A STUDY OF THE ECONOMIES OF SIZE
IN NEW ZEALAND DAIRY FARMING

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CHAPTER ONE

INTRODUCTION AND THESIS OUTLINE

1.1 INTRODUCTION

Over the last decade, the dairy industry in New Zealand has undergone a number of notable changes. Of particular interest is the trend towards fewer dairy farmers, a larger average herd size and greater milkfat production per farm. For example, in the 1958/59 dairying season, the number of dairy factory suppliers in New Zealand was 39,900 and the average herd size was 58 cows (1, pp. 18 - 19). In the 1968/69 dairying season, however, the number of suppliers had declined to 25,000 and the average herd size had risen to 92 cows (2, p.23). Over the period in question, the total milkfat processed increased by 99 million pounds from 489 million pounds in the 1958/59 season (1, p.22) to 588 million pounds in the 1968/69 season (2, p.24). Consequently in the 1958/59 season, the average quantity of milkfat supplied to dairy factories per supplier was 15,800 pounds (1, p.19), while in the 1968/69 season, the quantity had risen to 25,400 pounds (2, p.24).

Although there is a paucity of data on the subject, it seems likely that the average area of dairy farms also increased over this period. For example, data is available which indicates that over the seasons 1960/61 to 1967/68, the average area of all farms in New Zealand increased from 414 acres (3, p.32) to 448 acres (4, p.35). It is not possible to determine from such data the change in the average area of dairy farms. However when an examination is made of the data relating to the main dairying districts, a similar trend to that noted above is discernible. From this, it may be inferred that over the period in question, there has been an increase in the average area of dairy farms.

The period has also been marked by the evolution of a number of dairy farms on which relatively large dairy herds (i.e. 300 cows or more) were run in a single herd. A major factor contributing to the evolution of such farms was the development of large herringbone farm dairies. The appearance of these farms, in a period which has been characterised by a decline in the dairy farmers' terms of trade, plus the formation of a public farming company, has led a number of agricultural commentators to suggest that the future of dairy farming in New Zealand lies in taking advantage of economies of size. Farmer interest is directed towards economies of size because of the possibilities of lowering cost (and hence increasing profit) margins. The community should be interested because of a desire to make effective use of the nation's resources. Consequently this study is concerned with testing the hypothesis that economies of size exist in New Zealand dairy farming.

1.2 OUTLINE OF THE THESIS

The thesis consists of nine chapters and three appendices, and is presented in two volumes. The text (of nine chapters) is presented in Volume I, while Volume II contains the appendices. Chapter Two consists of two sections. In the first, certain aspects of economic theory which are relevant are discussed and the terms "economies of size" and "diseconomies of size" carefully defined. In the second section, a brief description is given of the various sources from which economies and diseconomies of size may arise. In the third chapter, first the various analytical procedures which can be adopted to study economies of size are discussed. Second, the analytical procedure adopted (in this study) is briefly discussed and the reasons for its adoption noted. Finally, two previous economies of size studies conducted in New Zealand are briefly reviewed. Various aspects of the farm survey (the data from which forms a basis for the assumptions made in the analysis), are discussed in Chapter Four. Included in this chapter is a discussion of the method of selecting the survey farms, the design of the questionnaire and the conduct of the farm survey. The results of the farm survey are presented in Chapter Five. The physical information is presented, (detailed physical data is presented in Appendix A), the attitudes of the respondents to various aspects of farm size are discussed, and possible sources of economies and diseconomies of size noted. In Chapter Six, the analytical procedure is discussed in detail and the basic assumptions of the analysis presented. (Details of the assumptions made are given in Appendix B.) The results of the analysis are presented in Chapters Seven and Eight. The sources of economies and diseconomies of size are described in Chapter Seven. In Chapter Eight, the nature of the cost-size and profit-size relationships are noted and discussed in detail, and a break-even analysis of the results given. (A series of diagrams which illustrate the results of the analysis are shown in Appendix C.)

CHAPTER TWO

ECONOMIES OF SIZE THEORY AND POSSIBILITIES FOR INCREASING AND DECREASING RETURNS TO SIZE

2.1 INTRODUCTION

This chapter consists of two sections. The first section discusses certain aspects of economic theory which are relevant to the study. The second section discusses the various sources from which economies and diseconomies of size may arise.

2.2 ECONOMIES OF SIZE THEORY

Economies of size analysis typically is based upon the theory of the firm under conditions of perfect competition. Two time periods are recognised, the short run and the long run.

1) The Short Run

The short run is viewed as a period of time in which at least one factor of production cannot be varied. The factor or factor(s) which cannot be varied are termed the fixed plant. The production function is therefore of the form:

$$y = f(x_1/x_2 \ldots\ldots\ldots\ldots x_n)$$

where y is the output of product

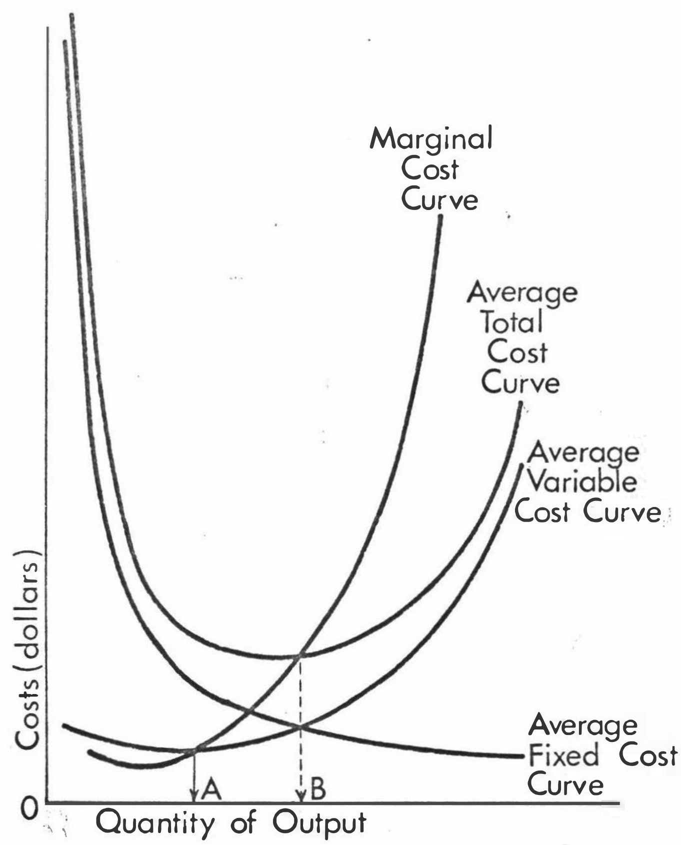
x_1 is the variable resource

$x_2 \ldots\ldots x_n$ are the fixed resources (i.e. fixed plant)

In the short run, average total cost curves can be drawn for each level of fixed resources (i.e. fixed plant). The curves SAC_1, SAC_2, SAC_3, and SAC_4 in Figure 2.2 represent such curves for four levels of fixed resources (i.e. fixed plants). For a particular fixed plant, for any given level of output, the average total cost is obtained by summing the average fixed and the average variable costs. Typically, average total cost curves are "u" shaped. The reasons for such a shape are: (5, pp 166 - 172)

a) Initially as output is increased, the average total cost of output falls because of declines in both the average fixed and average variable costs. (i.e. over range of output OA, in Figure 2.1.)

FIG. 2.1 AVERAGE AND MARGINAL COST CURVES FOR A GIVEN PLANT SIZE



THEORETICAL ILLUSTRATION OF SHORT RUN AVERAGE COST CURVES AND LONG RUN AVERAGE COST CURVE

FIG. 2.2 (FIXED RESOURCES CONTINUOUSLY DIVISIBLE)

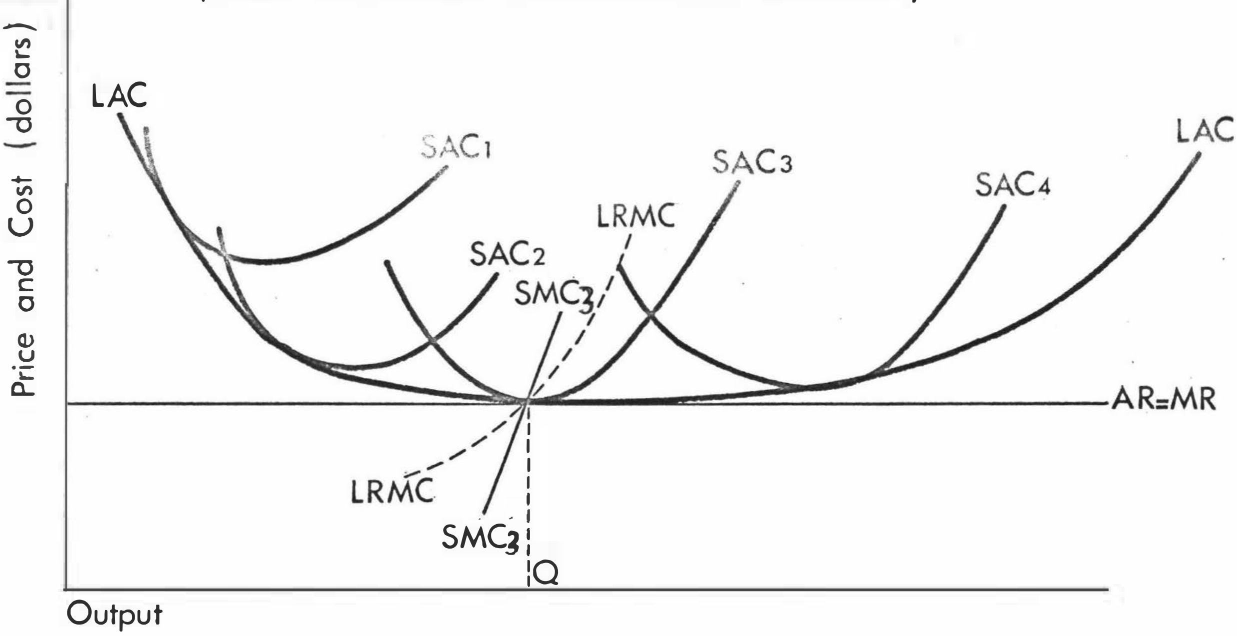
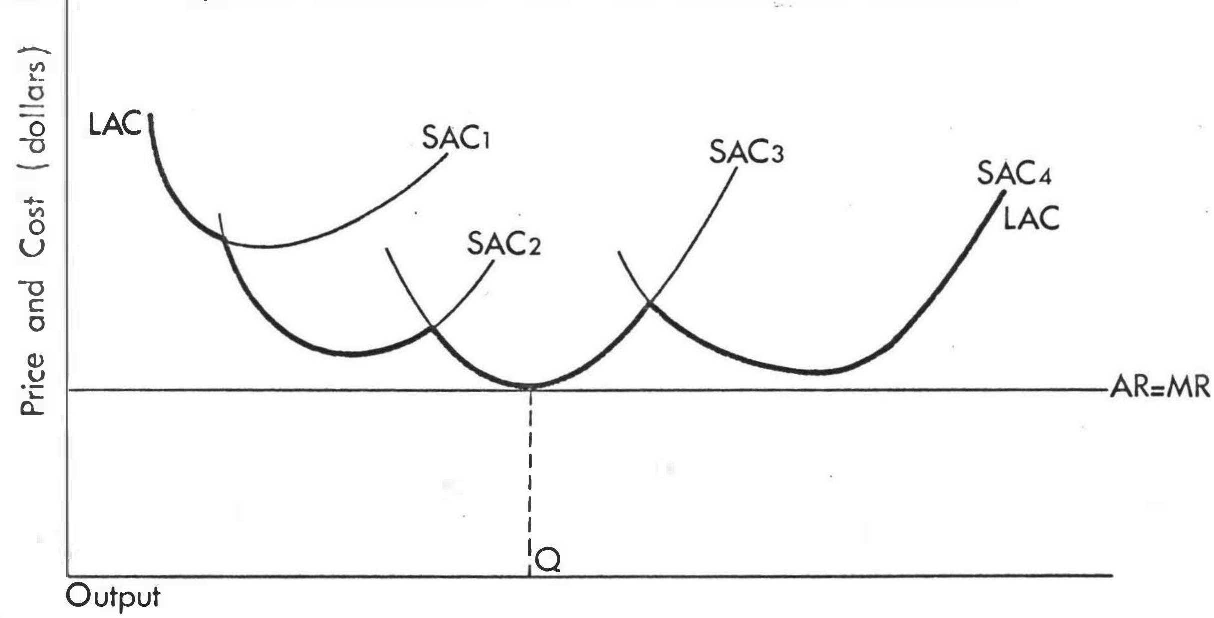


FIG. 2.3 (FIXED RESOURCES NOT CONTINUOUSLY DIVISIBLE)



<u>NOTES:</u> AR	=	Average Revenue Curve
MR	=	Marginal Revenue Curve
SAC_i	=	Short Run Average Cost Curve $i = 1 \ldots 4$
SMC	=	Short Run Marginal Cost Curve
LAC	=	Long Run Average Cost Curve
LRMC	=	Long Run Marginal Cost Curve

b) Further increases in output are accompanied by further decreases in the average total cost due to the decline in the average fixed costs being greater than the increase in the average variable costs. (i.e. Over the range of output in Figure 2.1, which is greater than A, but less than B)

c) Eventually a level of output is reached, at which the decline in the average fixed costs, is exactly [1] offset by the increase in the average variable costs. At this level of output, the average total cost is a minimum. (i.e. At output B in Figure 2.1.)

d) Further increases in output are accompanied by increases in the average total cost, due to the increase in the average variable costs, being greater than the decline in the average fixed costs. (i.e. For outputs greater than B, in Figure 2.1.)

2) <u>The Long Run</u>

The long run is viewed as an interval of sufficient duration to allow all factors of production to be varied. The production function is therefore of the form:

$$y = f(x_1\ x_2\ \ldots\ldots\ldots\ldots\ldots\ldots\ x_n)$$

where y is the output of product

x_1 .... x_n are the variable resources

An average cost curve can also be constructed for the long run situation. Such a curve is known as a Long Run Average Cost Curve, and is defined as a curve which shows for any given level of output the least cost way of producing that output. [2] The long run average cost curve is constructed from the short run average cost curves. In some literature (6, p.367), the long run average cost curve is described as an "envelope curve" which is plotted as the tangency of the short run average cost curves. Others (7, p.235) prefer not to view the long run average cost curve as a separate construction from the short run average cost curves, but describe it as being constructed from segments of the short run average cost curves.

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1. This assumes the variable resources are continuously divisible.
2. The long run average cost curve shows for each level of output what plant size should be utilised to produce the level of output in question at the lowest cost.

If the resource which is fixed in the short run (i.e. the fixed plant) can be employed in quantities that are continuously divisible, the long run average cost curves produced by the two methods of construction discussed do not differ. In this case, the long run average cost curve takes on a smooth shape. This is shown in Figure 2.2 by the curve LAC. In this case for every point on the long run average cost curve, there is conceptually a corresponding point of tangency with a short run average cost curve. (The long run average cost curve can therefore be described as consisting of the minimum cost points for particular outputs of an infinite number of short run average cost curves.)

If the resource which is fixed in the short run cannot be varied continuously, the long run average cost curves produced by the two methods of construction differ. The curve produced by constructing an envelope curve tangent to the short run average cost curves is similar to the curve LAC shown in Figure 2.2. However, the curve constructed by the second method takes on a scalloped effect. This is shown by the curve LAC in Figure 2.3. In this case, instead of each short run average cost curve (each fixed plant) contributing only a point to the long run average cost curve, each short run average cost curve contributes a segment to the long run average cost curve.

The long run average cost curve is used to indicate the existence of economies and diseconomies of size. A long run average cost curve which falls as output increases indicates that over the range of output in question, economies of size exist. Conversely a long run average cost curve which rises as output increases indicates that over the range of output in question, diseconomies of size exist. It follows that if the long run average cost curve remains horizontal over a range of output, then constant returns to size exist.

3) <u>Profit Maximisation</u>

In the short run, the output at which profits are maximised (for a particular plant size) is found by equating marginal costs with marginal revenue. In the short run, under the conditions of perfect competition, with one exception, the output at which profits are maximised is greater than the output at which the (short run) average total costs are a minimum. (Such profits are termed "super normal profits" (8, p.129).) The exception occurs when the average revenue curve (and hence marginal revenue curve) is tangent to the low point of an average total cost curve.

In this case (for a particular plant size) the output at which profits are maximised coincides with the output at which the average total costs are a minimum. (In this case, such a firm is said to be earning "normal profits" (8, p.129).

Similarly in the long run, the point of profit maximisation is found by equating marginal costs with marginal revenue. Under the assumptions of perfect competition, this will occur at output Q in Figure 2.2 where AR = MR = SMC_3 = SAC_3 = LAC = LRMC. In this case, the output at which (long run) profits are maximised, coincides with the output at which (long run) average total costs are a minimum. (Firms are said to be earning "normal profits".) If the assumptions of perfect competition are relaxed and it is assumed the average revenue curve is not forced down to the low point of the long run average total cost curve, profit maximisation occurs at an output which is greater than the output at which the long run average total costs are a minimum, (5, p.209) and (9, p.18). (In this case, firms are earning "super normal profits".) Profits are maximised if the plant corresponding to this point[3] on the long run average cost curve is constructed and operated at this capacity.

The long run average cost curve is sometimes called a planning curve. An entrepreneur might decide to enter an industry and produce a given level of output. From the long run average cost curve, the least cost (and consequently the most profitable) way of producing this output can be determined. The entrepreneur would construct the relevant plant, and operate the plant at the level of utilisation indicated by the long run average cost curve. Once the plant is constructed, the planning curve is of no further interest. Output may be further profitably increased by adding variable resources to the fixed plant, up to the output at which marginal costs equal marginal revenue. It should be noted, however, that although such increases in output may be profitable to the particular firm, the same output can be produced at less cost (and hence higher profits) by the use of another plant.

In general, it is not possible from the long run average cost curve to make inter-firm comparisons of profits, where various firms are represented by different plant sizes. This can be achieved only when one has information on the short run marginal cost curves corresponding to each plant size, (10, pp.37 - 38)

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3. i.e. The output at which long run marginal costs equals marginal revenue.

4) Economies of Size and Economies of Scale

Some confusion has arisen in the past because of the interchangeable use in the literature of the terms "size" and "scale". Investigations into the relationship between output and unit costs of production are sometimes called Economies of Size Studies, and sometimes Economies of Scale Studies.

