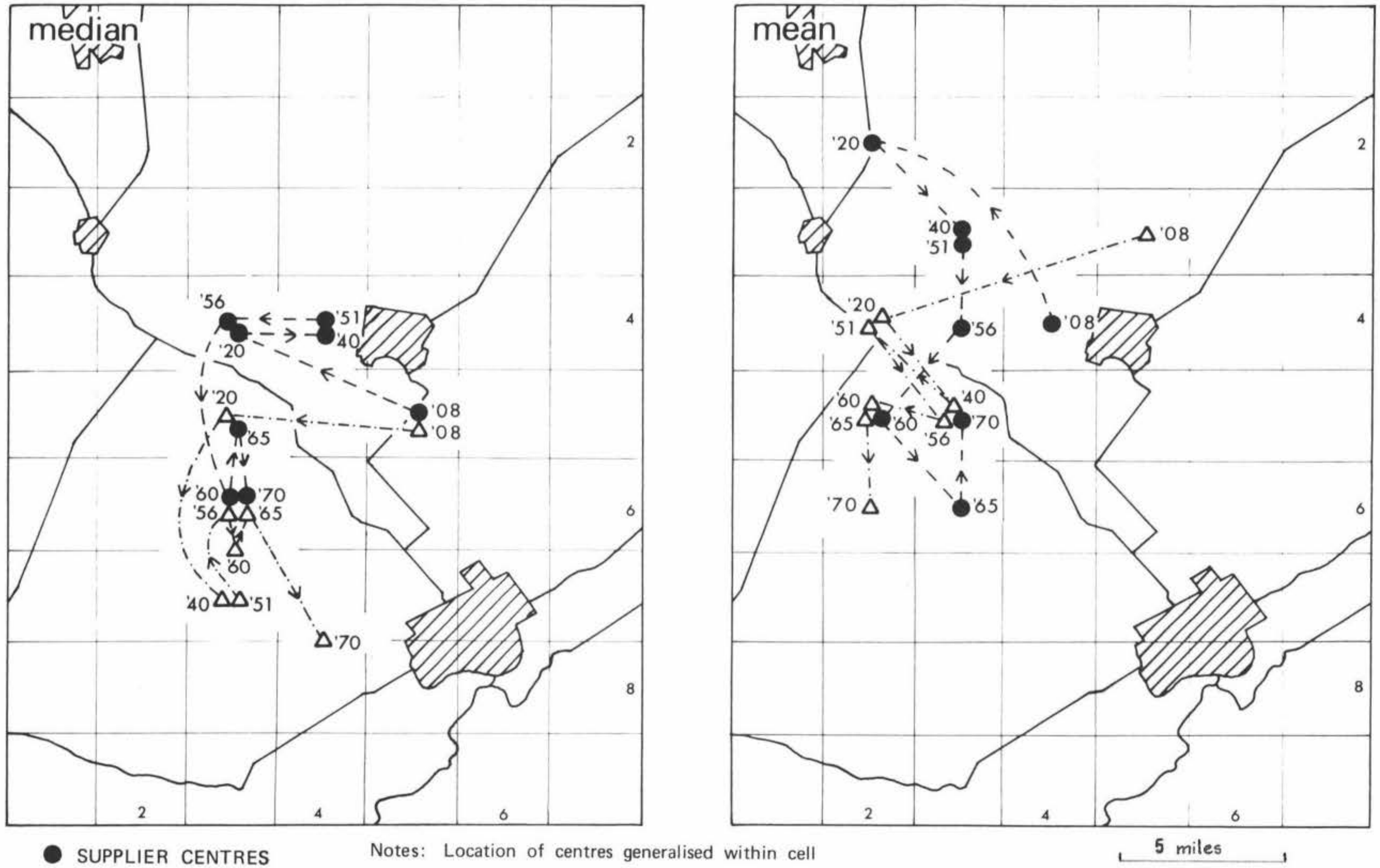
For all periods prior to 1970, however, the assumption has been made that the factory site (generalised to the mid-point of the cell in which it lies) is an adequate summary location of the suppliers to that factory. In an attempt to substantiate this assumption, potential, median and mean centres were calculated for the available supplier maps. It was found that the average distance deviation between the factories and the central points was 4600 yards. As this is less than the cell dimension, the assumption has been accepted as being within the bounds of reasonable error.

The assumption is supported for the period before c.1920 by reference to the transport constraints of that time. As has been suggested previously, the distance from a collection centre to its most distant supplier was not great. Supply areas would have tended to have been compact and the collection centres could be taken as adequate summary locations. For the 1908 potential calculations, suppliers to creameries have been apportioned equally to each creamery and its associated skimming stations. (A total figure only is given in the <u>Annual List of Creameries</u>.)

For the period between 1920 and 1950 there is no tangible evidence to support the assumption. Cheese factories and smaller creameries probably provide adequate summary locations. Large creameries such as the New Zealand Farmers' Dairy Union, Maoriland, and the Wanganui Fresh Food and Ice Co., each with large numbers of suppliers, may have had "skewed" supply areas. The use of these factory sites for supplier location has undoubtedly introduced error to the results for this period.

Centrality measures were calculated for the years 1908, 1920, 1940, 1951, 1956, 1960, 1965 and 1970. (Appendix G) Figure 9 shows the changes in the locations of the median and mean centres from 1908 to 1970. Given the degree of generalisation both in assembling the data for computation and in presenting the results graphically,[3] the amount of movement of the centres is remarkably limited. The strong north-west shift of the supplier mean centre in 1920 may be attributed to a high concentration of suppliers in the Wanganui area at that time, while the general southerly movement of both measures over the whole period is the result of declining numbers of factories and suppliers in the north of the Manawatu area.

The lack of convergence between supplier and factory median centres for any one year suggests that in aggregate terms, factories are poorly located with respect to suppliers. Individual factories, however, may be better located with respect to their own suppliers. (page 86) Further consideration of the suppliers to the Manawatu C.D.C. provides an interesting comparison. Supplier potential, median and mean centres for all suppliers and for wholemilk suppliers are in the north-west quadrant some six miles from the Longburn factory which, in terms of the errors incurred in straight-line measurement and the levels of generalisation, is not a great distance. For cream fig. 9 FACTORY AND SUPPLIER MEDIAN AND MEAN CENTRES, 1908 TO 1970



Notes: Location of centres generalised within cell

Supplier median centre, as point of minimum aggregate travel distance, is a theoretical optimal location for factory to serve all suppliers

R.E.W.

suppliers, however, the centrality points are approximately 18 miles from the Longburn factory but only 4 miles from the recently-closed Rangitikei (Bulls) creamery.