Scale relationships refer to situations where all the resources (including management) involved in a production process are varied in constant proportions. In this case the production function of interest is:

$$y = f(x_1, x_2 \ldots\ldots\ldots\ldots x_n)$$

where y is the output of product,

$x_1 \ldots\ldots x_n$ are resources combined in certain fixed proportions.

If the quantity of each resource is varied by some constant ϕ, one can write:

$$Ky = f(\phi x_1, \phi x_2 \ldots\ldots\ldots\ldots \phi x_n)$$

where K represents the change in output,

ϕ represents the change in the level of resource use.

In scale relationships, one is interested in the relationship between K and ϕ. Three outcomes are possible:

a) $K < \phi$ In this case, decreasing returns to scale are said to exist. The change in output is proportionately less than the change in the level of resource use.

b) $K = \phi$ In this case, constant returns to scale are said to exist, as the change in output is the same as the change in the level of resource use.

c) $K > \phi$ In this case, increasing returns to scale are said to exist, as the change in output is proportionately greater than the change in the level of resource use.

The concept of Economies of Scale has little relevance to the real world situation. There is general agreement amongst economists that firms do not in fact vary resources in constant proportions as output is increased. (9, p.1)

Size relationships involve a broader concept and include relationships where:

i) Where some resources are fixed and others variable. [4] (The short run production function concept.)

ii) Where the resources are varied in constant proportions. (The economies of scale concept.)

iii) Where the levels of some resources are increased, while others are decreased.

iv) Where the levels of some or all resources are varied at differing rates.

Maddern (9, p.1) defines economies of size as:

> "Reductions in the total cost per unit of production resulting from changes in the quantity of resources employed by the firm or in the firm's output."

A more lucid definition would be:

> Reductions in the total cost per unit of production, resulting from changes in the size of a firm's plant (plus the associated variable resources), or from changes in the output of a firm from a given plant.

Conversely diseconomies of size are increases in the total cost per unit of production resulting from the two types of changes. Constant returns to size exist when the two types of changes do not affect the total cost per unit of production.

2.3 POSSIBILITIES FOR INCREASING AND DECREASING RETURNS TO SIZE IN AGRICULTURE

Heady (6, pp.361 - 362) divides cost economies and diseconomies, (i.e. phenomena which cause unit costs to increase or decrease, as plant size or output from a plant are increased), into two classes; internal and external.

Internal economies result from adjustments made within the individual firm, while external economies are those which are concerned with changes within the industry to which the firm belongs. (External economies are ignored in this study, as in the author's opinion, they are largely outside the control of the individual farm manager.)

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4. Varied or variable in this context means resources are increased or decreased.

1) Cost Economies and Diseconomies Arising from a Greater Aggregate of Resources

Chamberlin (7, pp.235 - 236) notes that one of the main reasons for the L.R.A.C. curve [5] to slope downward is because increased specialisation is made possible because the aggregate of resources of larger firms is greater. If for example, the quantities of all resources required in a production process are increased by the same proportion, (the returns to scale concept), the increased number of workers, (assuming labour is a factor of production), should allow workers to specialise in particular tasks for which they have a natural aptitude. This, it is argued, leads to greater labour productivity and so results in a cost economy.

Certain farming tasks are considered to be extremely difficult for one labour unit to perform alone, (11, p.14), (e.g. haymaking, silage making). Cost economies may therefore accrue to multi-labour unit farms as such tasks on these farms can be performed more quickly and effectively by a larger labour force. Consequently an increase in labour productivity may result.

Because of the larger quantity of resources of large firms, there are some advantages in meeting contingencies. Maddern (9, p.11) notes that in the case of harvesting operations, it is reasonable to suppose that the proportion of back-up machines needed to provide a given probability of always being able to avoid delays due to breakdowns, would decrease as the size of firm and hence the number of machines is increased.

Cost diseconomies may also be realised because of the greater aggregate of resources employed by larger firms. Such diseconomies are due to managerial difficulties and are discussed on pages 14 - 16.

2) Economies due to Superior Techniques and Superior Resources

Large machines, which are utilised by larger firms, may be able to perform some operations more effectively than smaller machines. (i.e. from a given quantity of resources, produce a higher output of product.) Further a larger machine may be able to perform some operations which a smaller machine, (employed by a smaller firm), is unable to do. (7, p.236)

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5. L.R.A.C. is an abbreviation for long run average cost curve.

Both effects give rise to cost economies. The resources used by the two firms in question in both cases differ. In the first case, the cost economy results from the larger firm possessing superior resources, while in the latter, the cost economy arises from the larger firm being able to utilise a superior technique.

3) Economies and Diseconomies due to Proportionality Relationships

In the short run, (i.e. within a plant size), cost economies result from the fuller utilisation of the fixed plant by the addition of variable resources to it, with a consequent increase in output. Such cost reductions result, however, only if the decrease in the average fixed costs is greater than the increase in the average variable costs.[6] In this case, the proportions in which the fixed and variable resources are combined vary as the degree of plant utilisation increases.

Within a plant size (i.e. in the short run), cost economies and diseconomies result from changes in the proportions in which the variable resources are combined, as the degree of plant utilisation increases. For example, consider a simple production process in which three resources are employed, land, labour and capital. The fixed resoure in such a production process is taken to be labour and the variable resources, land and capital. In the short run, therefore, output is increased by adding varying quantities of land and capital to a fixed quantity of labour. For simplicity, imagine that land can only be added in discrete units [7] and as the quantity of land used in the production process increases, the output of product per acre remains constant, and the quantity of capital which must be employed increases. The total quantity of capital required can increase either continuously or discretely with increases in the quantity of land. In the case where the quantity of capital increases continuously with increases in farm area, (i.e. a different (total) quantity of capital is associated with each farm area), such increases can occur:

a) At a decreasing rate. That is, as farm area increases, the quantity of capital which must be employed with each acre of land declines. Relationships of this nature give rise to cost economies.

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6. Such reductions occur over the range of output OB in Figure 2.1
7. i.e. Land can only be added in increments of one acre.

b) At an increasing rate. That is, as farm area increases, the quantity of capital which must be employed with each acre of land increases. Relationships of this nature give rise to cost diseconomies.[8]

c) The third possibility is for there to be no alteration in the per acre requirements of capital as farm area increases (i.e. The proportions in which the two variable resources are combined remains constant.[9])

In the situation where the total quantity of capital required varies discretely with increases in farm area, a given quantity of capital remains constant over a specific range of farm areas, and assumes a new value at a specific farm area. Thus over the range of farm areas to which a given quantity of capital applies, the per acre requirement of land for capital declines steadily. (i.e. The proportions in which the variable resources are combined varies). Consequently cost economies result.

Between plant sizes (i.e. in the long run), cost economies may also result from the proportions in which resources are combined. For example, consider the simple production process discussed earlier again. Let there be two farms, one with a fixed plant of one labour unit, (this will be referred to as the plant size one farm), and another with a fixed plant of two labour units (i.e. the plant size two farm). If the per acre capital requirement declines continuously as farm area increases, (and further if for a given area, the per acre capital requirements and product output per acre are similar irrespective of the plant size used), then it follows that cost economies will accrue to a 200 acre plant size two farm, relative to a 100 acre plant size one farm, because of a more favourable combination of resources.

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8. Typically such diseconomies arise from engineering phenomena. Commonly quoted examples in agriculture are : (6, p.355)
   i) The relationship between horsepower requirements and size of plough.
   ii) The relationship between the quantities of materials required and volume, when the capacity of a silo is increased in a vertical manner.
9. One can also postulate that cost economies might result, if the quantity of a particular resource decreased continuously with increases in another. Such decreases could occur at an increasing or a decreasing rate.

4) Pecuniary Economies

In some fields of agricultural production, advantages accrue to larger farms because they are able to purchase resources and sell products in larger quantities. This means the cost per unit of resources decreases, and the return per unit of product increases, as size of plant and output from a plant are increased. (6, p.362)

5) Technical Diseconomies

Commonly quoted examples in agriculture are disease hazards, social problems associated with large numbers of animals, and problems due to distance and travel where acreages are extended contiguously. (6, p.363)

6) Managerial Economies and Diseconomies

The term management as a factor of production has a number of connotations. Traditionally, it is defined as consisting of three components, entrepreneurship, co-ordination and supervision. (12, p.14) (In some literature, management is defined as consisting of co-ordination and supervision and entrepreneurship is identified as a separate entity.)

Entrepreneurship is concerned with the major decisions of the firm. For example, what enterprises are to be engaged in, what resources are to be used, and what technology will be employed. Further it involves bearing the responsibility for the financial outcome of such decisions.

Heady (6, p.466) considers that management in the co-ordination sense is being performed when the manager:

a) Recognises problems and opportunities;

b) Obtains information and analyses alternative lines of action;

c) Makes decisions;

d) Takes actions and accepts the responsibility of these actions.

In some literature, the above four steps are described as the components of the decision making process (13, pp. 5 - 6). Supervision according to Heady (6, p.465) is a human activity of a lower order. It is concerned with the overseeing of day to day operations and ensuring that each operation is correctly performed.

The author, while agreeing that the managerial function can be divided into the three components discussed above, finds it extremely difficult, in some cases, to distinguish between entrepreneurship and co-ordination, and between co-ordination and supervision. In the author's opinion, all three components require the use of the decision making process and any activity which involves the use of the decision making process should be regarded as a managerial activity.

Heady (6, pp.535 - 538) notes that management in the co-ordination sense would not be needed if it were not for the combination of time and change, and the inability of being able to predict the future with certainty. If firms existed in a state of perfect knowledge of the future, management (co-ordination and entrepreneurship) would be needed only once, when the initial plan was formulated. After this, there would be no further need for decision making and the managerial function becomes one of routine supervision. It is not change alone, which requires that co-ordination continually function but it is the unpredictability of the nature of the change. In a state of perfect knowledge, one would be able to foresee all contingencies and a suitable course of action for each could be laid down. Where a state of imperfect knowledge exists, management must function continuously. By adding more plants, increasing plant size, and increasing the output of each plant, uncertainty increases and so the number of decisions which must be made by management increases. The greater the number of decisions which must be made by an individual, less time is available to that individual to devote to each decision and consequently the outcome of such decisions becomes less and less satisfactory. As Kaldor (14, p.68) claims, that it is the essence of co-ordination that it must pass through a single brain, it follows that the supply of co-ordinating ability cannot be increased alongside an increase in the supply of all factors. It follows from this that the costs of the individual firm must rise eventually, (i.e. the L.R.A.C. curve must rise) owing to the diminishing productivity of the other factors applied in increasing quantities to the fixed unit of co-ordinating ability. Maddern (9, pp.11 - 12) considers that in farming, two factors greatly increase the difficulty of management, as plant size and output from a plant increase. First, as plant size and output from a plant increase, it seems likely that the resources used by a farm will become less uniform. A large farm with several different soil types is said to be more difficult to manage than a smaller farm with a uniform soil type. Second, on farms of large areas, where a number of farm operations are proceeding simultaneously, supervision may be hampered by distances. Co-ordination is also hampered because of a lack of knowledge of what is happening in different places.

The author, while agreeing in principle with the comments of both Heady and Maddern, (discussed earlier), does not believe that all managerial tasks (in the co-ordination sense) must be performed by a single person. In the author's view, most farming activities involve the use of the decision making process and as the work load on a large farm is divided between the members of the labour force, it follows that all members of the labour force are engaged in managerial activities. Some (15, p.452) are of the opinion that in such circumstances, cost economies will result because the members of the labour force can specialise in particular (managerial) activities for which they have a natural aptitude. The author, however, is of the opinion that it is more likely that cost diseconomies will arise in these conditions, because some members of the labour force, due to a lack of experience, are unable to perform their (managerial) activities as competently as more experienced staff members.

2.4 SUMMARY

In this chapter, the underlying economic theory of economies of size studies has been presented. A most important point which must be borne in mind when considering economies of size studies, is that under conditions of perfect competition, both in the short run and long run, with one exception, the output at which profits are maximised is greater than the output at which average total costs are a minimum. Both in the short run and the long run, the exception occurs when the average revenue curve coincides with the low point of the average total cost curve. In such circumstances, the output at which profits are maximised corresponds with the output at which average total costs are a minimum. A careful distinction is made between the terms "economies of size" and "economies of scale". The concept of econcmies of scale has no relevance in the real world. Finally, the possible ways in which economies and diseconomies of size may arise in dairy farming are discussed.

CHAPTER THREE

ANALYTICAL PROCEDURES AND REVIEW OF PUBLISHED STUDIES

3.1 INTRODUCTION

In this chapter, first the various analytical procedures which may be used for studying cost-size relationships are discussed. Second the analytical procedure adopted in this study is briefly discussed and the reasons for its adoption given. Finally a brief review is made of two published studies concerning the nature of cost-size relationships in New Zealand dairy farming.

3.2 ANALYTICAL PROCEDURES FOR STUDYING COST-SIZE RELATIONSHIPS

Procedures that have been used for analysing cost-size relationships can be divided into four classes.

a) Cobb-Douglas Production Function analyses;
b) Survivorship Techniques;
c) Farm Record Analyses;
d) Economic-Engineering or Synthetic Firm Techniques;

1) Cobb-Douglas Production Function Analyses

A Cobb-Douglas Production Function (16, pp.585 - 593) can be fitted to input-output data and the sum of the exponents of the individual factors in the production function, (which in this particular production function are also the elasticities of the individual factors), can be taken as an indication of the nature of the returns to scale. If this sum equals 1.0, constant returns to scale can be said to exist. If this sum is less than 1.0, this can be taken as evidence of decreasing returns to scale, and conversely if this sum is greater than 1.0, increasing returns to scale are indicated. The technique is fraught with difficulties:

a) The underlying assumption upon which the analysis is based, is that resources are varied in constant proportions (i.e. the economies of scale concept). This, as discussed earlier, seldom occurs (if at all) in the real world situation.

b) Olsen (17, p.60) notes that because of computational difficulties, it is necessary to aggregate the factors into relatively few categories. A category such as machinery may include various combinations of combines, tractors, ploughs and other machinery. It is possible therefore, for two farms which have identical investment in machinery to have in fact, very dissimilar types and combinations of machines. This could lead to wide differences in the productivity of apparently similar levels of machinery investment.

c) A further difficulty discussed by Maddern (9, p.24) is that it is assumed that all resources and all products are infinitely divisible. It is not possible to accomodate within the analysis, discontinuities such as those resulting from discrete increments of particular resources.

d) The fitted Cobb-Douglas Production Function applies only at the geometric means of the inputs and so represents only the "average" of the sampled farms. It provides no indication of the relative efficiency [1] of larger or smaller farms.

2) Survivorship Technique

This method is based on the assumption that competition among firms will over time identify the most efficient size [2] of firms. Size of firm is measured by the firm's capacity as a percentage of the industry's capacity. Tabulations are prepared showing the number of firms in each class and also the percentage of the industry's capacity represented by each class for two points in time. Size classes that exhibit a declining proportion of the industry's capacity over time are said to be inefficient and conversely, an increasing proportion of the industry's capacity in a class is taken as evidence of efficiency.

This type of analysis is of little use in describing cost-size relationships. It provides little (if any) information about the shape of the long run average cost curve. Criticisms of the technique include:

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1. Efficiency in this context means the per unit cost of production.
2. Most efficient size of firm means the firm with the lowest per unit cost of production.

a) It is not clear from such an analysis that the reason the smaller firms disappear is because they are inefficient. (Assuming that the smaller size classes exhibit a declining proportion of the industry's capacity). It is only inferred that the very small firms leave the industry. It is possible that the small firms in the first period are in one size class, and in the second period, appear in another size class because of the process of growth. In circumstances where the L.R.A.C. curve reaches its minimum point at a relatively low output and where the average revenue curve is not forced down to the low point of the L.R.A.C. curve, firms can increase profits by:

i) Increasing the output from the plant size, (the short run average cost curve of which coincides with the low point on the L.R.A.C. curve), beyond the output indicated by the minimum point of the L.R.A.C. curve.

ii) Increasing the plant size and increasing the output from such a plant beyond the output indicated by the minimum point of the L.R.A.C. curve.

This does not mean that such adjustments make the firm more efficient as the per unit costs of production could be higher than those of a smaller firm. Firms may make such adjustments which lead them to larger and more profitable, but not necessarily more efficient operations.

b) Cost-size relationships can also be masked by other factors. No consideration is given to factors which might be responsible for the decline in the relative importance of a given size firm other than the inherent inefficiency of that size of operation. Such factors as the quality of management, labour productivity, degree of utilisation of the plant capacity and access to resources and markets are ignored.

3) <u>Farm Record Analysis</u>

Many attempts have been made by researchers to study cost-size relationships directly from a sample of farm records. In most cases, the records have been designed and collected for other purposes than research into cost-size relationships. Typically, farms are divided into size groups and the average cost per unit of production is calculated for each of the size groups. From this cost-size relationships are inferred. (17, pp.53 - 56) There are a number of methodological difficulties associated with the method including:

a) Farms selected vary widely in the combination of enterprises and in the nature of the resources.

b) Different farms employ different technologies and practices.

c) Differences exist between size classes in the degree of utilisation of fixed plant.

d) Cost accounting procedures vary widely between farms making comparison difficult.

e) The class averages are dependent on the arbitrarily determined class intervals. Alteration of the class intervals will alter the cost-size relationships. Further, the "typical" farms produced within each class by averaging the data, have an aggregation bias [3] making them inaccurate replicas of the farms they represent.

Maddern (9, pp.26 - 27) identifies a slightly modified approach to the procedure discussed above. There is fundamentally no difference except that the emphasis is on developing composite farm budgets from the data. The records are divided into classes and a composite farm for each class is developed using the averages of the various recorded parameters. The cost per unit of production is then calculated for each of the composite farms using the observed or assumed prices. Some workers have attempted to improve the method by making corrections to the data from individual farms. These usually involve making adjustments to take account of such problems as variations in the degree of plant utilisation and various accounting adjustments such as corrections to the cost of resources and product prices, and standardisation of interest rates and depreciation procedures.

In other cases regression equations have been fitted to the data from individual farms. In this procedure, the cost figures and output

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3. i.e. The resource and product combinations of the "average" farm may be such that it is not a realistic working proposition.

quantities for each farm represent a single observation. The same problems as discussed earlier still exist. The figures to which the regression is fitted are complex figures and do not represent valid points on a long run average cost curve. Different farms represent different short run plants, because different quantities and types of resources are used. Farm operators will for varying reasons, operate at various points along the short run average cost curve, and not necessarily at the point (or range of points) where the short run average cost curve becomes part of the long run average cost curve.

A regression analysis of this sort provides an estimate, not of the long run average cost curve but of a curve which Heady calls the "Regression Estimated Cost Curve" (17, p.80). This curve will probably lie above the "true" long run average cost curve because the regression analysis will not necessarily indicate the least cost way of producing any given level of output.

Bressler (19, p.529) has suggested that it would be possible to approximate the long run average cost curve by fitting an "envelope curve" to the bottom of the scatter of such points, or that a regression line could be fitted to the data from only those plants which were well designed, efficiently managed, and operated to capacity.

4) <u>The Economic-Engineering or Synthetic Firm Approach</u>

According to Maddern (9, p.21), this procedure should be used when the objectives of the research are to:

a) Determine the total cost per unit of output or profit that farms of various sizes could achieve using modern or advanced technologies.

b) Determine differences in the average cost per unit of output which are attributable solely to differences in the size of farms and not due to other factors such as obsolete techniques, substandard management practices, differences in the degree of plant utilisation, etc.

The method involves developing budgets for hypothetical farms using the best available estimates of the relevant parameters. Specific plant sizes are identified and represented by different levels of fixed factors. Short run average cost curves are then produced by constructing budgets representing varying degrees of plant utilisation, and calculating from these budgets a series of cost per unit of production figures. The long run average cost curve is produced from the short run average cost curves.

In situations where there are a large number of enterprises, of technologies and resource levels, linear programming can be employed. A similar procedure to the budgetary analysis described above is adopted. Specific plant sizes are identified represented by specific levels of fixed resources. Various degrees of plant utilisation are obtained by specifying various levels of gross income, and then in a cost minimising linear programming model obtaining the least cost combination of products and variable resources, for the relevant gross income. By calculating the cost revenue [4/] ratio, points on the short run average cost curve can be derived. This is repeated for the other fixed plants, producing other S.R.A.C. [5/] curves. The L.R.A.C. curve is constructed from the short run average cost curves. Linear programming has distinct advantages over the budgetary procedure where the number of enterprises, alternative technologies and levels of resources are numerous in that it arrives systematically and quickly at an optimum solution (i.e. the least cost way of producing any given level of gross income). With the budgeting procedure, in such circumstances, the least cost method of producing a given level of gross income can only be found by tiresome trial and error procedures.

Some (20, p.272) have criticised the economic-engineering approach on the grounds that in the synthesis of hypothetical firms, subtle sources of economies and diseconomies such as specialisation or diseconomies in labour use are ignored.

French (21, p.543) who has had considerable experience in applying the techniques to manufacturing studies, notes that it is extremely time consuming in terms of man hours. If the objectives of the study are to determine a L.R.A.C. curve for an industry, rather than to compare the costs of alternative methods of performing a specific operation or devising improved methods of production, he feels a less costly approach involving a combination of total cost data and engineering observations would be more suitable.

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4. When dealing with multiple product firms, cost-size relationships are expressed in terms of cost per dollar of gross income rather than cost per unit of production or output, as is the case with single product firms.
5. S.R.A.C. is an abbreviation for short run average cost curve.

3.3 THE ANALYTICAL PROCEDURE ADOPTED IN THIS STUDY

The purpose of this study is to test the hypothesis that economies of size exist in New Zealand dairy farming. Such a hypothesis (in the author's opinion) requires that:

a) The researcher analyses the cost-size relationships in terms of short run and long run average cost curves. (That is determine the least cost and hence most profitable way of producing any given level of gross income.)

b) Any differences so determined in the least cost (and hence most profitable), ways of producing any given levels of gross income must be solely attributable to differences in the size of farm.

In the author's opinion, the only analytical procedure which meets these requirements is the Economic-Engineering or Synthetic Firm approach. Consequently, the Economic-Engineering procedure is used in this study. In this study, fifteen short run average cost curves are constructed. The resources which are considered fixed in the short run are labour, certain buildings, and certain items of machinery and equipment. The short run average cost curves are produced by varying the number of cows milked [6] (i.e. varying the level of plant utilisation) and determining the total cost per dollar of gross farm income.

3.4 REVIEW OF PUBLISHED ECONOMIES OF SIZE STUDIES

Two studies have been conducted in New Zealand which are worthy of discussion. In both cases, the analytical procedure adopted was an analysis of farm records.

1) Parker and Turnbull (22, pp.6 - 14) conducted an analysis of the farm accounts of approximately ten per cent of the dairy farms in New Zealand in the 1967/68 dairying season. The technique employed was to divide the farm accounts into nine [7] size groups based upon herd size. For each of the nine size groups, the following indices were calculated:

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6. The construction of the short run average cost curves is discussed in detail in Chapter Six.

7. The nine size groups were:

i) 40 - 59 cows	ii) 60 - 79 cows	iii) 80 - 99 cows
iv) 100 - 119 cows	v) 120 - 149 cows	vi) 150 - 199 cows
vii) 200 - 249 cows	viii) 250 - 299 cows	ix) 300 or more cows

a) The average total cost [8] per pound of milkfat;

b) The average total farm income per cow;

c) The average cost per cow, of a number of items of farm expenditure. [9]

From such an analysis, they noted that the per cow costs of all items of expenditure (except labour) decreased as herd size increased. However such decreases were more than offset by the increases in (per cow) labour costs which accompanied increases in herd size. Further they noted that as herd size increased, there was a trend towards a decline in both the total farm income per cow and in the milkfat production per cow. Consequently, the average cost of production (i.e. the cost of producing one pound of milkfat) rose as herd size increased. (When an allowance was made for the owner operator's labour, the trend towards increasing costs of production being associated with increasing herd size was still evident.) The analysis also showed that the capital requirements (per cow) tended to fall as herd size increased. For example, the average total net assets (i.e. total assets less current liabilities) dropped from 590 dollars per cow in the case of the 40 - 59 cow group, to 370 dollars per cow in the case of the largest herd size group. The authors noted that it was likely that the farm accounts of the larger herds included proportionately more development expenditure than did those of the smaller herd sizes. This they added was due to the rapid rise in herd numbers on many of the farms of the larger herd size groups.

They concluded that in time, one would expect the production per cow in the larger herds to increase, the expenditure to drop to a maintenance level and "real economies of size will operate on larger farms".

2) Bradford (23, pp. 3 - 53) conducted a study in the Bay of Plenty district in which physical and financial data relating to two groups of farms were collected and compared. The first group comprised twelve farms on which herds of 300 cows or more were milked in the 1967/68 dairying season. The second group comprised twelve farms, on which one permanent labour unit was employed in the 1967/68 season and the herd size

8) The total cost used in this calculation included all cash costs (except interest and rent) and depreciation. (Special depreciation was excluded.) No allowances were made for the owner operator's labour, management or interest on investment.

9) e.g. Animal health, dairy shed, electricity, etc.

approximated 90 cows. [10] The sample of "small farms" (i.e. the second group) was purposively selected. For each of the twelve "large farms" Bradford selected a "small farm" which was in the same locality, had the same soil type and topography and in Bradford's opinion, the managerial ability of the two farm operators was similar.

The analytical procedure adopted was an analysis of farm records (i.e. farm accounts). Bradford made a detailed study of the farm accounts and made a number of modifications [11] in order to facilitate valid comparisons. In this study, an allowance was made for the owner operator's labour and management and for interest on total farm capital. For both groups of farms, the following indices were calculated:

a) Average income per cow;
b) Average cost per cow of seventeen individual items of farm expenditure;
c) Average "surplus" per cow;
d) Average "profit" per acre;
e) Total expenses per 1,000 pounds of milkfat;

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10. Farms of a herd size of approximately 90 cows were selected for the second group of farms as in the 1967/68 season, the national average herd size was 86 cows. Bradford therefore wished to compare a sample of farms where the herd size exceeded 300 cows, with another sample of farms where the herd size approximated the national average.
11. Such modifications included:
    i) Milkfat price was standardised for all farms;
    ii) Increases or decreases in stock numbers were valued at market values rather than standard or nil standard values;
    iii) Abnormalities in the stock accounts caused by excessive culling for tuberculosis were adjusted for;
    iv) On farms where a run-off was farmed in conjunction with the home farm, an allowance was made for any feedstuffs supplied by the run-off;
    v) Repairs and maintenance was adjusted to exclude expenditure of a capital nature;
    vi) Abnormal legal expenses were excluded from the administration costs.
    vii) Special depreciation was excluded;

On a per cow basis, Bradford noted that with three exceptions, for each of the seventeen individual items of expenditure, a lower figure was recorded by the 'large farm' group. The three exceptions were feed and grazing costs, general expenses and fertiliser and spreading costs. However, the increases in these three items of expenditure were not of sufficient magnitude to offset the cost reductions of the other fourteen items of expenditure, and consequently the total expenses per cow of the 'large farm' group were lower than those of the 'small farm' group. The average income per cow was however higher in the case of the 'small farm' group and was of sufficient magnitude to offset the higher total costs (per cow). Consequently the average 'surplus' per cow was greater in the case of the 'small farm' group. However, because the average stocking rate of the 'large farm' group was greater than that of the 'small farm' group, the average 'profit' per acre was greater in the case of the 'large farm' group. Finally, in terms of the average total costs per pound of milkfat there was a small difference in favour of the 'large farm' group. Bradford therefore concluded that "real economic advantages exist in large herd ownership".

The results of the two reviewed studies are therefore somewhat contradictory. Parker and Turnbull concluded that the average cost per pound of milkfat increased as herd size increased and hence diseconomies of size existed. In Bradford's study, the average cost per pound of milkfat was slightly lower in the case of the 'large farm' group and hence it can be inferred that economies of size exist. In the author's view, a major factor contributing to this difference of opinion is the definition of total cost. In Bradford's study, total cost is defined as including all cash costs, depreciation, interest on capital, and the opportunity cost of the operator's labour and management. In Parker and Turnbull's study, however, total cost is defined as including only all cash costs and depreciation.

3.5 SUMMARY

The various analytical procedures which can be used for economies of size studies are discussed in this chapter. In the author's view, the only satisfactory analytical procedure is the Economic-Engineering or Synthetic-Firm technique. Consequently, this technique is used in this study. The results of the two reviewed economies of size studies are somewhat contradictory. This, the author believes, is due to the differing definition of the term 'total costs'.

CHAPTER FOUR

THE FARM SURVEY

4.1 INTRODUCTION

The objective of the farm survey was to provide some of the basic information which would enable the hypothesis that economies of size exist in New Zealand dairy farming to be tested.

4.2 SELECTION OF THE SURVEY FARMS

In order to obtain the basic data necessary for the construction of the short run average cost curves, for each fixed plant, a number of farms representing a range of plant utilisations, (i.e. cow numbers) were selected for study. Although a number of resources have been used to represent the fixed plants for the construction of the short run average cost curves in the analysis, [1] in order to simplify the selection of the survey farms only one resource, labour, was used to denote the fixed plant. For the selection of the survey farms, therefore, five labour classes were chosen to represent five plant sizes. The labour classes were expressed in terms of the number of permanent [2] adult male labour units. [3]

The selection of the farms for the study was made from the records of all North Island Dairy Board Consulting Officers. Consulting Officers were asked to name farmers within their districts whom they considered to be of above average managerial ability, and whose farms could be classified into one of the five labour classes. In the case

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1. This is discussed in detail in Chapter Six.
2. Permanent labour units are considered to be those labour units who are employed for a complete dairying season (i.e. 12 months).
3. The five plant sizes therefore were: one man farms, two man farms, three man farms, four man farms, and five man farms. It should be noted that three short run average cost curves are produced for each of the above five labour classes. Hence fifteen short run average cost curves are produced.

of the one, two and three man farms, each plant size was divided into six subclasses. [4] These divisions resulted from preliminary discussions in November 1969 with Dairy Board Extension Officers prior to conducting the survey. For each of the six subclasses within each of the three plant sizes, Consulting Officers named farmers, within their districts, whomthey considered to be of above average managerial ability. In cases where a Consulting Officer had difficulty in choosing among a number of farmers for a particular subclass, the Consulting Officer was asked to name the farmer(s) with the highest milkfat production per labour unit. Each Consulting Officer was asked to provide at least one name, if possible, for each subclass. In the case of the four and five man farms, no such stratification was necessary. Consulting Officers named farmers within their districts whose farms could be classified as four or five man farms, arranging them in order of total milkfat production, and listing also the number [5] of cows milked.

It was extremely difficult, however, for Consulting Officers to classify the farms from their records precisely into the five labour classes given. [6] For this reason, farms where the wife and/or family [7] contributed to the labour force were classified as one man farms. Other

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4. The subclasses were:

One man farms		Two man farms		Three man farms	
i)	Less than 70 cows	i)	Less than 150 cows	i)	Less than 250 cows
ii)	70 - 89 cows	ii)	150 - 169 cows	ii)	250 - 269 cows
iii)	90 - 109 cows	iii)	170 - 189 cows	iii)	270 - 289 cows
iv)	110 - 129 cows	iv)	190 - 209 cows	iv)	290 - 309 cows
v)	130 - 149 cows	v)	210 - 229 cows	v)	310 - 329 cows
vi)	150 or more cows	vi)	230 or more cows	vi)	330 or more cows

5. The number of cows used to define the subclasses in the first three plant sizes and listed in the case of the two other plant sizes was based on the number of cows in milk in December 1968.
6. Initial discussions with Consulting Officers in November 1969 had indicated that if the selection was to be based only on those farms where the labour force consisted entirely of adult male workers, very few of the farms with which the Consulting Officers were familiar would be selected.
7. The term 'family' in this context refers only to children of school age.

types of labour units employed on farms such as youths, land girls and married couples, were classified as equivalent to an equal number of adult male labour units. [8] Individuals, who on some farms were primarily concerned with the managerial function and were not part of the normal milking staff, but were involved with some of the physical work on the farm, were classified as permanent labour units. Individuals, who were however concerned only with the entrepreneurial function, were not classified as permanent labour units. [9]

Consulting Officers were asked to select farmers on the basis of their records pertaining to the 1968/69 dairying season. Selection on the 1968/69 season was necessary for three reasons. First, as the survey was conducted in the autumn of 1970, farm accounts for the 1968/69 season only were available. Second, in some cases, Consulting Officers' records for the 1969/70 season were incomplete, and finally, it was considered that selection of farms on part production records of the 1969/70 season would be difficult and unsatisfactory. The farms nominated by Consulting Officers were dairy farms engaged in seasonal production. Town milk farms were therefore excluded. It seemed prudent at the time of selection not to restrict the sample solely to farms on which milk production and meat products (i.e. bobby calves and cull cows) were the only products, but to extend the sample so that farms on which various forms of diversification were practised could be included. Preliminary discussions with Extension Officers, prior to conducting the survey, had indicated that in some cases on multi labour unit farms, other enterprises

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8. The classification adopted was:

One youth	=	One adult male labour unit
One land girl	=	One adult male labour unit
One married couple	=	Two adult male labour units

(It should be noted that a married couple was classified as two permanent labour units, even if the wife only assisted with the milking.)

9. Included in this category were:

i) Absentee owners;

ii) Persons who although living on the farm in question managed other farms and other business activities.

were also involved to ensure that the labour force was continually employed on productive work. Further, at the time the farms were selected, dairy farmers were being offered special incentives to produce beef.

In addition, Consulting Officers were asked to name examples in their districts of:

a) A number of separate herds being milked through the one milking shed. (This will be referred to as Organisation 1.)

b) Shift milking. This in comparison with normal seasonal dairying means that in order to milk a given number of cows, a smaller farm dairy is used for longer periods each day. [10] The labour units employed on such farms tend to become specialist milkers. (This will be referred to as Organisation 2.)

c) Contract milking. This occurs where one farm dairy is used to milk a number of herds. One farmer supplies the farm dairy and the milking labour and milks other herds on a contract basis at an agreed rate per pound of milkfat. (This will be referred to as Organisation 3.)

d) One farm consisting of a number of separate dairying units, where the managerial task of all the separate units is performed by one person.[11] (This will be referred to as Organisation 4.)

e) Joint ownership of machinery between two or more farmers. [12] (This will be referred to as Organisation 5.)

From the lists of names submitted by each Consulting Officer, a catalogue of names was prepared for each of the five labour classes. In the case of the one, two and three man farms, catalogues were prepared for each of the six subclasses. Initially in the case of each of the three lower plant sizes, a minimum of six farmers was selected. Each of the six farmers selected for a particular plant size represented a different subclass. The basis of selection was farmers with the highest

10. Shift milking may also require that a given herd be divided into a number of smaller herds.
11. The organisation discussed in d) represents an increase in business size resulting from increasing the number of plants, rather than increasing the size of plant.
12. The organisations discussed in b), c) and e) all represent ways in which

output of milkfat per labour unit. To these six farmers, additional farmers who had adopted unusual management practices were added. Typically these involved management systems which enabled the output per labour unit to be extremely high. All farmers nominated by Consulting Officers in the last two plant sizes were selected. A total of forty seven farmers were selected from the names submitted by all Consulting Officers. Of these:

i) Forty-three were selected to represent the five plant sizes. 13/

ii) Two were selected because two separate herds were milked through one dairy. (i.e. Organisation 1)

iii) One farmer who was engaged in a contract milking agreement was selected. (i.e. Organisation 3)

iv) One farmer who was responsible for the management of a farm which consisted of a number of distinct units was selected. (i.e. Organisation 4)

No examples of shift milking and joint ownership of machinery were known to Consulting Officers.

4.3 SURVEY METHOD

Prior to carrying out the survey, five farms representing in total four labour classes (fixed plants) were visited in May 1969. 14/ These initial interviews together with discussions with Dairy Board Extension Officers, plus a review of overseas literature familiarised the author with the subject sufficiently to formulate a number of hypotheses which the survey was required to test.

Cartwright (24, p.28) divided the various types of farm surveys into two classes: descriptive and interview surveys. Descriptive surveys are concerned with obtaining facts about farmers, and interview surveys are concerned with obtaining facts from farmers. Cartwright noted further that interview surveys are concerned with obtaining both objective and subjective information from the farmer. Accordingly the surveys conducted in this study were of the interview type.