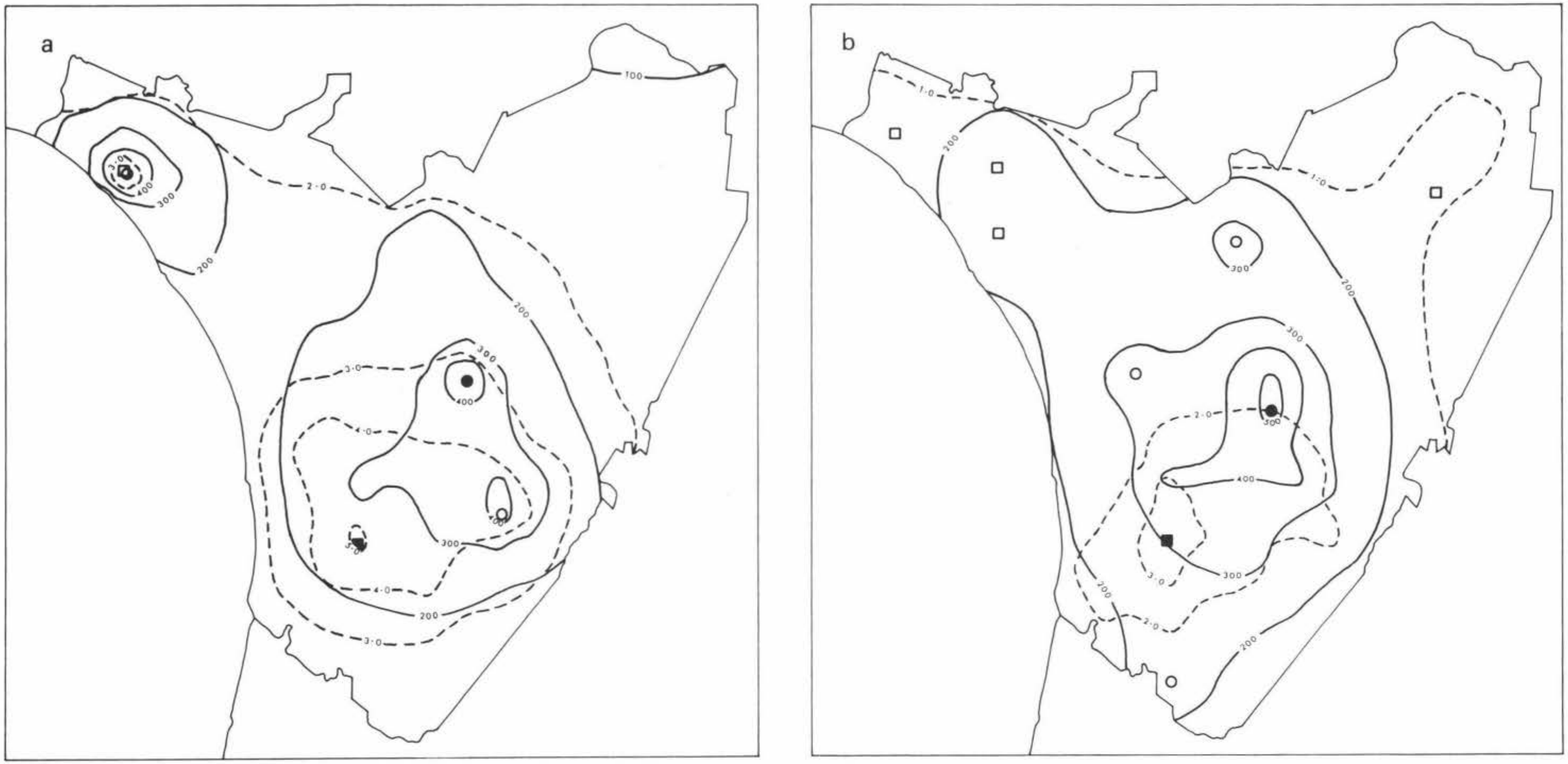
A consideration of potential alone provides a view of change over time. Figure 10 shows factory and supplier potential for selected years between 1920 and 1970. From these maps it can be seen that the peaks of potential for both suppliers and factories have remained relatively static over this time period. It can be assumed, therefore, that the areas of maximum supplier and factory density have also remained relatively static. The decline in potential values (Table XXII) suggests a decline in overall supplier and factory density. In view of the declining numbers of suppliers and factories in the Manawatu area, this trend is not unexpected.

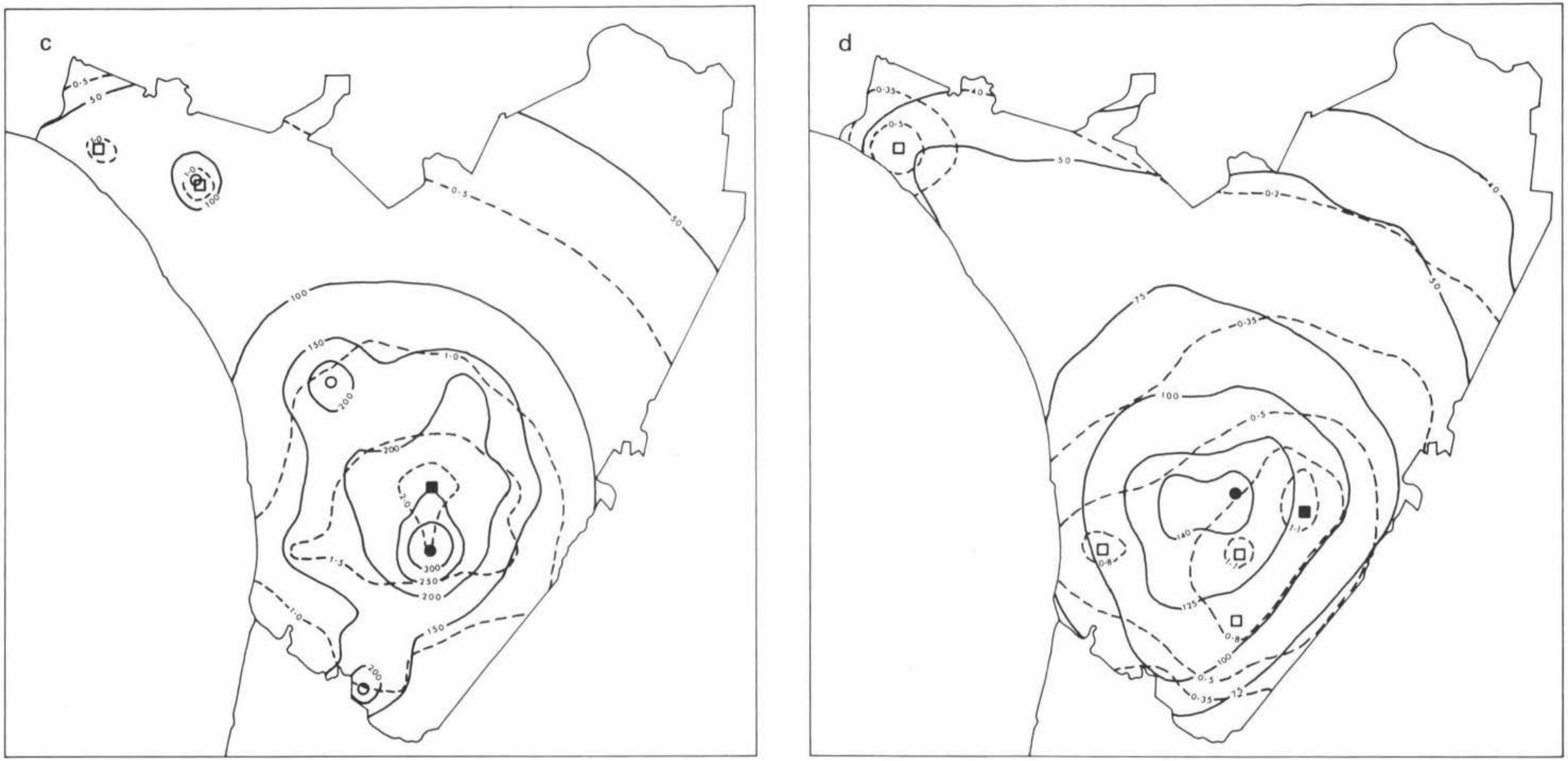
TABLE XXII PEAK VALUES OF FACTORY AND SUPPLIER POTENTIAL: 1908 TO 1970

Year	Supplier Potential (suppliers per mile)	Factory Potential (factories per mile)
1908	208	10.8[a]
1920	433	5.1
1940	575	4.2
1950	551	3.8
1956	439	3.4
1960	277	2.9
1965	379	2.6
1970	147	1.3

Notes: a estimated

The association between factories and suppliers can be measured by correlating the two continuous surfaces of factory and supplier potential. (Appendix G) Neft (1966:128) describes the so fig.10 FACTORY AND SUPPLIER POTENTIAL, 1920 TO 1970





ISOLINES OF POTENTIAL

- - - factories per mile
—— suppliers per mile

MAJOR POTENTIAL PEAKS

■ factories
● suppliers

MINOR POTENTIAL PEAKS

□ factories
○ suppliers

a 1920
b 1950
c 1965
d 1970

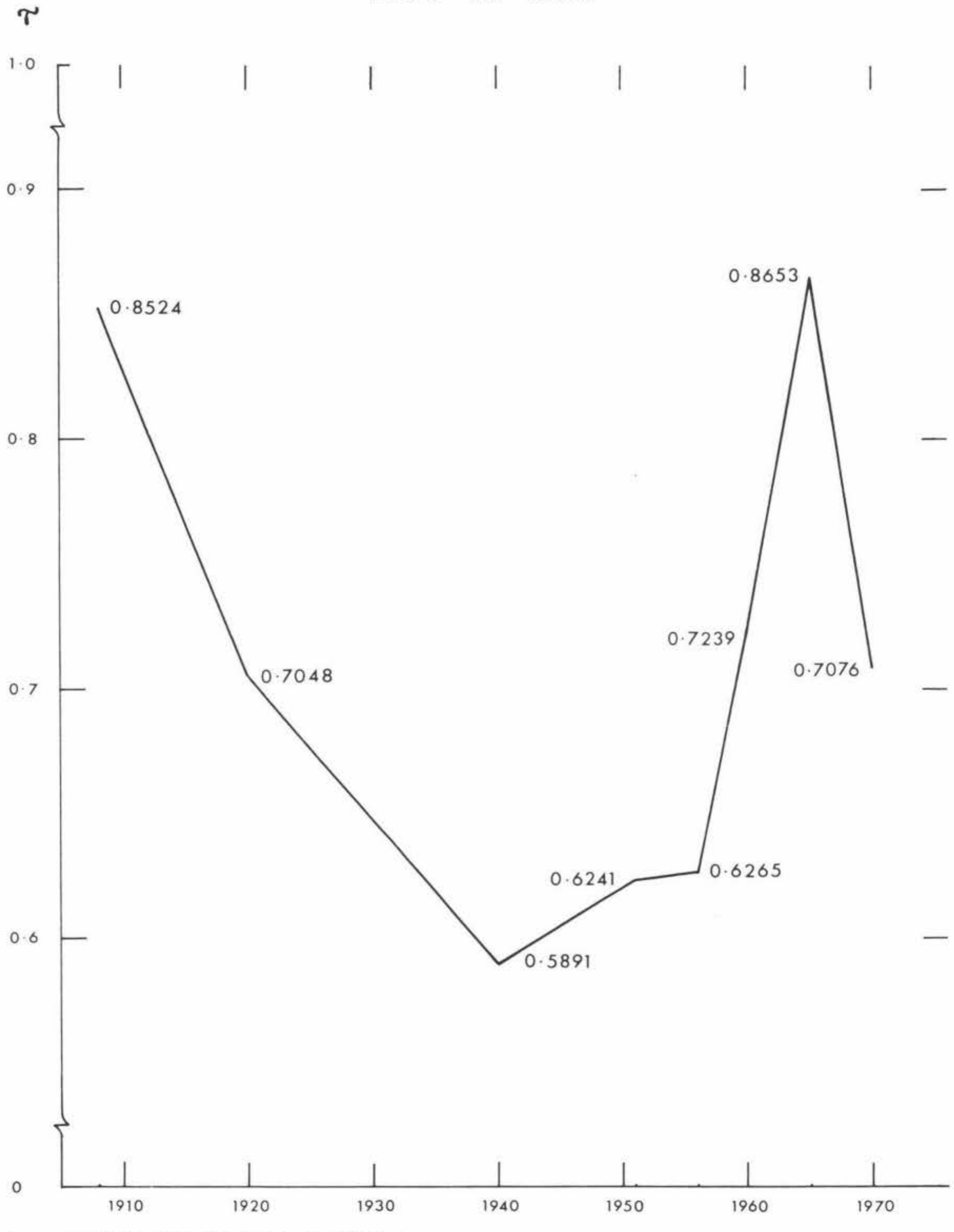
R.E.W.

derived measure as the "population coefficient of areal association."[4] As areal association cannot be readily visualised from the map surfaces (fig. 10), coefficients of areal association from 1908 to 1970 are presented in diagramatic form. (fig. 11)

The coefficients of association are high. Although the overall decline in association between 1908 and 1970 was expected in view of the changing nature of the relationships between supplier and factory management, the pronounced 'U' shape presents problems for interpretation.

There is a strong possibility that a decline in association represents a diseconomy in the dairy industry, particularly with respect to the transport relationships between supplier and factory. The peak of the "creamery system" is represented by the patterns of 1908.[5] As suppliers delivered their own wholemilk and cream to the factory or skimming station it could be expected that individuals would keep their transport to a minimum and that suppliers and factories would be in close association.

Between World War I and World War II, the industry in the Manawatu was characterised by a proliferation of small-scale factories and an increase in competition for supply. The latter was facilitated by the adoption of motorised transport for the cartage of cream. While it has been suggested that motorisation (coupled with home separation) was an innovation which reduced the obstacle of distance, it is clear from Figure 11 that motorisation did not result in higher areal association. By the mid 1930's competition for supply was acute and a commission was called to make an economic survey "with the object of eliminating overlapping or any other disabilities under which dairy companies are working...." (Frazer, 1936:3) Transport inefficiency fig. 11 COEFFICIENTS OF AREAL ASSOCIATION, 1908 TO 1970



(τ = Kendall's Rank Correlation Coefficient)

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associated with overlapping supply areas is not a sufficient explanation for the low value of areal association for 1940, although it may be argued that it is a symptomatic condition of the lower areal association between suppliers and factories.