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13. The numbers of farms selected for each of the five plant sizes were as follows:

One man farms	: 12	Four man farms	: 5
Two man farms	: 11	Five man farms	: 3
Three man farms	: 12		

14. Two one man, one two man, one three man and one five man farms were visited. The five man farm in question was later included in the survey.

In contrast to some other Farm Management Research studies (25, p.36) and (26, p.48), a questionnaire in conjunction with a check list was used in this study rather than a check list alone. The author is not in agreement with Cartwright (24, p.28) who, when discussing the use of questionnaires in surveys, states that each interview is restricted to the questions appearing on a prepared questionnaire. A question whether it be an open ended or a restricted type can serve exactly the same function as an item from a check list - that is it introduces a particular subject to the respondent. After allowing the respondent to answer the question, further information can be obtained by the use of probe questions. (27, pp. 359 - 366) The use of such probes can be extended to allow additional information obtained from earlier interviews to be introduced into the discussion and so new aspects of the original hypothesis can be considered.

Wright (28, p.23) has noted that it is either unwise or not possible to design a questionnaire prior to an interview survey. While agreeing with these comments in the context in which they are made, the author considers that whether a questionnaire can or should be designed prior to a survey depends on the researcher's prior knowledge of the subject. In the case of a check list, the researcher only defines fields in which information is required, whereas the use of a questionnaire may imply that the researcher has a greater knowledge of the subject and is able to specify more precisely what information is required. 15/

As noted earlier prior to conducting the survey, the author visited five farms and conducted a "free form" interview survey using a check list. On the basis of these interviews, plus discussions with Extension Officers and a review of overseas literature, sufficient hypotheses were formulated for a questionnaire to be constructed. While accepting the comment made by Cronin (26, p.48) that a danger in using a fixed questionnaire is that many intangible and unforeseen factors which may be brought out by permitting the farmer to talk freely about the farm and its problems may be overlooked, this can be countered to some extent by the use of probes, and also by devoting the initial part of the interview to a free form discussion with the farmer in which he is encouraged to talk freely about the farm. Further the author considers that a

15. The author is indebted to Mr. D. B. Gibbs for this point.

questionnaire may have advantages over a check list, in that as the same definite question is put to each respondent, difficulties associated with interviewer bias and question bias (29, p.55) are less than when using a check list, where the researcher reformulates the question for each respondent. 15/ A questionnaire also means that each respondent starts from the same point with each hypothesis, thus facilitating a more valid and thorough comparison of replies. 16/

Four interviews in this study were conducted on a free form basis using a check list alone (e.g. The two farms where more than one herd was milked through the one farm dairy, the farm where the contract milking agreement was in operation, and the farm consisting of a number of separate units, the overall management of which was retained by one man.) A check list was used primarily because the author had little prior knowledge of the farms in question.

4.4 PRE-TESTING THE QUESTIONNAIRE

The questionnaire was pre-tested on three farms in the Manawatu. This allowed the questionnaire to be amended and improved, familiarised the author with interviewing technique and gave some indication of the time necessary to conduct an interview.

4.5 INTERVIEWING PROCEDURE

The interview consisted of two parts. An initial inspection of the farm property in which no attempt was made to record any information, and the farmer was encouraged to talk freely about the farm. This was followed by a period at the farm house where the relevant information was obtained. (In three cases where the farmer was unable or unwilling to be interviewed during the day, the survey was conducted at night. In such cases no initial inspection of the property was carried out.)

4.6 REJECTION OF SELECTED FARMS

Of the forty-three farms selected for the main study, three have not been included in the results for the following reasons:

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16. In this study, subjective information concerning farmers' attitudes to various aspects of farm size was obtained from the farmers by the use of a questionnaire. Objective information however was obtained from the farmers by the use of a check list.

a) A misunderstanding between a Consulting Officer and the author resulted in the author visiting and interviewing the namesake of a selected farmer.

b) On two occasions unsatisfactory interviews were obtained. (In both cases the unsatisfactory interviews were the result of the farmers being unable to make sufficient time available.)

In only one case where one of the rejected farms had been selected to represent a particular subclass was selection of another necessary. The replacement farm for the subclass in question, was selected from the catalogue of farmers, compiled from names submitted by Consulting Officers. The basis of selection was the farmer with the highest milkfat production per labour unit, in districts which remained to be surveyed.

It should also be noted that names of farmers were accepted from Consulting Officers for the compilation of the catalogues, although the Consulting Officers were not able to specify precisely the physical details of the farm. This applied particularly to farms in the last three labour classes (i.e. three, four and five man farms). As a result, some farms which were selected to represent particular labour classes, were found to be representative of other labour classes when the survey was carried out. Similarly in the case of the two man farms, the herd numbers of two farms selected to represent a particular subclass, proved to be slightly inaccurate causing the farms in question to be representative of the neighbouring subclasses.

Since the purpose of the survey was to obtain some of the basic data for the construction of the short run average cost curves, and because of limitations in the author's resources, and time available for the completion of the study, no farms were excluded from the survey because of the selection difficulties just discussed. [17] The effect of these difficulties has been to cause the numbers of farms actually surveyed for each plant size, and in some cases for the subclasses within a plant

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17. i.e. Because some farms which were selected to represent particular labour classes were in fact representative of other labour classes, and because some farms which were selected to represent particular subclasses were representative of other subclasses.

size, to differ from the numbers originally selected. [18]

4.7 SUMMARY

In this chapter, a description has been given of the method of selecting the survey farms and the conduct of the farm survey. The survey farms were selected from the records of all North Island Dairy Board Consulting Officers and Consulting Officers named for selection only those farmers whom they considered to be of above average managerial ability. In total, 47 farms were selected for the survey - of these 43 were selected to represent the five labour classes and four were selected to represent other farm organisations which were considered relevant to the study. The farm survey was of the interview type and consisted of two parts. First an initial inspection of the farm property in which the farmer was encouraged to talk freely about the farm and second, a period at the farm house where all the relevant data were obtained. In contrast to some other Farm Management studies, a questionnaire was used in conjunction with a check list, rather than a check list alone.

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18. It should be appreciated that the data obtained from the farm survey serves only as a guide to the assumptions which should be made for the synthesis of the short run average cost curves. Because the short run average cost curves are synthesised, rather than being produced entirely from an analysis of the survey results, the author considers that differences in the number of farms actually surveyed for each plant size (and subclasses within a plant size) from the numbers originally selected, are of little importance.

CHAPTER FIVE

RESULTS OF THE FARM SURVEY

5.1 INTRODUCTION

In this chapter, the results of the farm survey are presented. In the first section, the forty-one farms selected to represent the five labour classes are discussed, while in the second, the four additional farms which were selected to represent the other farm organisations are discussed.

5.2 GEOGRAPHICAL DISTRIBUTION OF THE SURVEY FARMS

Figure 5.1 shows the geographical distribution of the survey farms. From Figure 5.1, it is apparent that the survey farms were widely distributed throughout the dairying districts of the North Island.

5.3 CLASSIFICATION OF THE SURVEY FARMS

As noted earlier, it was not possible for Consulting Officers to classify farms for selection precisely into the five labour classes given. Consequently a number of modifications [1] were necessary so that farms, upon which other types of labour units were employed, could be classified into one of the five labour classes. The survey results are presented in accordance with this system of classification. For ease of reference, the survey farms have been divided into four groups. [2]

a) Group I

This includes farms where the labour force normally consists of only one permanent labour unit. Additional labour in the form of family labour [3] may be used for milking and some other farm operations.

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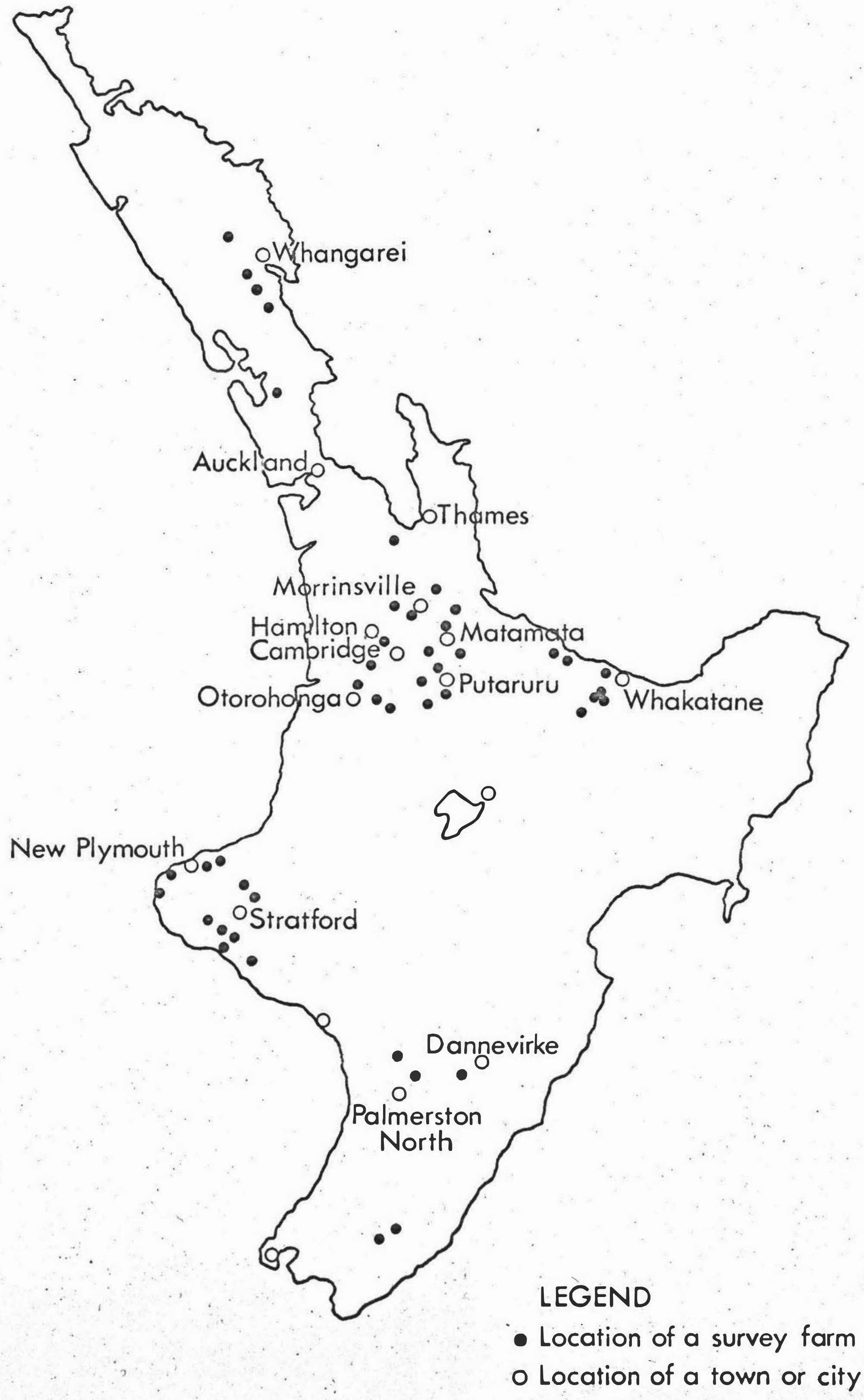
1. The modifications referred to are discussed in detail in section 4.2.
2. Because of the small number of farms available for selection in the upper two labour classes (i.e. four and five man farms), results from farms representing these two classes have been considered collectively in Group IV.
3. Any work performed by the wives, children or parents of <u>any</u> of the permanent labour units of a survey farm is described as work involving the use of family labour. This is further discussed in section 5.6, 6.

FIG. 5.1 LOCATION OF THE SURVEY FARMS



b) Group II

This group includes farms on which two permanent labour units are normally employed. On such farms, very little use is made of family labour.

c) Group III

This group includes farms where three permanent labour units are normally employed and cases where two permanent labour units and three permanent milking units are employed. (This latter situation represents farms on which a married couple is employed.) Very little use of family labour is made on these farms.

d) Group IV

This group includes farms where four or more permanent labour units are employed. Again very little use is made of family labour.

5.4 FARM AREA AND HERD SIZE

Table 5.1 shows the farm area, run-off area, and herd sizes of the survey farms. 4/ As shown in Table 5.1, the home farm areas ranged from 60 to 747 acres, and herd sizes from 60 to 650 cows in the 1968/69 season and from 67 to 760 cows in the 1969/70 season. Seventeen of the farms used additional areas in the form of run-offs or other farms. 5/

5.5 FARM ORGANISATION

Table 5.2 shows the form of ownership of the survey farms (at the time of the survey). From Table 5.2, of the 41 farms surveyed:

10 were described as owner operator organisations;
4 were described as family partnerships. These are indicated by the abbreviation (f);
3 were described as partnerships;

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4. Group I includes Farm Nos. 1 - 12.
Group II includes Farm Nos. 13 - 21.
Group III includes Farm Nos. 22 - 30.
Group IV includes Farm Nos. 31 - 41.
5. It should be noted that in the case of Farm No. 11, the run-off was acquired at the beginning of the 1969/70 season.

Table 5.1 Farm Area, Run-off Area, Herd Sizes of the Survey Farms

Farm. No. (1)	Area (acres) (2)	Run-off (acres) (3)	Herd Size 68/69 (4)	Herd Size 69/70 (5)	Farm No. (1)	Area (acres) (2)	Run-off (acres) (3)	Herd Size 68/69 (4)	Herd Size 69/70 (5)
1	60	12	60	67	22	238		225	266
2	69		90	96	23	209	other farm	232	262
3	90		89	88	24	284		250	280
4	103		101	108	25	350		335	270
5	112		116	120	26	335	other farm	406	345
6	160		130	143	27	246		308	305
7	215		138	130	28	240	11	310	315
8	279		142	152	29	258	40	289	293
9	230		220	215	30	320	90	380	340
10	223		184	267	31	372	other farms	350	370
11	200	65	224	210	32	247		274	278
12	429	500	366	333	33	310		320	340
13	107		150	162	34	225	80	284	284
14	125	80	138	140	35	253	66	280	280
15	151		161	169	36	300	40	298	325
16	127		154	158	37	300		350	350
17	173		208	212	38	347		390	398
18	272		226	226	39	325	110	458	462
19	180	other farm	242	235	40	747	138	650	760
20	147		205	211	41	330	60	496	464
21	278		330	340					

NOTES:

i) The farm area shown in column (2) refers to the surveyed acreage of the "home" farm.

ii) The third column shows the surveyed acreage of any additional land employed as a run-off. In some cases, other farms were farmed in conjunction with the farm in question, providing grazing and hay for the home farm. This is shown in the third column by the words 'other farm(s)'.

iii) Columns (4) and (5) refer to the number of cows in milk in December for the two dairying seasons, 1968/69 (Column (4)) and 1969/70 (Column (5)).

Table 5.2 Ownership of the Survey Farms

Farm No.	Form of Ownership	Farm No.	Form of Ownership
1	Owner Operator	22	Company
2	Partnership (f)	23	50% Sharemilker
3	Owner Operator	24	Partnership
4	Owner Operator	25	Combination (Trust - Company - Partnership (f))
5	50% Sharemilker		
6	50% Sharemilker	26	Company
7	25% Sharemilker	27	Combination (Trust - Company - Owner Operator)
8	Owner Operator		
9	Owner Operator	28	Owner Operator
10	50% Sharemilker	29	Partnership
11	Company	30	50% Sharemilker
12	Company	31	Company
13	Partnership (f)	32	Partnership (f)
14	Owner Operator	33	Combination (Company - 39% Sharemilker)
15	50% Sharemilker		
16	Owner Operator	34	Partnership (f)
17	Owner Operator	35	Owner Operator
18	Combination (50% Share-milker - Partnership)	36	Combination (Owner Operator - Trust)
19	Combination (39% Share-milker - Partnership (f))	37	Company
		38	Company
20	Combination (Owner Operator - Trust)	39	Trust
		40	Partnership
21	Company	41	Trust

7 were described as sharemilking arrangements;

8 were described as companies;

2 were described as trusts;

7 were described as combinations.

(Details of the various combinations are shown in Table 5.2 in brackets.)

5.6 LABOUR ON THE SURVEY FARMS

Detailed information was collected on the numbers and types of labour units employed on the survey farms and on various other aspects of labour use.

1) Numbers of Labour Units Employed on the Survey Farms

Table 5.3 shows the numbers of permanent labour units employed on the survey farms in the 1968/69 and 1969/70 dairying seasons.

From Table 5.3, it is apparent that the largest farm in terms of the number of labour units was Farm No. 40 where six labour units were employed in the 1969/70 season. It is important to note, however, that Farm No. 40 differed from all other survey farms in the utilisation of the labour force. Of the six labour units who were employed on Farm No. 40, on any normal working day, only five worked on the farm, the sixth being allowed a free day. (On this farm, free days were worked on a roster system which gave each member of the staff a free day every six days.)

It should also be noted that Farms Nos. 27, 29 and 38 in the 1969/70 season employed students for a period of 16 weeks over the summer months, in addition to the permanent labour force shown in the table. On Farms Nos. 27 and 29, a student was also employed for a similar period in the 1968/69 season. Farm No. 12 up until the 1969/70 season employed three permanent labour units. Because of the reorganisation of a family company and difficulties in obtaining suitable labour, the farmer in question decided to attempt to continue the farming enterprise single-handed. (The farmer's wife, however, assisted with milking.) The farmer was, however, after his experience in the 1969/70 season, confident that one labour unit was sufficient and proposed to continue in the 1970/71 season without employing any additional labour. [6] Conversely on Farm No. 26, where two labour units were employed in the 1969/70 season, it was

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6. For this reason, the farm has been classified as a Group I farm.

proposed to revert back to three in the 1970/71 season [7] as the work load was considered to be too great for two labour units.

It should be noted that on four of the Group IV farms, one [8] of the labour units was not employed full time on the particular farm surveyed being involved with other farms and activities. On two of these farms, the contribution made by such labour units was extremely low. Both estimated they spent only a quarter of their total working time on the farms in question.

2) <u>Types of Labour Units Employed on the Survey Farms</u>

The types of permanent labour units employed on the survey farms in the 1968/69 and 1969/70 seasons are shown in Tables A.1 - A.4 of Appendix A.

There were no marked differences between the three groups of farms which employed labour (i.e. Groups II, III and IV) in the type of labour employed. In all groups, there were examples of farms on which either single or married male labour was employed, and in the case of the latter two groups, examples of farms on which both were employed. On only one farm (Farm No. 38) was a land girl employed but as indicated earlier, the period of employment was for 16 weeks in the summer of the 1969/70 season.

3) <u>Numbers and Types of Milking Units Employed on the Survey Farms</u>

The number of milking units employed on the survey farms in the 1968/69 and 1969/70 dairying seasons is shown in Table 5.4. Details of the types of milking units employed on the survey farms in the 1968/69 and 1969/70 seasons are shown in Tables A.5 - A.8 of Appendix A.

On six of the Group I farms, wives were utilised as milking units. [9] On a further two farms of Group I, wives assisted with the milking in the spring months only. The only other examples of women making a substantial contribution to the milking force were:

a) On Farm No. 16, where the owner operator was replaced in the milking shed from October to February, in the both seasons, by the wife of the employed man.

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7. As three labour units were employed in the 1968/69 season and a similar number was to be employed in the 1970/71 season, the farm has been classified as a Group III farm.
8. On all such farms the labour unit in question was concerned with the managerial function.
9. In the 1968/69 season, on one of these farms (Farm No. 9), the farmer's wife did not milk.

Table 5.3 Numbers of Permanent Labour Units Employed on the Survey Farms

1968/69 Season		1969/70 Season	
No. of Permanent Labour Units	Farm Numbers	No. of Permanent Labour Units	Farm Numbers
1	1 - 11	1	1 - 12
2	13 - 22	2	13 - 22, 24, 26
3	12, 23 - 31, 36	3	23, 25, 27 - 30
4	32, 34, 35, 38	4	31, 32, 34 - 36, 38
5	33, 37, 39 - 41	5	33, 37, 39, 41
		6	40

NOTE: Permanent labour units are considered to be those who are employed for a complete season, and who contribute to the physical work of the farm or perform the managerial function. Those performing the entrepreneurial function only have been excluded. On some farms, particular labour units were involved with other farms and activities. In such cases, no attempt has been made to apportion such a labour unit's time between the various farms and activities. The labour unit has been classified as one permanent labour unit for the farm in question.

Table 5.4 Numbers of Milking Units Employed on the Survey Farms

1968/69 Season		1969/70 Season	
No. of Milking Units	Farm Numbers	No. of Milking Units	Farm Numbers
1	1, 2, 5, 6, 9, 11	1	1, 2, 5 - 7, 11
2	3, 4, 7, 8, 10, 13 - 21	2	3, 4, 8 - 10, 12 - 21, 26
3	22 - 31, 34 - 36	3	22 - 25, 27 - 30, 34 - 36
4	12, 32, 33, 37 - 39, 41	4	31 - 33, 37 - 39, 41
5	40	5	
		6	40

NOTE: Milking units are considered to be only those who are normally engaged with milking for the entire duration of the milking season. Additional labour may be utilised for milking, on the various survey farms, for varying periods of time during the season. This has not been included in the data shown in Table 5.4. It is discussed however later in the text.

b) On Farm No. 38, where the manager who milked during the spring and autumn months was replaced over the summer months by the wife of an employed labour unit (1968/69) and by a land girl (1969/70).

c) On Farms Nos. 22 and 24, where married couples were employed.[10] The employment of such labour typically provides one labour and two milking units.

On nine farms in Group IV, a labour unit [11] was not employed as a full time milking unit but acted as a relief milker only. On four of these Group IV farms, however, the labour unit in question milked during the spring months.

4) Ratio of Cows per Labour Unit

The ratio of cows per labour unit for the survey farms in the 1968/69 and 1969/70 seasons is shown in Table 5.5. The ratio of cows per labour unit was extremely high in the uppermost subclass of Group I. On four farms (e.g. Farm Nos. 9, 10, 11, 12), in the 1969/70 season, the ratio was above 200. Some high ratios of cows per labour unit were also recorded in the corresponding subclasses of the other three groups, but they were not as high as those of Group I. The maximum figures for each group being: Group I - 333; Group II - 170; Group III - 140; and Group IV - 126.6. [12]

5) Ratio of Cows per Milking Unit

Table 5.6 shows the ratio of cows per milking unit for the survey farms in the two seasons 1968/69 and 1969/70.

In terms of cows per milking unit, the differences between the groups tend to be less marked than comparable figures relating to cows per labour unit. For example, the maximum [12] ratio for each of the four groups is: Group I - 210; Group II - 170; Group III - 113.3; Group IV - 126.6.

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10. A married couple was employed on Farm No. 24 only in the 1969/70 season.
11. On all such farms, the labour unit in question was concerned with the managerial function.
12. It should be noted that Farm No. 26 has been excluded from this comparison as in the 1969/70 season, only two labour units were employed. As discussed earlier, the normal complement of labour for this farm is considered to be three labour units.

Table 5.5 Ratio of Cows per Labour Unit.

Farm Number	Cows per Labour Unit 1968/69	Cows per Labour Unit 1969/70	Farm Number	Cows per Labour Unit 1968/69	Cows per Labour Unit 1969/70
1	60.00	67.00	22	112.50	133.00
2	90.00	96.00	23	77.30	87.30
3	89.00	88.00	24	83.30	140.00
4	101.00	108.00	25	111.60	90.00
5	116.00	120.00	26	135.30	172.50
6	130.00	143.00	27	102.60	101.60
7	138.00	130.00	28	103.30	105.00
8	142.00	152.00	29	96.30	97.60
9	220.00	215.00	30	126.60	113.30
10	184.00	267.00	31	116.60	92.50
11	224.00	210.00	32	68.50	69.50
12	122.00	333.00	33	64.00	68.00
13	75.00	81.00	34	71.00	71.00
14	69.00	70.00	35	70.00	70.00
15	80.50	84.50	36	99.33	81.20
16	77.00	79.00	37	70.00	70.00
17	104.00	106.00	38	97.50	99.50
18	113.00	113.00	39	91.60	92.40
19	121.00	117.50	40	130.00	126.60
20	102.50	105.50	41	99.20	92.80
21	165.00	170			

NOTE: The ratio of cows per labour unit has been derived by dividing the herd size as shown in Table 5.1 by the number of labour units shown in Table 5.3.

Table 5.6 Ratio of Cows per Milking Unit.

Farm Number	Cows per Milking Unit 1968/69	Cows per Milking Unit 1969/70	Farm Number	Cows per Milking Unit 1968/69	Cows per Milking Unit 1969/70
1	60.00	67.00	22	75.00	88.60
2	90.00	96.00	23	77.30	87.30
3	44.50	44.00	24	83.30	93.30
4	50.50	54.00	25	111.60	90.00
5	116.00	120.00	26	135.30	172.50
6	130.00	143.00	27	102.60	101.60
7	69.00	130.00	28	103.30	105.00
8	71.00	76.00	29	96.30	97.60
9	220.00	107.50	30	126.60	113.30
10	92.00	133.50	31	116.60	92.50
11	224.00	210.00	32	68.50	69.50
12	91.50	166.50	33	80.00	85.00
13	75.00	81.00	34	94.60	94.60
14	69.00	70.00	35	93.30	93.30
15	80.50	84.50	36	99.30	108.30
16	77.00	79.00	37	87.50	87.50
17	104.00	106.00	38	97.50	99.50
18	113.00	113.00	39	114.50	115.50
19	121.00	117.50	40	130.00	126.60
20	102.50	105.50	41	124.00	116.00
21	165.00	170.00			

NOTE: The ratio of cows per milking unit has been derived by dividing the herd size as shown in Table 5.1 by the number of milking units shown in Table 5.4.

6) Dependence of the Survey Farms on Family and Casual Labour and Contractors

Table A.9 of Appendix A shows the use made by the survey farms of family labour, casual labour and contractors.

Dependence on Family Labour in the 1969/70 Season

There was a tendency for the farms of Group I to make a greater use of family labour for milking than the farms of the other three groups. For example, on six of the Group I farms, wives milked full time. On two other farms in Group I, wives assisted with the milking in the spring time only. The only other examples of wives milking full time were the two farms in Group III on which married couples were employed. Farm No. 16, as noted earlier, was the only other example of a wife contributing substantially to the milking labour force. On some other farms, wives contributed to the milking force as relief milkers allowing some or all of the milking units time off during the milking season.

Similarly, there was a greater tendency for family labour to assist with other farm work on the Group I farms. The other main farming operation which utilised family labour was calf rearing. On six of the Group I farms, family labour was used for calf rearing. Comparable figures for the other three groups are two in Group II, two in Group III and one in Group IV. The range of farm operations in which family labour was involved was on some farms much wider than that discussed above. Typically this occurred on farms where there were children of secondary school age and included such tasks as haymaking, stock work and tractor work. On three farms, family labour in the form of parents [13] was used for various farm operations.

Dependence on Casual Labour and Contractors in the 1969/70 Season

The extent to which casual labour and contractors were used on the survey farms varied considerably. Table 5.7 shows a number of farm operations for which casual labour or contractors could be employed and the proportion of farms within each group which employed casual labour or contractors for these particular operations.

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13. On Farm Nos. 7 and 29, the fathers of the farm operators assisted with some farm operations, while in the case of Farm No. 10, the farm operator's father-in-law assisted.

Table 5.7 Proportion of Farms within each Group which Employed Casual or Contract Labour for a Number of Farm Operations

Operation	Group I	Group II	Group III	Group IV
1) Hay Loading	11/12	8/8	4/8	6/11
2) Casual Labour for Silage Making	2/4	2/4	0/4	1/9
3) Repairs and Maintenance	3/12	2/9	0/9	1/11
4) Relief Milkers (for time-off)	2/3	3/6	3/8	0/11
5) Hay Baling	11/12	7/8	4/8	5/11
6) Silage Making	4/4	2/4	1/4	1/9
7) Topdressing	8/12	9/9	8/9	4/11

NOTES:

i) The proportion of farms in each of the four groups on which hay was made and contractors and casual labour were employed for hay loading is shown in Row 1). (i.e. In Group I, 12 farmers made hay and 11 employed contractors or casual labour for hay loading.)

ii) The proportion of the farms on which silage was made, where casual labour was employed for this operation, is shown in Row 2). (i.e. In Group I, four farmers made silage and two employed casual labour.)

iii) The proportion of farms on which casual labour was employed for repairs and maintenance work is shown in Row 3).

iv) The proportion of farms on which time-off was taken by the milking units during the season, and where such time-off was obtained by employing relief milkers is shown in Row 4). (i.e. On three Group I farms, time-off was taken, on two of these farms, the time-off was obtained by employing relief milkers.)

v) The proportion of farms, on which hay was made and where contract balers were employed is shown in Row 5).

vi) The proportion of farms on which silage was made and where contractors were employed is shown in Row 6).

vii) The proportion of farms where topdressing contractors were employed is shown in Row 7).

There was a trend towards a greater input of casual labour on the Group I farms, particularly for work which is difficult to perform alone. For instance, on eleven farms in Group I, some casual labour (or contract labour) was employed to assist with the loading of hay. Similarly on two of the four farms in Group I which made silage, casual labour was employed to assist in the harvest field. Further on three of the Group I farms, casual labour was employed for the normal repairs and maintenance work. Comparable figures for the other three groups are shown in Table 5.7.

The number of farms on which the milking units took, or were allowed, time-off during the milking season increased from Group I to Group IV. (This will be discussed in more detail later on page 51. It was particularly noticeable that the provision of such time-off on Group IV farms did not entail the employment of any casual labour. On these farms, a reduced milking staff was able for a short period to easily handle the increased ratio of cows per milking unit, and further most of these farms had unused capacity for milking in the form of a labour unit who was not a regular milker. The provision of time-off on farms in the other three groups was in most cases accomplished by utilising either family or casual labour.

Similarly, there was a trend for the farms of Groups III and IV to make less use of contractors and so engage the farm staff in a greater range of farm operations. For example 11/12 and 7/8 of the farmers who made hay in Groups I and II used contract balers. For Groups III and IV the corresponding figures were 4/8 and 5/11. A similar trend is discernible from the table in the case of silage making. In the case of topdressing, however, there was a trend towards the Group IV farms only making less use of contractors and consequently a greater use of the farm staff.

It should be noted that on Farms Nos. 9, 10, 11, 12, 21 and 40 where the ratio of cows per labour unit was extremely high, extensive use was made of casual labour and contractors.

7) Working Times, Milking Times, Time-off and Holidays

Table A.10 of Appendix A presents data on the hours of work 14/ of the permanent labour units, milking times, time-off and holidays available to the permanent labour units of the various survey farms. The data shown in the table indicates:

a) That on some of the farms (e.g. Farm Nos. 10, 11, 12, 26) where the ratio of cows per labour unit was extremely high, the working hours of the labour units in the spring tended to be extremely high.

It is interesting to note that on two of the farms where the ratio of cows per labour unit was high (e.g. Farm Nos. 9 and 11), the labour input during the winter months moved to the other extreme, becoming extremely low. In both cases, winter grazing was obtained for the herd which did not involve the permanent labour units in question in any work.

14. Two estimates of the hours worked by the labour units of the survey farms in a normal working day and week at two periods of the year are shown in Table A.10 of Appendix A. Detailed estimates of the hours worked for a complete season were not collected, as it was felt that this would prove to be too time consuming.

b) The labour units on the farms of Group III and IV in general tended to work shorter hours in the spring time than their counterparts in Groups I and II; no such trend was discernible in the data relating to the second period, the winter.

As would be expected, the milking times varied considerably within each group. It is interesting to observe that on six of the Group I farms, the spring morning milking took $2\frac{1}{2}$ hours or more. In the other three groups, there were fewer examples of the spring morning milking time being of such length. Comparable figures for the other groups are four in Group II, two in Group III and one in Group IV.

As noted earlier, on all Group IV farms some provision was made for the milking units to take time off during the milking season. Comparable figures for the other three groups are three in Group I, six in Group II, and eight in Group III.

The provision of time off, plus the shorter spring working hours discussed earlier, suggests that in general the total labour input over the season (in terms of hours) of each of the permanent labour units on the Group III and IV farms, was likely to be less than those of the Group I and II farms.

8) <u>Specialisation and Division of Labour on the Survey Farms</u>

The following question was put to all farmers in Groups II, III and IV. "Do you and any of your employees specialise in particular jobs? Who and what jobs?" (A work sheet was used to assist in the collection of data on the specialisation and division of labour.)

On all farms, there was to some extent some division and specialisation of labour. At one extreme was one farm on which all except two tasks (repairs and maintenance to machinery and calf rearing) were shared between all members of the staff. At the other extreme were two farms on which there was a most noticeable division of labour between stock and machinery work and nine farms on which the most senior member of the staff specialised in four or five specific tasks.

From the replies to the question, work on the survey farms in relation to division and specialisation of labour can be divided into three classes.

a) Jobs which were regarded as being extremely vital to the profitable organisation of the farm. This includes the various components of stock work such as bringing and taking the herd to and from the farm dairy mating management, bloat control, calf rearing and various animal health activities.

b) Jobs requiring special skills or experience, such as machinery work (e.g. haymowing, haybaling, ploughing, off-farm contracting), repairs and maintenance to machinery and buildings and fencing.

c) Jobs which were regarded as being less vital to the profitable organisation of the farm, or which require no (or little) special skills or experience, (e.g. tedding hay, topdressing, weed control, cleaning farm dairies and yards, general repairs and maintenance. [15/])

Discussion

Class I

Eighteen of the twenty-nine farmers questioned emphasised that in their view it was most important for management to bring the cows to (and in some cases from) the milking shed. One difficulty encountered in milking a large number of cows, it was stated, is that management does not see every cow each milking and so has to rely on the staff to detect and report any abnormalities in the herd. By driving the cows to (and from) the milking shed, management has an opportunity to see each cow at least two (or four) times per day. Three managers stressed the importance of this, particularly during the artificial breeding season.

Eighteen of the twenty-eight farmers who used A.B. [16/] indicated that one labour unit specialised in the detection of in-season cows for mating. In all cases, this was performed by a senior member of the staff.

Calf rearing, on eighteen of the twenty-nine farms was a specialist task, although this did not necessarily involve the most senior member(s) of the staff. On fourteen farms, bloat prevention was the responsibility of one person.

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15. Tedding hay and topdressing were regarded by a number of farmers as being jobs which required little skill or experience. Cleaning milking yards, general repairs and maintenance work, and weed control were cited as three jobs which were not vital to the profitable organisation of the farm.
16. A.B. is an abbreviation for Artificial Breeding.

Class II

Of the twenty-nine farmers questioned, nineteen indicated that one labour unit tended to specialise in the repairs and maintenance work done on the farm.

Hay cutting was performed by the senior member(s) of the staff in fifteen cases. Of the twelve farms using their own balers, in eight cases, the baler was operated by the most senior staff member(s). The same was true of all six farmers who undertook some form of outside contracting with machinery.

Class III

These jobs tended to be the responsibility of the more junior and inexperienced members of the staff. On three of the farms, where Farm Cadets were employed, any division and specialisation of labour was not markedly pronounced as the cadets were being instructed in all basic farming skills.

5.7 MACHINERY USED ON THE SURVEY FARMS

Farmers were asked to name the items of machinery they used [17] on the farm and to indicate whether the machinery was:

a) Owned;[18]

b) Shared;

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17. Data on machinery usage were collected only for the 1969/70 dairying season. Items of machinery which were not used on an annual basis however, such as hedgecutters, drain cleaners, etc. were included in the list of machinery.

18. The term 'owned' is used in this context to indicate that in the case of farms where the organisation is described as:

    i) An owner operator organisation;

    ii) Family partnership;

    iii) Partnership;

    iv) Company;

    v) Trust;

    the machine can be viewed as an asset of the organisation in question. Similarly, where the organisation is described as a combination, the machine can be regarded as an asset of one of the components of the combination. Where the organisation is described as a sharemilking agreement, the term 'owned' is used to denote machinery which can be viewed either as an asset of the sharemilker or the other party to the sharemilking agreement.

c) Borrowed;

d) Rented or hired;

e) Supplied by contractors;

There were no marked differences in the range [19] of machinery used on the four groups of survey farms. Variations did occur on particular farms within each group mainly because of the growing of forage crops, the conservation of different forms of supplementary feed, and the presence on some farms of drains and hedges.

On some farms in Groups III and IV various items of machinery were used which were not found on the farms of the other two groups. Typically these items of machinery were such that if they were to be used on most of the farms in Groups I and II, the cost of such items per unit of output would be extremely high. For example, on one farm an irrigation plant was used, on another the machinery complement included a self unloading hay trailer, while on another a self unloading silage trailer was used.