During World War II, rationing of rubber for tyres and of petrol resulted in the zoning of supply areas on a more rational basis. In addition, the period was characterised by the closure of small-scale factories. The net effect can be seen in the slight increase in areal association between 1940 and 1955.

The introduction of tanker collection from the 1950's has been accompanied by a marked increase in areal association. This trend may be partly explained in terms of amalgamation of companies and the associated closure of uneconomic factories. It has been argued that tanker transport has enabled amalgamations to be undertaken; as a result, company management has been provided with the opportunity to locate its major processing units with regard for the distribution of suppliers.[6] The general absence of such activities since the mid 1960's may account for the decline in areal association by 1970.

If the 1940 to 1955 period, and 1965 are taken as major turning points in the degree of areal association, the position of transport technology becomes clearer. (Although 1940 is the actual turning point, it is believed that this change was strongly influenced by the unusual conditions of a war-time economy. This assumption is supported by the minor change between 1950 and 1955 and the more rapid change between 1955 and 1960 when the return to 'normal' conditions had been achieved.) It can be postulated on the evidence presented that where transport technology is relatively stable and in a stage of consolidation, the degree of areal association between factories and suppliers will decline. The introduction of a new transport technology will, on the other hand, lead to a rapid increase in association. During the periods of transport stability, a variety of non-transport variables are free to operate, their major influence being to alter the distribution of suppliers with respect to factories. Tanker collection, as a major transport innovation, has facilitated a rationalisation of factory organisation (amalgamation is an important aspect of this rationalisation), the effect of these changes being a closer areal association between suppliers and factories. Most recently, however, association has declined in the face of changing supplier distribution with respect to factories.

Notes

1 Stewart and Warntz (1958b:111-3) note with respect to population in England and Wales that "the density of population in rural districts ... was found to be equal to 55.55×10^{-10} times potential of population to the second power." (Density was measured in persons per sq. mile and potential in persons per mile.) They noted further that the least squares coefficient for this relationship was $r = 0.70$.

2 Other criteria, particularly the availability of suitable building sites, would have an important influence on the location decision.

3 The computer printout was generalised to the same degree as the input data. Thus the location of the minimum value of median and mean has been taken as the midpoint of the cell in which it lies. It is considered that movements of less than 10,000 yards are of little significance. Finer detail could have been achieved with a finer grid size but this would have involved a considerable escalation of computer time.

4 Although Neft (1966) suggests that the parametric product moment formula is usually the most satisfactory method of correlation, Kendall's coefficient has been used in the present study. As it was not practicable to make limiting assumptions about the nature of the population, and as all that was required was a simple measure of correlation (the total population was used) for comparison over time, Kendall's coefficient was selected as the most appropriate. (Appendix G)

5 The Annual List of Creameries show 1907 to 1909 as the years with the greatest number of skimming stations. This is generally taken as the criteria for the rise and decline of the "Creamery system".

6 See 2 above.

CHAPTER NINE

CONCLUSION

In the introduction (page 4) it was suggested that obstacles to the movement of dairy products from farm to factory, from factory to port, and from New Zealand to her overseas markets were impediments to the progress of the dairy industry. The overcoming of these obstacles by a series of transport innovations has, however, facilitated more rapid development. The ensuing changes in the spatial organisation of dairy factories, and in factory - supplier relationships, have been discussed at length in order to demonstrate the importance of transport and the effects of changing transport technology.

Prior to the 1880's self-sufficiency was an important motivation for pioneering farming activity. Dairying tended to be little more than a subsistence activity, an "adjunct to the household" (page 10), with small irregular surpluses being disposed of on the local market. Internal transport difficulties limited the distance dairy products could be transported, while inadequate storage facilities on board ships hampered the export of any surplus dairy produce. Despite these difficulties, quantities of New Zealand butter and cheese were landed on Australian and English markets before the 1880's. (Table I) The small scale of dairying meant that it was a widely dispersed activity and that there was little regional specialisation.

The adoption of refrigeration after the 1880's enabled dairy produce to be preserved reliably during the voyage to distant markets. The effect of refrigeration was to reduce the obstacle of distance and thus increase the effective overseas demand. Despite the provision of refrigerated wagons on New Zealand railways and cooling facilities on coastal vessels, internal transport remained unreliable and difficult as far as the transport of dairy produce was concerned. Increased demand led to the expansion of the early "factory-type" manufacturing (page 11) while restricted internal transport influenced the regional specialisation in dairying and localisation of butter or cheese manufacture. The "creamery system" was partly a response to the need for greater quantities of both wholemilk and cream in order to expand production. In general, the major response to the new conditions was a growth in the number of creameries and associated skimming stations (page 21) and, in some areas, the rapid growth in the number of cheese factories.

By World War I a system of relatively closely-spaced cheese factories and of more-dispersed creameries had been developed, while localised activity and regional specialisation was becoming increasingly apparent. There was a close spatial relationship between supplier and factory. The constraints on transport limited the distance between supplier and factory to about four miles. (Table XX) Variations in cow density added to the influence of transport, producing localised specialisation in butter or cheese production, and subsequently, distinctive landscape patterns.

From the 1920's, motorised transport was adopted for the transport of cream and wholemilk. For creameries in particular, the restrictions of distance imposed by horse-drawn transport no longer applied and the need for skimming stations was lessened.

Home separation was adopted on an increasingly wider scale from about the same time. Together with motorisation, this innovation eliminated the need for skimming stations and enabled creameries to expand their potential area of operation. (page 33) Whereas previously there had been close daily contact between supplier and factory, extended range of operation meant increased competition for supply and a lessening of personal contact. (pages 36-37)

By the end of World War II, internal and external restrictions on transport were largely eliminated. The increasing desire for economies of scale led to the closing of uneconomic factories and an increase in the average size of those remaining. It was soon found, however, that the increases in volumes of milk and cream to be transported imposed additional burdens on existing transport methods. Further, in order to gain the maximum benefit from larger scale operation it was necessary to increase by-product processing. Existing methods of transport were inadequate for assembling sufficient quantities of by-products for further processing.

The adoption of tanker vehicles enabled dairy companies to transport wholemilk and milk by-products economically. Sufficient quantities of by-products could be assembled for further processing leading to a rationalisation of wholemilk utilisation. (page 54)

Each of these major transport innovations (refrigeration, motorisation and home separation, and tanker transport) have had important implications for the spatial organisation of dairy factories and suppliers and for the relationships between factories and suppliers. By reducing the obstacles of distance, these transport innovations have facilitated the development of larger scale processing units and company organisation with attendant economies. It has been argued, therefore, that the move from a large number of small-scale factories producing a relatively limited range of dairy products to a smaller number of larger scale factories producing a greater range of products could not have been achieved without tanker transport.

Changes in the spatial organisation of dairy factories resulting from transport innovation are described in Part II from two viewpoints. Physical distance between supplier and factory and between factories are described in terms of distribution while nearest neighbour analysis was employed to specify the nature of the distribution. While both methods have limitations they provide useful information. From the analysis of distribution, the suggestion of increasing average distance between supplier and factory is supported. Nearest neighbour analysis adds support to this suggestion and also to the claim that the average distance from supplier to factory before motorisation was less than about four miles.