There was a trend towards the numbers of tractors and of particular items of machinery which were used on the survey farms, to increase from Group I to Group IV. However in terms of the ratio of cows per tractor, there did appear to be some advantage to some of the Group II, III and IV farms. (The lowest ratios were found in Group I where four were under 100. The highest (two) were recorded in Group III and IV, being 345 and 380 respectively.) Similarly, advantages seemed likely to accrue to some of the farms of Groups II, III and IV because of a high ratio of cows to particular items of machinery.

The numbers of tractors and of particular items of machinery which the survey farms used, tended to increase from Group I to Group IV for the following reasons:

i) There was a general trend for the farms of Group III and IV to make less use of contractors and so to own more of the machinery used on the farm, particularly for harvesting operations. In order to complete such work as quickly and effectively as possible, a number of tractors (and of particular types of machines) were considered necessary.

19. i.e. Types of machine.

ii) The late winter and early spring, because of the need to feed large quantities of supplementary feed and to perform a great deal of stock work, was a further period when the requirements for tractors and associated implements on some of the Group III and IV farms was relatively high.

iii) It was noticeable that as farm size (in terms of acres) increased, there was a trend towards the use of a tractor as a means of transport about the farm. [20]

There would appear to be, therefore, two periods of the year when the requirements for tractors on some of these farms was extremely high. As it is usually not possible to borrow or hire tractors for these periods, the farmers tended to own that number of tractors which satisfied the "peak demand" accepting that for the rest of the year one or more of the tractors was not required. Similarly, farmers tended to own that number of other items of machinery which were required to meet the "peak demand". However, as detailed information was not collected on the size of the various items of machinery, the data on the numbers of particular items of machinery used on the survey farms should be interpreted carefully.

There was a considerable variation in the size of the tractors (in terms horsepower) used on a particular farm and between farms. There was a tendency for those farmers in Group III and IV who owned such items of machinery as hay balers, forage harvesters, draincleaners and front-end loaders to have a large tractor to power such implements. It was also noticeable that in Groups III and IV the additional tractors used were usually smaller tractors and further they were often old models. Further, the tractors used on the farms where contractors were employed extensively, were either small or extremely old tractors.

There was a tendency for the farms of Groups III and IV to own [21] a greater range of the machinery used on the farm and so to make less use of contractors. Table 5.8 shows the proportion of farms in each of the four groups where various items of machinery were owned by the farm in question.

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20. This is discussed later in section 5.17.

21. The phrase "owned by the farm" means the machine(s) in question can be regarded as an asset of the appropriate farm organisation (e.g. Trust, Company, Owner Operator, etc.).

Table 5.8 Proportion of Farms in Each Group Owning Various Items of Machinery

Item of Machinery	Group I	Group II	Group III	Group IV
1) Trucks	2/12	1/9	0/9	5/11
2) Hay Balers	1/12	1/8	4/8	6/11
3) Hay Loaders	1/12	0/8	5/8	6/11
4) Flail or Forage Harvesters	0/4	2/4	3/4	8/9
5) Topdressers	4/12	0/9	1/9	7/11

NOTES: i) The proportion of farms in each of the four groups owning trucks is shown in Row 1).

ii) The proportion of farms making hay in each of the four groups where the farm owned the baler used is shown in Row 2).

iii) The proportion of farms making hay in each of the four groups where the farm owned the hay loader used is shown in Row 3).

iv) The proportion of farms making silage in each of the four groups where the farm owned the flail or forage harvester used is shown in Row 4).

v) The proportion of farms in each of the four groups where fertiliser was applied entirely with machinery owned by the farm is shown in Row 3).

An examination of Table 5.8 reveals that for all items of machinery listed, the proportion of farms owning such items of machinery was greatest in Group IV.

Most of the machinery used on the survey farms was either owned (by the farms) or supplied by contractors. There were some instances of machinery being rented or hired and borrowed but these were of minor significance. Farm No. 8 provided the only example of a machinery sharing agreement in which most of the major items of machinery were shared between three farms.

On only six farms was off-farm contracting undertaken. Of the six, two were Group II farms, two Group III farms, and two Group IV farms. In all cases, the work in question was hay contracting (i.e. hay mowing or hay baling).

5.8 BUILDINGS ON THE SURVEY FARMS

A check list was used to obtain a list of the buildings on each of the survey farms. Farmers were then asked the question "What buildings do you consider you could not do without?" This question allowed the author to formulate some ideas as to what the farmers considered to be the minimum building investment necessary for their respective farms. Buildings which farmers considered they could do without included:

a) Particular types of buildings which for various reasons had in the past been duplicated, but with changes in circumstances one (or more) of these buildings was considered to be unnecessary for the effective running of the farm, (e.g. houses, barns, implement sheds, etc.)

b) Buildings which because of changes in farming systems, were now considered to be obsolete (e.g. calf sheds, manure sheds, etc.)

On some farms the building complement did not include certain types of buildings. In such cases, the farmer was asked if he would like the particular building in question to be erected. Where the reply was in the affirmative, the particular building was added to the list of buildings denoting the minimum building investment necessary.

All farmers felt tractor sheds, implement sheds, farm dairies, some form of workshop, barns [22] and dwellings were buildings they could not do without.

The number of houses the farmers considered their respective farms required in general tended to increase as one moves from Group I to Group IV. However extremely high ratios (i.e. cows per house) were achieved by the following Group I farms, Farm Nos. 9, 10, 11 and 12. (On all these farms, the ratio was in excess of 200.[23] As mentioned earlier, with the exception of Farm No. 11, on all these farms, wives were employed as full time milking units, thereby allowing one house to accommodate two milking units. The ratio of cows per house was extremely low in Groups II, III and IV where the staff consisted entirely of married men. (Each married man employed required one house.)

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22. There was one exception. On Farm No. 16, no hay was made, silage being the only form of supplementary feed. Consequently a barn was not considered necessary on this farm.
23. The ratio is based upon the data of the 1969/70 season.

Certain farms in Groups II, III and IV were able to achieve extremely high ratios because of the employment of single labour. This is most noticeable in the case of Farms Nos. 17, 30, 37 and 40. (The ratios were Farm No. 17, 212, Farm No. 30, 170, Farm No. 37, 175 and Farm No. 40, 253.) In the case of Farms Nos. 37 and 40, although five and six permanent labour units were employed on the two farms respectively, only two houses were needed for Farm No. 37 and three for Farm No. 40. In the case of Farm No. 37, the manager was paid to board all three single boys, while in the case of Farm No. 40, all four single boys occupied one house. The employment of married couples also tended to give rise to an extremely high ratio as two milking units were accommodated in one house.

Table 5.9 shows the type and size of the farm dairies on the survey farms. (Size of farm dairy is measured in terms of the number of sets of cups.) Table 5.9 indicates that with the exception of Farms Nos. 4, 5 and 19, on all farms a type of herringbone farm dairy was used.

There were some differences between the farms in the range of other buildings the farmers considered they required. On six of the farms, it was felt some form of wintering device was required. There was some disagreement as to the place of calf sheds and manure sheds. Typically those who reared calves on nurse cows or employed bulk topdressing contractors felt these two types of buildings could be dispensed with. Further it was noted that other types of buildings could substitute for them if the need should arise. On one farm a slaughter house was provided enabling the farm staff to obtain a regular supply of perquisite meat.

There were some variations in the types and sizes of buildings used on the survey farms but with the exception of farm dairies, detailed information was not collected.

5.9 EQUIPMENT, SUBDIVISION, FARM RACES AND WATER RETICULATION SYSTEMS

1) Equipment used on the Survey Farms

Information was collected on the usage of a number of selected items of equipment, most of which were considered to be of a labour saving nature. Farmers were also asked to name any other items of equipment they used which they considered to be important labour saving devices.

Table 5.9 Size and Type of Farm Dairies on the Survey Farms.

Farm No.	Type of Farm Dairy	Size (No. of sets of cups)	Farm No.	Type of Farm Dairy	Size (No. of sets of cups)
1	HB/HLS	8	22	HB/HLDU	20
2	HB/HLS	8	23	HB/LLDU	24
3	HB/HLS	6	24	HB/HLS	16
4	WT/DU	8	25	HB/HLS	20
5	WT/S	5	26	HB/HLS	24
6	HB/HLS	9	27	HB/HLS	20
7	HB/HLS	8	28	HB/HLS	18
8	HB/HLS	8	29	HB/HLS	20
9	HB/HLS	18	30	HB/HLS	24(2 pits)
10	HB/HLS	10	31	HB/HLS	33
11	HB/HLS	12	32	HB/HLS	20
12	HB/HLS	20	33	HB/HLS	24
13	HB/HLS	12	34	HB/HLDU	24
14	HB/HLS	8	35	HB/HLDU	24
15	HB/HLS	11	36	HB/HLS	20
16	HB/HLS	10	37	HB/HLDU	48(2 pits)
17	HB/HLS	11	38	HB/HLS	24
18	HB/LLDU	20	39	HB/HLDU	48(2 pits)
19	A/P	16	40	HB/HLS	50
20	HB/HLDU	20	41	HB/HLS	28(2 pits)
21	HB/HLS	14			

NOTE: The following abbreviations are used to denote the various types of farm dairy.

WT/DU	:	Doubled up walk through.
WT/S	:	Single walk through.
HB/HLS	:	Highline single herringbone.
HB/LLDU	:	Lowline doubled-up herringbone.
HB/HLDU	:	Highline doubled-up herringbone.
A/P	:	Angle park.

Motorbikes were used on some farms in all four groups. (Motorbikes were used on five Group I farms, two Group II farms, five Group III farms and two Group IV farms.)

Items of equipment such as welders and bloat applicators were used on farms of all four groups. Welders appeared to be equally distributed between the four groups, while bloat applicators were used most frequently on Group I farms. (6/15 were found on Group I farms.)

Telephone systems from the farm dairy to the house(s) were used on twelve farms, tending to occur more frequently on farms of the latter three groups. For example, telephone systems were used on one Group I farm, five Group II farms, three Group III farms and four Group IV farms.

Cattle sprayers were used on farms of all four groups, being used most frequently however on the farms of Group IV where they were used on seven farms. Comparable figures for the other groups were, three on Group III farms, one on Group II farms and one on Group I farms.

Various other items of equipment were used on the survey farms. Of particular interest was a set of cattle scales found on one Group III farm. This, according to the farmer, had proved to be a most useful aid for such tasks as drenching young stock and wintering cows. 24/

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24. The farmer in question weighed all young stock prior to each drenching. Knowledge of each animal's weight allowed the farmer to administer the correct quantity of drench. Similarly a periodic check was made of each animal's live weight during winter. Any animal, for which excessive live weight losses were recorded was given preferential wintering treatment.

In all four groups, the highline single herringbone milking plant was used most frequently. Of the four farmers using a double pit herringbone dairy, three indicated that because of difficulties in the supervision and organisation of milkers, single pit herringbone dairies would be preferred.

Only five farmers indicated that they had encountered problems with the operation of the milking machines. Two farmers in Group IV felt the problem had not yet been rectified and had given rise to poor milkfat production per cow and a high incidence of mastitis in the herd. A further three (one in Group III and two in Group IV) stated that although they were now satisfied with the performance of the milking machines, the bringing of the milking plants to a satisfactory standard of performance had been a time consuming and expensive task.

Shed wash-down units were found on all farms, while on only twelve of the farms surveyed were effluent disposal units installed. (Again there was no marked tendency for such disposal units to occur more frequently in any particular group.)

Fourteen farms had in place cleaning devices installed in the milk vats. These devices which were built-in, to only the extremely large milk vats, were described by all fourteen farmers as being extremely effective labour saving devices.

2) Subdivision on the Survey Farms

The number of permanent paddocks into which the farms were sub-divided (for grazing by the herd during the milking season) varied considerably, there being a trend towards a larger number of permanent paddocks on the farms where the larger herds were run. Twenty four farms had 35 or more permanent paddocks which were used for grazing the herd over the milking season. (On twenty of these farms, the herd size exceeded 250 cows.)

3) Farm Races

Data were first collected on the width of races on the various farms and second, farmers were asked to indicate whether they felt the width of races on their particular farms was satisfactory for their particular herds. The actual width of races found on the survey farms varied considerably both within an individual farm and between farms, there being examples of wide races on farms where small herd sizes were run and vice versa.

From the replies to the second question, it was apparent that in general, it was considered that larger herds necessitated wider races. However, a race width of twenty five feet (fence to fence) would appear to be of sufficient width to handle the largest herd size encountered (i.e. 760 cows). There were no marked differences between the farms in the construction of races.

4) Water Reticulation Systems

Only on four farms was a supply of water not available to the herd in every paddock. Pipe sizes used tended to increase as herd sizes increased. (The main pipeline increasing from $\frac{3}{4}$" diameter on seven Group I farms to 2" diamter on two Group IV farms.)

5.10 STOCKING RATES

Actual stocking rates are difficult to determine exactly because of differences between farms in such things as the grazing out of young stock, the raising of other livestock products such as beef and lamb, and varying degrees of utilisation by stock of so called waste areas.

Table A.11 of Appendix A consists of seven columns which if studied collectively give an indication of the actual stocking rates on the survey farms.

It can be seen that the stocking rates on the survey farms were reasonably high. Thirty-four of the forty-one survey farms were stocked at a rate of one milking cow per effective acre or above (based on the 1969/70 season). Of the remaining seven, which were stocked at below one milking cow per effective acre, six were completely self-contained.[25] Further, four of the above six also farmed other livestock such as beef steers and dairy heifers for sale. Four farmers fed meal. In all cases the quantity was small, its use being confined to the early spring. Two farmers fed mother liquor,[26] one feeding substantial quantities throughout the dairying season. Nine farmers bought hay, but in all nine cases, at least fifty per cent of the hay used was made on the home farm. On twenty-eight farms, young stock were grazed away from the home farm. In all cases, this involved the rising two year heifers (usually for a period of twelve months) and in ten cases, calves were involved as

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25. No feedstuffs were bought and no livestock were grazed out.
26. Mother liquor is a by-product of lactose production.

well.[27] On three farms the herd was grazed away from the home farm for a period during the winter. In two cases as noted earlier (Farms Nos. 9 and 11), this was done to relieve the labour force rather than as a means of acquiring extra feed.

It is interesting to observe that the stocking rate as expressed in column 4 of Table A.11 of Appendix A was for all Group IV farms one milking cow per effective acre or greater. However, on only one farm in Group IV, was no grazing out of stock practised. The highest stocking rates as indicated in column 4 were on Farms Nos. 13, 20, 39 and 41, all being above 1.4 milking cows per effective acre.

5.11 MILKFAT PRODUCTION ON THE SURVEY FARMS

1) Milkfat Production per Cow and per Acre

The milkfat production per cow and per acre of the survey farms for the 1968/69 and 1969/70 seasons is shown in Tables 5.10 and 5.11.

It should be realised that the method of calculating the milkfat per cow and per acre statistics shown in Tables 5.10 and 5.11 differs from that adopted by official sources of such statistics, such as the New Zealand Dairy Board. The New Zealand Dairy Board in their Annual Farm Production Report publish what is known as the effective average production per cow. This figure is derived by dividing the total amount of milkfat sent from a farm to the factory by the number of cows in milk in December. This method has not been adopted in Tables 5.10 and 5.11 because it was apparent to the author, that the numbers and percentages of calves reared either for dairying or beef production on the various survey farms varied considerably. (Percentage of calves reared refers to the total number of calves reared expressed as a percentage of the total number of cows wintered.) Consequently, the milkfat per cow figures shown in Table 5.10 will be greater than the "effective average production" figures because of the addition to the total milkfat supplied to the factory of an estimate of the milkfat used for calf rearing.

Similarly, the numerator used in the calculation of the milkfat per acre figures shown in Table 5.11 is the total milkfat supplied to the

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27. e.g. On 9 farms the grazing period for calves (i.e. the time the calves were away from the "home" farm) extended over approximately 18 months. The calves were sent out to graze immediately after weaning and were returned as rising two year old heifers. On one farm, the calves were grazed away from the home farm for two months to relieve grazing pressure on the home farm in the autumn.

Table 5.10 Production per Cow of the Survey Farms

Farm No.	Milkfat per cow 1968/69	Milkfat per cow 1969/70	Farm No.	Milkfat per cow 1968/69	Milkfat per cow 1969/70
1	392	367	22	324	307
2	327	291	23	318	238
3	365	293	24	317	240
4	375	357	25	242	243
5	349	239	26	212	208
6	325	254	27	306	283
7	331	366	28	308	298
8	328	323	29	346	308
9	234	243	30	266	205
10	286	254	31	246	227
11	281	248	32	320	303
12	203	216	33	274	235
13	296	272	34	320	267
14	329	273	35	332	291
15	335	283	36	318	244
16	387	317	37	306	233
17	321	297	38	300	294
18	302	243	39	296	260
19	286	277	40	228	198
20	337	276	41	309	296
21	265	224			

NOTE: Milkfat per cow has been obtained by dividing the total milkfat production by the number of cows in milk in December.

Table 5.11 Production per Acre of the Survey Farms

Farm No.	Milkfat per acre 1968/69	Milkfat per acre 1969/70	Farm No.	Milkfat per acre 1968/69	Milkfat per acre 1969/70
1	413	432	22	311	349
2	426	405	23	359	304
3	361	287	24	283	240
4	399	406	25	238	193
5	369	261	26	269	224
6	325	280	27	388	355
7	228	238	28	401	395
8	173	182	29	403	364
9	228	231	30	326	225
10	263	340	31	234	229
11	318	264	32	370	355
12	212	206	33	303	275
13	423	420	34	421	345
14	378	318	35	379	333
15	382	340	36	344	288
16	480	405	37	369	281
17	398	375	38	340	340
18	263	211	39	424	375
19	394	370	40	203	206
20	494	407	41	472	423
21	339	395			

NOTE: Milkfat per acre has been calculated by dividing the total milkfat production by the effective area of the farm.

factory plus an estimate of the milkfat used for calf rearing. The denominator is the effective number of acres, which is defined as the area in any form of pasture, crop, races and buildings. (Surveyed acreage and effective acreage differ because of waste areas which are not utilised by stock.)

For comparative purposes, the milkfat production per cow of the survey farms has been recalculated using the method adopted by the New Zealand Dairy Board. (That is the "effective average production" per cow has been calculated.) This is shown in Table 5.12.