Nearest neighbour analysis has established a broad pattern of changing spatial organisation of factories over time. Although there are limitations in the method, and the changes observed are small, the overall trend clearly suggests a return to agglomeration of factories since tanker collection. In addition, there has been an associated series of factory closures and company amalgamations.

The application of centrality analysis has provided two further methods of examining change. Because the potential surfaces are approximations of supplier and factory density, changes in potential over time may be used to deduce changes in supplier and factory distribution. It was noted (page 87) that there had been relatively little change in the location of the peak of potential although its value had declined. This would appear to indicate little change in the spatial pattern of density but a decline in the values of supplier and factory density.

Correlation of supplier and factory potential gives a second measure of change. The derived measure, areal association, indicates that during periods of relative transport stability (i.e. few transport innovations of a major nature) the relationships between supplier and factory decline. Periods of active innovation, however, present opportunities for factory management to reorient factories with respect to the location of suppliers and thus increase the areal association between factory and suppliers.

Although the working hypothesis (pages 6 and 68) is an over-simplification it would appear to be basically valid. It is concluded from Part II that there is an inverse relationship between transport technology and the spatial association between supplier and factory. From Part I it may be concluded that variations in the personal interaction between supplier and factory is related to variations in the ease and frequency of contact between the two and that this contact is conditioned by transport technology. As spatial association is also conditioned by transport technology it may be concluded that spatial and personal interaction are related. It is probable that where there is a high spatial association the opportunities for personal interaction will be greatest. The implications of this are summarised in figure 8. (page 62)

Although these conclusions are of a general nature and are subject to the restraints of the initial assumptions, it is considered that further study and refinement of the measures and the analysis would support these conclusions.

APPENDICES

APPENDIX A

BUTTER AND CHEESE MAKING

1 Butter Making

Wholemilk was set aside in large shallow pans for the cream to rise to the surface, a process taking from 24 to 48 hours. The cream was skimmed off and set aside until sufficient had been collected for churning. Meanwhile, the skimmed milk was either fed to the pigs or thrown away. Churning was undertaken as the need arose, perhaps two or three times a week. The butter was then kneaded to work in the salt and eliminate as much of the buttermilk as possible. Wooden paddles, or butter pats, were then used to shape the butter. It was then cooled in a nearby stream or the cellar before consumption. The time taken to churn the butter varied considerably depending on the sourness of the cream, its temperature, and the enthusiasm of the churn operator. Variations in the quality of the butter were consequent upon its churning and the elimination of the buttermilk.

2 Cheese Making

Wholemilk was strained into the cheese vat and kept at a temperature of about 90°F to allow "ripening" and the development of acidity. Once the correct acidity had been achieved, rennet (usually home made) was added to coagulate the milk to form the curd, a process taking about an hour. The whey was run off and the curd cut into cubes and raked to a knobbley consistency. It was then scalded and cooked, this process being followed by salting, pressing, and, finally, curing. Cheese was much more durable than butter and could be stored for longer periods providing it had been well made and was not exposed to undue warmth. It was, however, much more difficult to make than butter.

APPENDIX B

THE GROWTH OF CO-OPERATIVES

Although the first dairy factory in New Zealand at Springfield on the Otago Peninsula (established in 1871) was of a co-operative type based on Irish and Scandanavian examples, most of the later factories were opened and operated by proprietary interests. Improved access to overseas markets after the 1880's provided a strong incentive for the expansion of the factory system of manufacture. The New Zealand Government saw advantages in the factory manufacture of butter and cheese when, in 1881, it offered £500 for the first 25 tons of butter or 50 tons of cheese landed on an overseas market and having been manufactured by the factory system. The Edendale factory took the prize in 1882. Although the Edendale factory was initially owned by the New Zealand and Australia Land Company, it was always envisaged as a co-operative concern and became a co-operative company in 1903. (Wilson, 1961)

As dairying spread, the need for factories increased. In a country poor in capital resources, and in capitalists, the only way to raise sufficient capital for dairy factory development was from the suppliers themselves. Groups of farmers acted together and set up new factories or purchased existing ones. In some instances skimming stations were purchased and converted for the factory production of butter or cheese. The suppliers were paid for their milk and participated at the end of the season in any profits; the basis of participation being initially the number of cows owned and later by the pounds of butterfat supplied during the season.

By 1903, co-operatives were as numerous as proprietary concerns, and by 1919 over 80 percent of all dairy factories were co-operatively owned. (Table B I) By 1935 the figure was over 93 percent. (Philpott, 1937:397)

TABLE B I GROWTH OF CO-OPERATIVES IN NEW ZEALAND: 1894 TO 1934

Year	CREAMERIES Proprie-tary	Co-op-erative	% Co-op	CHEESE FACTORIES Proprie-tary	Co-op-erative	% Co-op	TOTAL % Co-op
1894	59	23	39	17	25	60	39
1899	94	64	41	35	47	57	46
1904	103	114	53	28	50	64	56
1909	67	126	65	52	100	66	66
1914	47	134	74	86	207	71	72
1919	36	123	77	35	353	91	87
1924	46	174	79	16	343	96	89
1929	31	186	86	11	325	96	92
1934	24	171	88	10	309	94	93

Source: Annual List of Creameries, 1894 to 1934

The principal advantage of co-operative ownership of factories was that suppliers were encouraged by self interest to ensure that the finest butter was produced, and this meant that they were obliged to supply the best milk possible to the skimming station. McCallum (1888:6) noted, "I consider the factories could be better worked on the co-operative principle than on any other. ... It would be in the interest of everyone connected with the factory to make the concern pay." Scholefield (1909:144) noted the main advantage to be with obtaining the best machinery and the employment of the most skilful managers, and also in the production of a large quantity of uniform quality product.

APPENDIX C

DISTANCE MEASUREMENT

Both road-miles and air-miles have been used for the measurement of distance. For the distribution of suppliers by distance from the dairy factory, road-miles have been used. The actual distance wholemilk or cream must be carted is an important feature of what is essentially a transport problem. Table XVII of Chapter Seven (page 77) is based on road-mile distances. It has been assumed that the data from Vautier's (1956) work was also based on road-mile measurement although he makes no reference to this.

Differences between road- and air-miles are considerable (Table C I) and may be attributed to the rivers which have relatively few bridging points (especially the Manawatu and Rangitikei Rivers and the Oroua River below Feilding).

Distances for nearest neighbour and centrality analysis have been based on air-miles. Both of these measures of spatial distributions are independent of road distances. Their implications for transport, however, suggest that road-mile measurement would be an additional refinement, particularly with regard to areal association between factories and suppliers. Air-mile measurement was used for nearest neighbour analysis in order that the results would be comparable to those gained by Brooks (1970) in his study of dairying in the Taranaki. With regard to the centrality analysis, the use of air-miles was necessary because of constraints imposed by the computing system.