Tables 5.10, 5.11 and 5.12 indicate that there is a trend towards a decline in both milkfat per cow [28] and milkfat per acre on the farms. where the ratio of cows per labour unit is high, (e.g. Farm Nos. 9, 10, 11, 12, 21 and 40). The highest milkfat per cow figures (as shown in both tables) were achieved on Farm Nos. 1, 3, 4, and 16 - all being above 350 pounds of milkfat per cow. Some farms in all four groups produced at a level above 400 pounds of milkfat per acre. It is interesting to note that Farm No. 41 (which produced the greatest total quantity of milkfat in the 1968/69 season) produced at a level per acre which was only surpassed by Farm Nos. 16 and 20. Such information, however, should be considered carefully along with the data given in Table A.11 of Appendix A.

It was interesting to note that thirteen of the survey farms had in previous seasons supplied a greater total quantity of milkfat to the factory. As detailed information was not collected on the number of calves reared, estimates of the quantities of milkfat used for calf rearing in previous seasons could not be made. Similarly as detailed information was not collected on farm areas in use in those seasons, no calculations of milkfat production per acre for previous seasons could be made. Of particular interest, however, are the "effective average production" per cow figures. Table 5.13 shows the "effective average production" per cow achieved and the corresponding herd size of the thirteen farms, in the season the maximum total milkfat production was sent to the factory.

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28. It should be realised that in the 1969/70 season, many dairying districts experienced a severe drought. Consequently the discussion that follows is confined to the data of the 1968/69 season.

Table 5.12 "Effective Average Milkfat Production" per Cow on the Survey Farm

Farm No.	"Effective Average Production" 1968/69	"Effective Average Production" 1969/70	Farm No.	"Effective Average Production" 1968/69	"Effective Average Production" 1969/70
1	392	367	22	317	300
2	321	286	23	309	231
3	357	286	24	310	233
4	366	353	25	219	232
5	341	232	26	206	200
6	318	248	27	299	278
7	325	359	28	302	293
8	318	315	29	339	302
9	227	239	30	258	196
10	278	246	31	230	219
11	273	243	32	313	296
12	199	205	33	271	230
13	296	264	34	320	255
14	312	261	35	325	283
15	319	276	36	311	235
16	384	314	37	284	210
17	315	292	38	293	287
18	296	235	39	290	254
19	282	272	40	222	192
20	330	268	41	301	289
21	256	216			

Table 5.13 "Effective Average Production" per Cow in the Seasons of Maximum Milkfat Production

Farm No.	Milkfat per cow	Herd Size	Farm No.	Milkfat per cow	Herd Size
4	389	98	25	233	335
9	286	205	31	280	320
11	326	193	33	263	345
12	237	352	37	320	380
13	289	163	39	292	458
14	314	150	40	271	576
19	331	235			

2) Milkfat Output per Labour Unit

The output of the survey farms in terms of milkfat production per labour unit in the 1968/69 and 1969/70 seasons is shown in Table 5.14. It can be seen that the output per labour unit of some of the Group I farms was extremely high. For example, Farm Nos. 5, 6, 7, 8, 9, 10 and 11. On only one other farm (Farm No. 21) were comparable figures achieved. The output per labour unit was relatively low however on the following Group IV farms. Farm Nos. 32, 33, 34, 35 and 37. This was due either to a low ratio of cows per labour unit or a poor level of production per cow, or both.

3) Milkfat Output per Milking Unit

Table 5.15 shows the milkfat production per labour unit of the survey farms in the 1968/69 and 1969/70 seasons. The data shown indicates that the following Group I farms, 5, 6, 9 and 11 also achieved a relatively high output per milking unit. Again only Farm No. 21 achieved comparable figures in the other three groups. If these five farms are ignored, differences between the groups in terms of the maximum output of milkfat per milking unit become less marked. In such circumstances, the maximum output per milking unit was achieved by Farm No. 41. (The farm which produced the greatest total amount of milkfat.)

Such data however should be interpreted carefully along with the information presented earlier on various aspects of labour usage.

Table 5.14 Milkfat Production per Labour Unit

Farm No.	Milkfat per Labour Unit 1968/69	Milkfat per Labour Unit 1969/70	Farm No.	Milkfat per Labour Unit 1968/69	Milkfat per Labour Unit 1969/70
1	23,528	24,591	22	36,401	40,822
2	29,404	27,976	23	24,556	20,763
3	32,480	25,797	24	26,388	33,536
4	37,910	38,569	25	27,001	21,876
5	40,559	28,694	26	28,743	35,896
6	42,300	36,455	27	31,442	28,735
7	45,677	47,554	28	31,785	31,338
8	46,613	49,135	29	33,369	30,090
9	51,567	52,218	30	33,734	23,217
10	52,543	67,987	31	28,652	21,031
11	62,880	52,236	32	21,910	21,032
12	24,753	71,940	33	17,565	15,952
13	22,211	22,039	34	23,137	18,987
14	22,698	19,081	35	23,207	20,391
15	26,957	23,939	36	31,565	19,787
16	29,769	25,080	37	21,392	16,301
17	33,409	31,501	38	29,285	29,266
18	34,175	27,442	39	27,125	24,018
19	34,660	32,547	40	29,676	25,127
20	34,571	29,089	41	30,680	27,533
21	43,784	38,048			

NOTE: The output per labour unit figures shown in Table 5.14 have been derived by dividing the total milkfat production (as defined on page 63) by the numbers of labour units shown in Table 5.3

Table 5.15 Milkfat Production per Milking Unit

Farm No.	Milkfat per Milking Unit 1968/69	Milkfat per Milking Unit 1969/70	Farm No.	Milkfat per Milking Unit 1968/69	Milkfat per Milking Unit 1969/70
1	23,528	24,591	22	24,267	27,215
2	29,404	27,976	23	24,556	20,763
3	16,240	12,898	24	26,388	22,357
4	18,955	19,294	25	27,001	21,876
5	40,559	28,694	26	28,743	35,896
6	42,300	36,455	27	31,442	28,735
7	22,838	47,554	28	31,785	31,338
8	23,307	24,567	29	33,369	30,090
9	51,567	26,109	30	33,734	23,217
10	26,272	33,993	31	28,652	21,031
11	62,880	52,236	32	21,910	21,032
12	18,564	35,970	33	21,956	19,941
13	22,211	22,039	34	30,850	25,316
14	22,698	19,081	35	30,943	27,188
15	26,957	23,939	36	31,565	26,383
16	29,769	25,080	37	26,740	20,377
17	33,409	31,501	38	29,285	29,266
18	34,175	27,442	39	33,906	30,002
19	34,660	32,547	40	29,676	25,127
20	34,571	29,089	41	38,350	34,441
21	43,784	38,048			

NOTE: The data shown in Table 5.15 has been derived by dividing the total milkfat production (as defined on page 63) by the numbers of milking units shown in Table 5.4.

5.12 STOCK LOSSES AND HERD WASTAGE

1) Stock Losses

Tables 5.16, 5.17, 5.18 and 5.19 present data concerning the various sources of stock losses on the survey farms in the 1968/69 and 1969/70 seasons.

There were no marked differences between the four groups of farms in terms of cow losses. The highest figures recorded were those of Farms Nos. 21 and 33 in the 1968/69 season. Both farms were located in the same district and the high losses were put down to a severe outbreak of facial eczema during the autumn of 1968. Early spring losses consequently were extremely high.

Similarly there appeared to be no marked difference between the four groups of farms in terms of the percentage of heifers lost. There were two farms on which the losses however appeared to be relatively high (i.e. Farm No. 18 (1968/69) and Farm No. 25 (1969/70)). In both cases, the high losses were said to have resulted from the young stock being used to "stock" newly developed areas.

Calf losses (both bulls and heifers) varied considerably within each group. In both seasons, within each group, there were farms where there were no losses. The highest losses recorded were those of Farms Nos. 2, 23, 31 and 40 in the 1968/69 season and of Farm No. 31 in the 1969/70 season. On Farms Nos. 23 and 40, serious difficulties were encountered in the 1968/69 season resulting in serious outbreaks of scours. The apparently high losses on Farm No. 2 were due to the death of <u>only two calves</u> out of a total of twenty-two, while the relatively high losses recorded on Farm No. 31 in both seasons, were due to an ill thrift problem.

Finally there appeared to be no great differences between the four groups of farms in terms of the availability of live calves.

2) Herd Wastage

Table 5.20 presents information on herd wastage on the survey farms in the 1968/69 and 1969/70 seasons. The wastage figures as presented in Table 5.20 should be carefully interpreted. In some cases, such figures may be high because of factors which are to some extent outside the

Table 5.16 Percentage Losses of Cows on the Survey Farms

Farm No.	Losses 1968/69	Losses 1969/70	Farm No.	Losses 1968/69	Losses 1969/70
1	1.6	0.0	22	2.5	1.8
2	4.1	3.0	23	4.3	3.0
3	4.4	6.6	24	3.0	3.1
4	0.0	1.0	25	6.3	2.3
5	0.0	N.A	26	2.0	1.3
6	5.6	3.2	27	3.1	0.9
7	3.6	2.1	28	1.5	2.7
8	1.4	3.8	29	2.8	3.0
9	2.6	1.3	30	3.9	3.2
10	5.2	2.8	31	1.4	3.5
11	1.8	N.A	32	2.7	2.0
12	3.2	1.1	33	10.8	N.A
13	1.9	1.2	34	3.8	1.3
14	1.4	1.4	35	5.3	4.3
15	6.3	N.A	36	0.7	1.2
16	1.9	1.7	37	1.3	3.4
17	2.3	4.5	38	2.4	1.9
18	4.8	1.6	39	3.3	5.5
19	3.6	2.0	40	N.A	4.4
20	2.3	2.7	41	1.9	3.5
21	10.8	5.9			

NOTES: i) The figures shown in Table 5.16 have been calculated by expressing the number of cows which died on each of the survey farms, in the two seasons, as a percentage of the maximum numbers of cows wintered, plus any additional cows bought during the season.

ii) N.A. denotes 'Not available'.

Table 5.17 Percentage Losses of Heifers on the Survey Farms

Farm No.	Losses 1968/69	Losses 1969/70	Farm No.	Losses 1968/69	Losses 1969/70
1	0.0	0.0	22	3.2	3.5
2	4.3	5.0	23	0.0	1.8
3	0.0	0.0	24	1.5	1.5
4	4.4	0.0	25	0.0	17.1
5	0.0	N.A	26	0.0	2.1
6	0.0	2.9	27	0.0	2.5
7	0.0	0.0	28	1.5	3.0
8	0.0	0.0	29	0.0	0.0
9	0.0	1.7	30	2.7	0.0
10	4.4	1.8	31	1.8	4.9
11	0.0	N.A	32	1.5	0.0
12	0.0	0.0	33	N.A	N.A
13	0.0	2.1	34	4.3	1.6
14	0.0	3.1	35	0.0	0.0
15	0.0	N.A	36	0.0	0.0
16	0.0	0.0	37	2.9	2.7
17	6.4	2.3	38	0.0	1.9
18	11.5	1.6	39	0.0	6.1
19	0.0	N.A	40	1.5	1.5
20	5.7	8.6	41	0.0	1.3
21	1.4	0.0			

NOTES: i) The figures shown in Table 5.17 have been calculated by expressing the number of heifers which died on each of the survey farms, in each of the two seasons, as a percentage of the total number of (yearling) heifers wintered.

ii) N.A. denotes 'Not available'.

Table 5.18 Percentage Losses of Calves on the Survey Farms

Farm No.	Losses 1968/69	Losses 1969/70	Farm No.	Losses 1968/69	Losses 1969/70
1	0.0	0.0	22	1.7	0.0
2	11.0	0.0	23	12.5	2.8
3	0.0	0.0	24	1.4	4.1
4	0.0	0.0	25	2.0	0.0
5	2.5	N.A	26	1.9	2.6
6	0.0	2.6	27	0.0	1.6
7	0.0	0.0	28	0.0	3.0
8	5.4	2.1	29	5.9	4.2
9	5.8	4.7	30	0.0	2.1
10	6.3	2.1	31	11.3	17.6
11	5.8	N.A	32	0.0	0.0
12	3.3	0.0	33	4.0	N.A
13	0.0	0.0	34	1.4	3.3
14	0.0	1.5	35	7.7	3.1
15	4.3	N.A	36	0.0	0.0
16	0.0	0.0	37	6.3	6.3
17	6.6	2.4	38	0.0	0.0
18	1.5	2.8	39	3.7	0.0
19	0.0	N.A	40	12.3	7.4
20	3.2	3.2	41	0.6	4.1
21	1.4	0.0			

NOTES: i) The figures shown in Table 5.18 have been derived by expressing the number of calves which died (both pre and post weaning losses) as a percentage of the total number of calves reared, intended for replacement purposes.

ii) N.A. denotes 'Not available'.

Table 5.19 Calving Percentages on the Survey Farms

Farm No.	Percentage of Live Calves	Farm No.	Percentage of Live Calves
1	93	22	92
2	90	23	93
3	98	24	95
4	96	25	93
5	95	26	90
6	92	27	93
7	93	28	90
8	91	29	86
9	92	30	91
10	91	31	96
11	87	32	91
12	96	33	88
13	75	34	N.A
14	93	35	87
15	N.A	36	93
16	91	37	86
17	N.A	38	93
18	95	39	86
19	95	40	82
20	95	41	90
21	92		

NOTES: i) The figures shown in Table 5.19 have been derived by expressing the number of live calves as a percentage of the maximum number of cows wintered.

ii) N.A. denotes 'Not available'.

Table 5.20 Herd Wastage on the Survey Farms

Farm No.	Wastage 1968/69	Wastage 1969/70	Farm No.	Wastage 1968/69	Wastage 1969/70
1	17.6	14.5	22	24.7	15.3
2	19.4	19.8	23	21.5	18.9
3	16.5	36.3	24	27.3	23.8
4	12.8	14.4	25	14.9	34.3
5	19.4	N.A	26	24.2	41.3
6	33.8	21.1	27	24.1	25.8
7	34.6	27.6	28	15.1	18.9
8	18.3	20.0	29	24.4	28.0
9	22.2	13.9	30	34.2	37.3
10	24.9	33.4	31	25.6	26.0
11	47.4	N.A	32	20.1	22.0
12	30.2	13.4	33.	N.A	N.A
13	32.9	21.9	34	24.4	21.3
14	17.6	13.9	35	21.8	25.0
15	26.1	N.A	36	12.7	16.4
16	23.7	29.8	37	14.5	19.1
17	14.6	12.6	38	28.2	26.7
18	25.0	13.5	39	16.3	23.8
19	4.8	13.4	40	N.A	26.4
20	34.1	28.0	41	21.2	31.6
21	21.6	33.2			

NOTES: i) The figures shown in Table 5.20 have been calculated for each farm by summing the culling percentage and the percentage of cows which died. The culling percentage has been calculated by expressing the number of cows culled, as a percentage of the maximum number of cows wintered plus any additional cows bought during the season. The percentage of cows which died in each herd is shown in Table 5.16.

ii) N.A. denotes 'Not available'.

farmers' control or are such that they are unlikely to occur each season. For example, the apparently high wastage figures of Farm No. 11 (1968/69 season) were due to excessive culling in order to reduce cow numbers. (A decision which because of a later change in circumstances, which led to a decision to maintain cow numbers in the next season, necessitated the purchasing of additional stock.) Similarly in the case of Farm No. 3, the apparently high wastage rate in the 1969/70 season was due to a severe outbreak of facial eczema in the autumn of 1970, while in the case of Farm No. 26, the high wastage rate was due to a desire to replace a large number of animals with animals of higher genetic merit.

Further such figures alone give very little information about the incidence of disease or the general state of the herd as it was apparent that different farmers base their culling upon different criteria. In this context, five farms (Farm Nos. 20, 25, 30, 38 and 40) indicated that an important factor influencing their culling policies was the relative price of replacement and boner cows. Similarly, low wastage figures may result from a desire to increase cow numbers and are not necessarily indicative of low disease incidence or a favourable state of the herd. (This explains the extremely low figure of Farm No. 19 recorded in the 1968/69 season.)

A recent study conducted by the New Zealand Dairy Board (30, p.52) indicated that the average wastage in New Zealand herds in the 1968/69 season was 20.71 per cent. The proportion of farms in each of the four groups where the wastage rate was greater than 20.71 per cent in the 1968/69 and 1969/70 seasons is shown below:

a)	Group I	6/12	(1968/69)	4/10	(1969/70)
b)	Group II	6/9	"	4/8	"
c)	Group III	7/9	"	6/9	"
d)	Group IV	6/9	"	8/10	"

5.13 <u>HERD IMPROVEMENT PRACTICES</u>

1) <u>Herd Testing</u>

Of the forty-one farmers, twenty-two farmers herd tested during the 1969/70 dairying season. Of these:

7 used the Monthly system;

13 used the Alternate monthly system;

2 used the Production ranking test.

(For a description of the various herd testing systems, see (31, pp.5 - 8)

2) Artificial Breeding

Of the forty-one farms surveyed, all but one (Farm No. 19) did not use the Standard Artificial Breeding service. The length of the Artificial Breeding service period adopted on the survey farms varied considerably between farms. The distribution is shown in Table 5.21.

Table 5.21 Distribution of the Length of the Artificial Breeding Service Period According to Group Size

Group	Length of Artificial Breeding Service Period		
	0 - 21 days	22 - 42 days	43 days or more
Group I	2	4	6
Group II	1	4	3
Group III	1	4	4
Group IV	1	5	5

3) Breed of Herd

Although detailed information was not collected, the overall impression gained was that the herds were predominantly of the Jersey breed. (Only on Farm No. 11 was the herd entirely Friesian.) There did however appear to be a trend towards the Friesian breed. Of the forty farmers using A.B., twenty-seven indicated that they were either using or intended to use some Friesian semen.

4) Artificial Breeding Procedures

All farmers were asked to describe in detail what procedures they normally adopted in order to select in-season cows for artificial breeding. Although procedures adopted varied widely, it was possible to identify nine separate procedures which were used either alone or in combination. The nine procedures were:

a) The use of records of pre-mating heats.

b) In-season cows were detected while the herd was being driven to (and from) the farm dairy night and morning.

c) The herd was observed in the paddock for some time before going to the farm dairy, and any in-season cows noted.

d) Other members of the farm staff watched the herd enter the milking yards prior to milking, noted any in-season cows, and compared their observations with those made by the farm staff member driving the herd.

e) Some time was spent by one or more members of the farm staff before milking, looking at the whole herd in the milking yard.

f) Before each batch of cows was released from the herringbone, one milker moved along the edge of the milking platform looking for marks on the cows' backs. (Such marks were taken as evidence that a cow was likely to be in-season.)

g) The herd was held in a small holding paddock, after milking, close to the milking shed and checked for in-season cows prior to returning to pasture.

h) Special visits were made to the paddocks where the herd was grazing, during the day to check for in-season cows (and bloat).

i) The herd was observed for a period immediately after being returned to pasture from the milking shed.