TABLE C I DISTANCE DISTRIBUTION OF 683 SUPPLIERS[a] BY ROAD-MILES AND AIR-MILES FROM THE LONGBURN FACTORY

Distance from Factory(miles)	Numbers of Suppliers by Road Miles	Numbers of Suppliers by Air Miles	Percentage of Suppliers by Road Miles	Percentage of Suppliers by Air Miles
0-1[b]	2	5	0.3	0.7
1-2[c]	8	6	1.2	0.9
2-3	3	15	0.4	2.2
3-4	13	28	1.9	4.1
4-5	6	23	0.9	3.4
5-6	9	30	1.3	4.4
6-7	18	62	2.6	9.1
7-8	23	68	3.4	9.9
8-9	42	44	6.1	6.4
9-10	43	36	6.3	5.3
10-11	57	39	8.3	5.7
11-12	53	69	7.8	10.1
12-13	60	49	8.8	7.2
13-14	55	42	8.1	6.1
14-15	39	34	5.7	5.0
15-16	44	30	6.4	4.4
16-17	34	18	5.0	2.6
17-18	25	25	3.7	3.7
18-19	18	10	2.6	1.5
19-20	17	8	2.5	1.2
20-21	28	6	4.1	0.9
21-22	16	13	2.3	1.9
22-23	7	14	1.0	2.0
23-24	9	5	1.3	0.7
24-25	11	4	1.6	0.6
25-26	10	0	1.5	0
26-27	9	0	1.3	0
27-28	10	0	1.5	0
28-29	8	0	1.2	0
29-30	6	0	0.9	0
	683	683	100.0	100.0

Notes: a All are suppliers to the Manawatu C.D.C. as at 17.12.70

b Read "less than one"

c Read "one, less than two" etc.

Source: Supplier Maps, Manawatu C.D.C.

APPENDIX D

DATA LIMITATIONS

Data for the chapters in Part II has been limited both in time and in spatial coverage. In many cases, particularly before 1950, the location of factory sites has been generalised to the locality in which they are known to have existed. In some instances (mainly with pre-1920 data) even this has not been possible requiring the omission of the factory from the study.

The major sources of data have been the Annual List of Creameries and Annual Reports of dairy companies. The Annual List of Creameries gives a consistent presentation of the numbers of cheese factories, creameries, skimming stations and other factories from 1894. It must be noted, however, that while these lists are consistent within themselves, they are often at variance with other records of factory numbers and supplier totals. Although there is a gap in these records as held at Massey University from 1910 to 1919, they have been a most detailed and useful reference.

Annual Reports for dairy companies have provided additional detail for the Manawatu area, particularly for the period since 1950. Unfortunately these records, held in the files of the Department of Agriculture (Palmerston North), do not cover the period before 1950 in any detail.

Company reports, minute books, share registers, and supplier maps have been a supplementary source. Their incomplete coverage of companies, and the fact that many years are not represented means that their value is limited.

These data limitations have encouraged the use of methods most suited to overcoming the limitations. The measures of centrality have been based on data in the Annual List of Creameries for all years except 1970 when detailed supplier maps have been used.

APPENDIX E

DERIVATION AND USE OF NEAREST NEIGHBOUR ANALYSIS

Nearest neighbour analysis was developed by Clark and Evans to estimate the number and character of plant populations on the basis of a random selection. They define the nearest neighbour statistic 'R' as "a measure of the manner and degree to which the distribution of individuals in a population on a given area departs from that of a random distribution." (Clark and Evans, 1954:446) The measure is defined as:

$$'R' = \frac{\bar{r}A}{\bar{r}E} = \frac{\frac{\sum r}{N}}{\frac{1}{2\sqrt{\rho}}}$$

where 'R' is the nearest neighbour statistic

$\sum r$ is the sum of distances between nearest neighbours of the population in specified units of measurement

N is the number of individuals in the population

ρ is the density of the observed distribution in the same specified units of measurement as for r

$\bar{r}A$ is the mean of the distances between nearest neighbours

$\bar{r}E$ is the mean distance between nearest neighbours expected in an infinitely large random distribution of density rho

The range of 'R' is from 0 to 2.1491 and is interpreted as:

0	total aggregation of the population
1	random distribution
2.1491	maximum dispersion of the population

King used nearest neighbour analysis to give a quantitative expression to settlement patterns and concluded that the statistic was "sufficiently sensitive in character to point up differences which do exist between various distribution patterns." (King, 1962:7)

The validity of nearest neighbour analysis in testing the hypothesis that a distribution has a specific, non-random pattern generalised by non-random variables is questioned by Dacey. He states, "If there is a reason to believe that the factors generating the point distribution are not random variables, as is the case with the hexagonal distribution of cities derived from central place theory, nearest neighbour methods are not applicable." (Dacey, 1960:82) An important limitation of the measure is its dependence on a selected base area. Both Dacey (1963:505) and Clark and Evans (1954:446-7) note this problem, suggesting that care should be taken in the selection of the study area to prevent bias in the final results.

The use of 'R' in this study has been aimed at detecting <u>change</u> in the spatial organisation of suppliers and factories and to arrive at comparable figures for the Manawatu area as have been presented by Brooks (1970) for Taranaki. The criticisms levelled by Dacey (1960) and King (1962) lead one to be circumspect of the values of 'R'. For the purpose of comparison, however, the values are useful. Further, the intermediate values obtained, rA, ρ, and $\frac{1}{\rho}$, are of use in explaining the features associated with the distribution of suppliers and factories in the Manawatu area.

APPENDIX F

DERIVATION OF CENTRALITY MEASURES

Centrality measures (potential, median centre and mean centre) have been derived from two sources, Newtonian Physics and physical "moments". Both derivations are presented here, although greater emphasis is given to the second, more rigorous, method.

J.Q. Stewart defined demographic force, a direct analogy from Newtonian Physics, as:

$$F = \frac{G\ P_i P_j}{d_{ij}^2}$$

where G is a constant

P_i, P_j are the populations of cities i and j

d_{ij} is the distance between cities i and j

Stewart also defined demographic energy and demographic potential, the latter as:

$${}_iV_j = G \frac{P_j}{d_{ij}}$$

This expression gives the potential created by i on j. The total potential created on i by all of a number of j is expressed as:

$${}_iV = G \sum_{j=1}^{n} \frac{P_j}{d_{ij}}$$

Defined in this way, potential is a measure of the "influence each place exerts on all other places and that in this sense [is a measure of] the proximity of a place to all other places." (Olsson, 1965:45)

Potential, median centre and mean centre have been derived from the physical concept of moments by D.S. Neft.[1] He defines the n^{th} areal moment as $\int_A s.dA$ where s is the perpendicular distance from the reference axis to the element of area dA. An analogy is drawn with the n^{th} statistical moment[2] to show that the value of the n^{th} areal moment (M'n) at a point j is:

$$jM'n = \frac{\sum_{x=1}^{P} r_{jx}^{n}}{P}$$

where r_{jx} is the distance between j and the location of a member of a population x

P is the number of items in the population

From this it can be shown that:

1 Potential, $$V_i = \sum_{j=1}^{N} \left(\frac{P_j}{d_{ij}} \right)$$

2 Median, $$MD_i = \sum_{j=1}^{N} \left(P_j d_{ij} \right)$$

3 Mean, $$ME_1 = \sum_{j=1}^{N} \left(P_j d_{ij}^2 \right)$$

These measures correspond to the inverse first, the first and the second areal moments.

The properties of each measure are discussed on pages 84-86. It should be noted in addition that the location of $\sqrt[n]{M'n}$ is a measure of average position. When $n > 0$, the average position or point of centrality is where M'n = MINIMUM. When $n < 0$, the point of centrality is where M'n = MAXIMUM. Also, where $n < 0$, the point must be in the area under study. This location must also correspond to the area where the density of the population is high in relation to the density over the rest of the area.

Neft (1966:20) notes that "since j can be any one of the infinite number of points comprising an area, these moments are areally continuous variables. ... If values of an areal moment are computed for a large number of points, a map of the area can be drawn showing iso-lines connecting points of equal value."

For a more detailed discussion of the derivation of areal moments the reader should consult Neft, D.S., 1966, Statistical Analysis for Areal Distributions. This volume contains a bibliography of some 126 titles relating to areal distribution and areal association.

Notes

1 The physical moment is defined as the product of a force times the perpendicular distance between the line of application and the axis of rotation.

2 The n^{th} statistical moment may be defined as $\frac{\sum f(d^n)}{N}$,

where f is the class frequency (force), d is the deviation between a given point and all the class mid-values (distance) and N is the number of observations.

APPENDIX G

COMPUTATIONAL PROCEDURES

1 Nearest Neighbour Analysis

The formula used was:

$$'R' = \frac{\frac{\sum r}{N}}{\frac{1}{2\sqrt{\rho}}}$$

Measurements of r, the distance between nearest neighbours, were taken as air-mile distances. For some tables it was found convenient to present the average distances between nearest neighbours in yards.

Calculation of rho was based on a total area of 1810.07 square miles, this being the extent of the area as defined. (see Part I Introduction)

2 Centrality Analysis

The formulae used were:

1 $$V_i = \sum_{j=1}^{N} \left(\frac{P_j}{d_{ij}} \right)$$

2 $$MD_i = \sum_{j=1}^{N} \left(P_j d_{ij} \right)$$

$$3 \qquad ME_i = \sum_{j=1}^{N} \left(P_i d_{ij}^2 \right)$$

A program was written for the IBM 1130 computing system.

The basic data was in grid form, the total grid having a dimension of 22 by 22 in units of 5000 yards. V_i, MD_i and ME_i were calculated for all cells but those values lying outside the Manawatu area were ignored. (In terms of the model, a cell having a zero population creates no potential but it will have potential created upon it.) These values were used to construct a 'contour' map and were used also as input data to determine areal association.

3 Areal Association

The Kendall Rank Correlation Coefficient was used in favour of product moment and Spearman's coefficient. (See note 4, page 96) All relevant values of V_i were used thus eliminating the problems associated with sampling.

APPENDIX H

TABLE H I DAIRY PRODUCTION STATISTICS: 1884 TO 1969

Year	Creameries (1)	Cheese Factories (2)	Production (tons) Butter (3a)	Cheese (3b)	Suppliers Butter (4a)	Cheese (4b)	Dairy Cows in Milk (000's) (5)
1884	36a		123	823	-	-	-
1889	74a		879	1960	-	-	-
1894	82	42	5061	4323	-	-	-
1900	172	91	13285	6985	-	-	372
1905	214	84	23133	7503	13632b	1935b	518
1910	189	194	27092	23705	14572	4608	583c
1915	167	330	30173	40205	19429	7585	725c
1920	154	384	28853	63144	24157	10447	894
1921	155d	376d	40623	55782	42281e	13684	890
1923	165	370	77685	62399	40099	13333	1125
1925	156	336	81217	71827	43381	11807	1196
1927	162	337	85411	78214	42472	12635	1182
1929	151	336	97558	89112	43153	12944	1291
1931	147	329	115342	92893	46906	13839	1479
1933	150	321	146323	103559	56819	12803	1703
1935	149	317	155299	95723	58358	12372	1807
1937	142	297	175360	91315	58104	11594	1785
1939	121	281	145532	85264	54256	10707	1924
1941	121	284	161809	122371	49405	11717	1759
1943	114	299	139803	102847	48528	14531	1715
1945	116	271	151637	103676	43861	9989	1697
1947	113f	250f	143226	91646	42990f	9662f	1658
1949	109	247	162876	98858	41968	9505	1747
1950	109	239	165969	105063	42503	9194	1850
1951	108	232	178106	108229	42371	8768	1898
1952	112	214	188715	95455	43355	7366	1906
1953	112	218	196809	107552	41277	6813	1962
1954	111	213	180868	103130	40380	7697	1999
1955	110	211	186580	102374	38723	7473	1995
1956	108	189	200321	96421	36436	6661	-
1957	-	-	198200	94600	-	-	1998
1958	102	169	208138	96288	34522	5736	1967
1959	103	165	218677	84838	32970	5531	1931
1960	101	164	207964	93076	31040	6021	1887g
1961	99	155	208556	98108	28928	5615	1929
1962	96	147	207521	100457	27467	5676	1968
1963	94	144	213297	98105	26036	5391	1997
1964	92	144	228621	94207	22368	4865	2011
1965	91	131	241455	106179	20869	4396	2032
1966	-	-	251300	105700	-	-	2088
1967	-	-	251800	109700	-	-	2131
1968	75	87h	235439	99627	15961	3392i	2232
1969	73	85h	263539	87467	14855	3351i	2304

Notes & Sources on following page.

TABLE H I (Cont.)

Notes:

- a Number of establishments
- b 1906
- c Geometric mean
- d Estimated
- e Including suppliers to dual plant factories
- f 1948
- g Figures refer to holdings over 1 acre before, and over 10 acres from 1960
- h Excluding dual plant factories
- i Excluding suppliers to dual plant factories

Numbers of cheese factories (2) and suppliers to cheese factories (4b) includes numbers of, and suppliers to dual plant factories except where specifically excluded.

Sources:

Columns 1 & 2
- to 1889, Philpott, 1937:395.
- 1889 to 1969, Annual List of Creameries for years given.

Columns 3a & 3b
- to 1920, Philpott, 1937:395.
- 1921 to 1954, Evans, 1956:A37.
- 1955 to 1969, A. & P. Stats. for years given.
- Except for: 1921 (N.Z.O.Y., 1923), 1923 (N.Z.O.Y., 1925), 1957(N.Z. O.Y., 1958) 1966 (N.Z.O.Y., 1968), and 1967 (N.Z.O.Y., 1969)

Columns 4a and 4b
- Annual List of Creameries for years given.
- Except for 1921 (N.Z.O.Y., 1924).

Column 5
- to 1915, Philpott, 1937:403.
- 1920 to 1969, N.Z.O.Y., 1971.

APPENDIX J

WHOLEMILK AND CREAM COLLECTION CENTRES 1907 TO 1971

TABLE J I WHOLEMILK AND CREAM COLLECTION CENTRES OPERATING IN THE MANAWATU BY 1907 WITH SEASON OF CLOSURE

No. (1)	Collection centre (2)	Season of Closure
1	Rapanui	1948-49
2a	Westmere	operating(3)
2b	Westmere	1908-09
3	Brunswick	1923-24
5	Upokongaro	1910(4)
6a	Okoia	1964-65
7	Marangai	1919-20
8a	Whangaehu	1963-64
12	Rata	1963-64
13	Silverhope	1910
14	Hunterville	1910
15	Rewa	1910
16	Pakihikura	1907-08
17	Sandon Block	1910
18	Mangaonoho	1910
19a	Defiance Mangaweka	1910
19b	Mangaweka	1907-08
20	Ruahine	1910
21	Rangiwahia (Later Rangiwahia-Ruahine	1958-59
22	Main South Road	1910
23	Table Flat	1910
24	Norsewood Road	1910
25	Utuwai	1910
26	Ridge Road	1910
27a	Clover Valley (Apiti)	1910
27b	Apiti	1957-58
28	Kimbolton	1910
29	Kimbolton Road	1910
30	Waituna West	1922-23
31	Beaconsfield	1910
32	Cheltenham	1919-20
33	Junction Road	1910
34	Makino	1910
35	Cheltenham (Makino Station)	1964-65
36	Halcombe	1910
38	Rangitikei (Bulls)	1970-71
40	Ohakea	1922-23
41a	Sandon (Sanson)	1910
41b	Mickeytown (Sanson)	1907-08

Cont.

TABLE J I Cont.

No. (1)	Collection centre (2)	Season of Closure
42	Jones Line	1919-20
43	Awahuri	1907-08
44	Reliance (Te Arakura)	1907-08
45a	Aorangi	1919-20
45b	Aorangi	1910
46a	Colyton	1910
46b	Colyton	1910
46c	Colyton	1910
47	Pohangina	1919-20
48	Awahou	1910
49	Raumai	1919-20
50a	Ashhurst	1935-36
50b	Ashhurst	1922-23
50c	Ashhurst	1908-09
51a	Hiwinui	1910
52a	Whakaronga	1936-37
52b	Stony Creek (Whakaronga)	1910
52c	Stony Creek (Whakaronga)	1907-08
53a	Defiance Bunnythorpe (Later Glaxo)	operating
53b	Bunnythorpe	1919-20
53c	Bunnythorpe	1910
55	Awahuri (Kauwhata)	1964-65
56	Rongotea	1964-65
59	Carnarvon	1919-20
61	Glen Oroua (Later Tui)	1963-64
62	Hughes Line	1958-59
63	Silverleys (Rangitikei Line)	1967-68
64a	New Zealand Farmers' Dairy Union (Palmerston North)	1944-45
65a	Kairanga	1936-37
65b	Kairanga	1907-08
66	Mangawhata	1966-67
67	Taikorea	1964-65
68	Oroua Downs	operating
70	Rangiotu	1950-51(5)
72	Kairanga (Longburn)	operating(3)
73	Awapuni	1910
74	Fitzherbert (Aokautere)	1963-64
75	Fitzherbert West	1910
76a	Linton (Later Loch Moig)	1947-48
76b	Linton	1910
77a	Tokomaru (6)	operating(3)
77b	Tokomaru	1910
78	Makerua	1910
79a	Shannon	1964-65
79b	Shannon	1910
79c	Kingston (Shannon)	1907-08
80	Moutoa	1908-09
81a	Foxton	1908-09
81b	Foxton	1907-08

Notes and Source: See Table J II

TABLE J II WHOLEMILK AND CREAM COLLECTION CENTRES IN THE MANAWATU WHOSE OPERATIONS COMMENCED AFTER 1907 WITH SEASON OF OPENING AND SEASON OF CLOSURE

No. (1)	Collection Centre (2)	Season of Opening	Season of Closure
4a	Aramoho	1909-10	1937-38
4b	Wanganui Fresh Food and Ice Co. (St Johns Hill)	1909-10	1934-35
4c	Maoriland (Wanganui East)	1919(7)	1931-32
6b	Okoia	1909-10	1910(4)
8b	Whangaehu	1909-10	1910
9	Turakina	1919	1930-31
10	Marton (Tutaenui Road)	1919	1937-38
11	Paraekaretu (Leedstown)	1909-10	1919-20
37	Kakariki	1909-10	1910
39	Bulls	1919	1931-32
51b	Hiwinui	1909-10	1910
54	Manawatu Reliance (Rangitikei Line)	1919	1954-55
57	Makowai	1909-10	1935-36
58	Parewanui	1919	1930-31
60	Kaimaterau	1909-10	1922-23
64b	Palmerston (Later Palm)	1909-10	1932-33
64c	Milk Treatment Station (Palmerston North)	1944-45	operating
69	Bainesse	1919	1957-58
71	Tiakitahuna	1909-10	1935-36
76c	Linton	1908-09	1924-25

Notes to Tables J I and J II:

(1) Numbers relate to Figures 2

(2) Factories and skimming stations as named in Annual List of Creameries. Localities and additional information in parentheses.

(3) Branch of Manawatu C.D.C.

(4) Closed between 1910-11 and 1918-19

(5) Operated as a skimming station between 1955-56 and 1966-67

(6) Operating half seasons only

(7) Opened between 1910-11 and 1918-19

Source for Tables J I and J II:

Annual List of Creameries, 1906, 1908-10, 1920, 1922-45, 1948-56, 1958-65, 1968-69

Miscellaneous Dairy Company Records

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LIST OF ABBREVIATIONS

A.J.H.R.	Appendices to the Journals of the House of Representatives
* Ann. Ass. Am. Geogr.	Annals of the Association of American Geographers
Dairy Fmg A.	Dairy Farming Annual
* Econ. Geogr.	Economic Geography
* Fm. Economist	Farm Economist
* Geogr. Annlr	Geografiska Annaler
* Geogrl Rev.	Geographical Review
* Impact Sci. Soc.	Impact of Science on Society
J. Am. Inst. Plann.	Journal of the American Institute of Planners
* J. Am. statist. Ass.	Journal of the American Statistical Association
* J. reg. Sci.	Journal of Regional Science
* N.Z. Dairy Export.	New Zealand Dairy Exporter
* N.Z. Geogr.	New Zealand Geographer
* N.Z. geogr. Soc. Rec.	New Zealand Geographical Society Record
* N.Z. Jl Agric.	New Zealand Journal of Agriculture
N.Z. Jl Dairy Technol.	New Zealand Journal of Dairy Technology
Oxf. Econ. Pap.	Oxford Economic Papers
Pap. Proc. reg. Sci. Ass.	Papers and Proceedings of the Regional Science Association
Proc. (date) mkt mlk wk Confr.	Proceedings of the (date) Market Milk "Week" Conference
Proc. (number) N.Z. geogr. Confr.	Proceedings of the (number) New Zealand Geography Conference
* Tijdschr. econ. soc. Geogr.	Tijdschrift voor Economische en Sociale Geografie
Transp.News N.Z.	Transport News of New Zealand

* From World List of Scientific Periodicals.

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