The use of such procedures on the various survey farms is shown in Table A.12 of Appendix A. It is hoped that the table does not convey the impression that those procedures marked were the only ones used by the farmers in question and the others were entirely excluded. Those marked are those which the farmer in question felt important and used regularly, (i.e. on most days during the Artificial Breeding service period). The other procedures, not marked, may be used by such farmers to a greater or lesser extent. It is apparent from Table A.12 that the range of procedures adopted on the various survey farms varied considerably. As would be expected, the most popular procedure was Procedure b). As data was not collected on the time devoted to each procedure, it is difficult to make any factual comments on the total time the labour force on the various survey farms spent performing the task. The overall impression gained by the author was that increasing herd sizes requires the labour force to devote a proportionately greater amount of time to this activity. The reasons being:

i) As size of herd increases, it becomes increasingly difficult for one person to notice all the in-season cows within a herd.

ii) The use of herringbone farm dairies (rather than walk through dairies) to milk large herds, which because the milkers work in a pit at a lower level than the cows, means that it is more difficult to notice in-season cows during milking.

iii) As it apparently becomes increasingly difficult to know every cow individually within a herd, as herd size increases, [29] it is less likely that in-season cows can be recognised from a distance. Instead labour must get within close proximity to the animal, to identify her, or in cases where animals are not identified, (i.e. not numbered), to mark her.

5) Percentages of Empty [30] Cows and Empty Heifers

Table 5.22 and Table 5.23 show the percentages of empty cows and empty heifers respectively on the survey farms. The data relates to the 1968/69 and 1969/70 seasons.

In terms of the percentage of empty cows, there appeared to be little difference between the four groups of farms. The highest figures recorded were those of Farm No. 6 and Farm No. 37 (1968/69 season). In the case of Farm No. 6, the relatively high percentage of empty cows was attributed to an outbreak of vibrio. The relatively high percentage of empty cows recorded on Farm No. 37 however, was attributed to a severe outbreak of facial eczema in the autumn of 1968, resulting in the herd being in poor condition when mated in the spring of 1968.

Similarly, there appeared to be little difference between the four groups of farms in terms of the percentage of empty heifers. The relatively high percentage of empty heifers recorded on Farm No. 6 in the 1968/69 season was also attributed to the outbreak of vibrio. In the case of

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29. This is discussed in more detail in section 5.13, 6).
30. The term 'empty' is synonymous with the phrase 'not in calf'.

Table 5.22 Percentage of Empty Cows on the Survey Farms

Farm No.	Percentage of empty cows 1968/69	Percentage of empty cows 1969/70	Farm No.	Percentage of empty cows 1968/69	Percentage of empty cows 1969/70
1	10.0	7.5	22	6.2	7.1
2	8.8	7.3	23	7.7	11.4
3	2.2	3.4	24	8.8	5.7
4	6.9	2.8	25	9.0	5.6
5	10.3	N.A	26	6.1	5.8
6	32.8	8.4	27	3.9	9.5
7	10.1	13.8	28	4.9	6.0
8	2.9	7.9	29	10.4	7.8
9	6.8	10.7	30	9.2	5.3
10	4.9	4.1	31	7.2	4.3
11	5.3	N.A	32	8.0	6.5
12	5.5	3.0	33	9.1	N.A
13	1.3	2.5	34	10.6	9.2
14	5.3	7.9	35	4.3	2.9
15	5.6	N.A	36	6.1	15.4
16	7.7	6.3	37	20.0	10.9
17	2.9	5.7	38	5.1	5.0
18	3.1	6.2	39	6.6	13.2
19	1.2	4.3	40	4.9	8.2
20	6.9	4.7	41	10.0	8.6
21	10.6	3.2			

NOTES: i) The percentages of empty cows shown in Table 5.22 have been calculated by expressing the number of empty cows (at the end of the season) as a percentage of the number of cows in milk in December.

ii) N.A. denotes 'Not available'.

Table 5.23 Percentage of Empty Heifers on the Survey Farms

Farm No.	Percentage of empty heifers 1968/69	Percentage of empty heifers 1969/70	Farm No.	Percentage of empty heifers 1968/69	Percentage of empty heifers 1969/70
1	8.3	0.0	22	1.6	1.8
2	8.7	0.0	23	4.8	3.6
3	0.0	6.5	24	7.4	4.4
4	0.0	0.0	25	1.7	15.3
5	3.3	N.A	26	2.1	3.1
6	28.6	20.0	27	2.4	0.0
7	2.5	6.3	28	0.0	1.5
8	2.7	13.0	29	1.3	1.3
9	8.9	23.3	30	7.1	5.6
10	4.4	3.6	31	2.4	9.1
11	N.A	N.A	32	4.4	1.4
12	5.7	6.9	33	N.A	N.A
13	2.0	0.0	34	4.3	4.7
14	0.0	6.3	35	2.6	0.0
15	N.A	N.A	36	5.7	8.1
16	2.6	5.3	37	5.7	5.3
17	4.3	9.3	38	2.7	1.9
18	4.9	4.8	39	0.0	0.0
19	0.0	N.A	40	7.4	7.6
20	3.8	1.7	41	2.0	0.0
21	0.0	1.4			

NOTES: i) The percentages of empty heifers shown in Table 5.23 have been calculated by expressing the number of empty heifers (at the end of the season) as a percentage of the number of heifers wintered.

ii) N.A. denotes 'Not available'.

Farm No. 25, in the 1969/70 season, the relatively high percentage of empty heifers was attributed to the heifers being in poor condition, due to being grazed on recently developed areas of the farm.

6) <u>Means of Identification</u>

Of the forty-one farmers surveyed, only one did not have any permanent means of herd identification (Farm No. 19). Of the forty with permanent herd identification:

Twenty-one used a form of acid branding;
Fifteen used eartags;
Two used both eartags and a form of acid branding;
One used fire branding;
One used freeze branding.

As it was considered initially [31] that it was extremely unlikely that the managers (or any of the farm staff) of large herds knew each cow individually, and further as some considered this to be a technical diseconomy, all farmers were asked:

a) "Do you know every cow in the herd individually? (i.e. If a list of names or numbers of cows was read out, could you visualise each cow?)".

b) To those who answered "Yes", a further question was asked, "Do you think it is an advantage? (i.e. knowing every cow individually)".

To those who answered "No", the corresponding question was, "Do you think it is a disadvantage? (i.e. not knowing every cow individually)".

The results are shown in Column 10 of Table A12 of Appendix A. Of the forty-one farmers, sixteen indicated that they did know every cow individually. Of these, eight were in Group I, three in Group II, one in Group III and four in Group IV. (On one farm, Farm No. 19, there was no permanent means of herd identification, i.e. neither names nor numbers. The question discussed above in a) could not therefore be asked. However, the farmer claimed he knew them all, meaning that when confronted with a particular animal, he would be able to describe some

31. The author obtained this impression from discussions with Extension Officers prior to carrying out the survey.

of the cow's characteristics.) The remaining twenty-four farmers indicated that they knew varying percentages of their herds. (Thirteen indicated that they knew ninety per cent or more while two believed the staff collectively knew all cows.)

The sixteen who replied that they knew all cows individually all considered it was an advantage. Of the twenty-four who did not, seven felt it put them at no disadvantage, while the remaining seventeen considered they were at a disadvantage because of it. Fourteen farmers claimed that selecting in-season cows required less effort when one knew all cows individually because of the reasons discussed earlier. 32/ Twelve claimed such knowledge was advantageous as milking techniques could be modified according to the individual requirements of each cow. Eleven noted that it was extremely useful from a stock health point of view. They considered that a knowledge of each cow's habits meant that any abnormalities due to poor health could be quickly detected and remedied. In this context, six farmers stated that they, because of being able to remember a particular animal's susceptibility to metabolic and calving disorders, were able to give such animals the necessary preferential treatment. Similarly two farmers used particular cows as marker cows for bloat. Other advantages mentioned were first, general stock work. Such tasks as separating individual cows from the herd for such things as preferential wintering treatment, or for culling, are more easily done if one knows each individual animal. Second, herd testing. In a herringbone farm dairy, herd testing is made easier and quicker if one is able to recognise individual cows without having to resort to reading each number. (This can be time consuming if the animals are branded on the rump, or ear tags are used as a means of identification.) Third, interest. On two farms, where there was a large number of cows per milker, some knowledge of individual cows was cited as a means of overcoming the boredom which was felt to be inherent in milking a large number of cows per milking unit.

Six of the seven farmers who felt not knowing every cow individually put them at no disadvantage explained that in their herds they knew only the cows which required individual attention. This they added was likely to be a very small percentage of their herds.

The data from Column 10 of Table A.12 has been reorganised into Table 5.24. Table 5.24 divides the survey farms into six classes based

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32. See section 5.13, 4).

on herd size. The proportion of farmers in each of the six classes who indicated they knew each cow individually is shown in Column (2). As the proportion shown in Column (2) tends to decline as one moves down the table (i.e. as herd size increases) this supports the contention made earlier [33] that as herd size increases, it becomes increasingly difficult to know each cow individually.

Table 5.24 Proportion of Farmers Knowing Every Cow in the Herd Individually According to Size

Range of Herd Size (1)	Proportion Answering Yes (2)
0 - 99	3/3
100 - 149	3/5
150 - 199	2/4
200 - 249	3/6
250 - 299	2/9
300 +	3/14

5.14 STOCK HEALTH

1) All farmers were asked to describe the preventive and treatment methods they used for a number of animal health problems, and further were asked to discuss any other animal health problem which concerned them. It was hoped this question would make apparent any major differences between the survey farms in the incidence of the various animal health problems and in the preventive methods adopted.

a) Bloat

Only one farmer did not undertake some method of bloat prevention (in the 1969/70 season). There appeared to be little to suggest that bloat differed in severity between the four groups of farms. There was however a considerable variation between farms in the preventive methods employed and in the quantities of materials used.

33. This contention was made in Section 5.13, 4).

b) <u>Metabolics</u>

In the absence of a detailed study on the incidence of the various metabolic disorders in the herds concerned, little can be said about the incidence of such disorders. The impression gained by the author however was that the incidence of metabolic disorders did not vary greatly between the four groups of farms. For example, on six of the Group I farms, some form of preventive for grass staggers and acidosis was fed in the 1969/70 season. Such a procedure was also adopted on four farms of each of the other three groups.

c) <u>Mastitis</u>

All farmers stated that they had some cases of mastitis each year. Again, in the absence of a detailed study, it is difficult to reach any valid conclusions on the severity of the problem in the various herds.

d) <u>Facial Eczema</u>

This appeared to be related more to locality than to herd size per se. Only eleven farmers surveyed had, or intended to, take preventive measures during the 1969/70 season.

e) <u>Internal Parasites</u> 34/

All farmers indicated that they normally undertook some drenching programme for calves. The frequency of drenching and the material used varied considerably. The highest frequency of drenching was recorded on fifteen farms where calves were drenched at three to four weekly intervals from weaning until twelve months of age. Of these two were Group I farms, three were Group II farms, five were Group III farms and five Group IV farms.

f) <u>External Parasites</u> 35/

On all but one farm, calves were sprayed for lice. On nineteen farms, calves were treated more than once. On twenty-

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34. Haemonchus placei, Oestestagia ostertgi, Trichostrongylus axei (i.e. stomach worms), Dictyocoulus vivipcrus (i.e. lungworm).
35. Damalima bovis, Linognathus vituli (i.e. lice).

one farms, adult stock were sprayed as well.

g) Other Animal Health Problems

Problems discussed here appeared to be mainly district problems and not related to herd size per se. Twenty-two farmers had no comments to make on this subject.

2) In order to obtain some indication of the farmers' opinions of the effect of animal numbers on stock health problems, on all farms in Groups II, III and IV, and on five farms in Group I, where the cows numbers exceeded 150 cows, the following question was asked. "Do you feel you have to pay more attention to stock health than say a one man farm (milking 80 - 100 cows) would?"

Twelve replied that calf rearing was more difficult with larger mobs of calves. A greater incidence of scours, worms and ill thrift was thought to result. Two qualified their statements by saying calf rearing was a problem only when Jersey calves were reared. In their opinion, there was little trouble with Friesian calves.

Eight replied that herd size had some effect on animal condition. This particularly applied to the two year old heifers, a relatively high proportion of which, it was said, ended their first lactation in comparatively poor condition.

Five farmers indicated that it was more difficult to notice an animal suffering from a disorder in a larger herd compared with a small herd, and consequently an animal suffering from a disorder could remain undetected and untreated for a longer time. (This it was said necessitates the management on such farms spending more time observing the stock.) In this context, two farmers noted that they, on multi-labour unit farms, were dependent on the labour to detect, treat, and take steps to prevent the various disorders which could arise. If the labour adopted a lackadaisical attitude, serious animal health problems could arise. The problem it was said was accentuated in a double pit herring-bone farm dairy. In such cases, there are in effect two herds as it is thought that the individual cows tend to prefer a particular pit. A manager, if a full time milking unit, in such circumstances normally would only see half the cows per milking. Disorders such as mastitis, it was considered could easily arise on multi-labour unit farms in such circumstances.

Mr. D. C. Anderson, the Senior Veterinarian of the Rangitaiki Plains Dairy Company, was also asked to give his impressions of the effect of animal numbers on stock health problems. As he personally visits four of the Group IV farms and one of the Group III farms and since the district is characterised by a wide range of herd sizes, it was felt that the veterinarian in question should be in a position to provide some authoritative answers. A summary of the interview follows.

a) There appears to be little relationship between the incidence and severity of bloat and herd size.

b) There is little to suggest there is any relationship between herd size and the incidence of metabolic disorders. (Metabolics however are not a great problem in this district.)

c) It is more likely that larger herds (i.e. herds of 300 cows or more) will have mastitis problems. The reason being that management is unlikely to embark upon the same procedures as those adopted by farmers with smaller herds because of the seemingly vastness of the task.

d) In the Rangitaiki Plains District, the larger herds appear to be less severely affected by facial eczema than the smaller herds.

e) The larger the number of calves being reared the more difficult the task. Initially, losses are likely to be high but as calf rearers gain experience and their stockmanship improves, the losses tend to drop. A variety of methods are being used successfully to rear large numbers of calves.

f) Lice could be more of a problem in larger herd because if one animal is missed, (which could occur more easily with a large number of animals), such an animal could act as a reservoir and reinfect the remainder.

g) Infertility (empty cows) would be the main animal health problem in larger herds. This is due mainly to difficulties in the detection of in-season animals.

h) There appears to be little problem from "population diseases". Population diseases include a wide range of conditions including:

i) Infectious respiratory conditions (e.g. catarrh and enteritis);

ii) Stress conditions;

iii) Infectious abortion conditions (e.g. leptospirosis and brucellosis).

5.15 DISTANCES OF TRAVEL AND TIME AWAY FROM PASTURES

Data were collected, for all survey farms, on the longest distances the herd had to walk from a grazing paddock to the milking shed, the time the herd normally took to walk such a distance and from this, in conjunction with milking times and any other relevant data,[36] an estimate made of the longest time a cow would be away from pasture to be milked in any twenty-four hour period.

Table 5.25 shows the longest distances and the estimates of time away from pasture for all survey farms. The figures (shown in Column (1)) indicate that the walking distances, although in general being greater on the farms where larger herds were run, could, on specific farms because of a favourable layout, be relatively low. (e.g. Farm Nos. 12, 25, 26 and 34.)

No attempt was made to obtain information which would enable the average time the cows in each of the survey herds were away from pasture per day over the whole season, or any parts of the season, to be calculated. The collection of such information, it was felt, would be too time-consuming. Further it should be noted that the figures shown in Column (2) of Table 5.25 will relate only to a small number of days during the season, because of seasonal changes in the total milking times and the adoption on all survey farms of rotational grazing practices.

From the table, it is apparent that with the exceptions of Farms Nos. 1, 2, 3, 4, 11, 18, 21 [37] there were no marked differences between the

36. In some cases, during the spring, the herd was held in a holding paddock close to the shed for some time after milking in order to detect in-season cows for artificial breeding.

37. On Farm Nos. 1, 2 and 3, the longest time cows were away from pasture was less than 240 minutes. On Farm Nos. 4, 11, 18 and 21, the longest time cows were away from pasture was greater than 400 minutes.

Table 5.25 Longest Distances of Travel and Maximum Times Away from Pasture

Farm No.	Longest Distance Chains (1)	Time Away from Pasture Minutes (2)	Farm No.	Longest Distance Chains (1)	Time Away from Pasture Minutes (2)
1	30	210	22	45	310
2	30	240	23	75	350
3	50	230	24	60	320
4	64	450	25	40	270
5	60	360	26	40	370
6	25	360	27	60	320
7	60	360	28	80	345
8	80	320	29	80	390
9	80	315	30	80	320
10	50	355	31	100	330
11	68	485	32	80	335
12	56	360	33	100	360
13	32	280	34	40	315
14	70	300	35	60	375
15	100	360	36	70	350
16	60	270	37	80	395
17	60	360	38	80	330
18	40	415	39	80	380
19	20	375	40	80	340
20	60	390	41	80	350
21	100	450			

NOTES: i) The figures shown in Column (1) are in some cases estimates rather than exact measurements.

ii) The figures shown in Column (2) refer in all but two cases to the last cow or group of cows. (Two farmers indicated that all cows were held in a holding paddock after milking before being allowed to return to grazing.)

survey farms in terms of figures shown in Column (2). The relatively short times recorded on Farms Nos. 1, 2 and 3 were the result of relatively short milking times and the short distances the herd had to travel. The comparatively long times observed in the case of Farm Nos. 4, 11, 18 and 21 appear to be due to:

a) An extremely long milking time (Farm Nos. 4, 11, 18 and 21). (It should be noted that the ratio of cows per milking unit was extremely high on Farm Nos 11 and 21.)

b) A rigid twenty-four hour grazing rotation (Farm Nos. 4 and 18).

c) A relatively slow droving time (Farm Nos. 4, 18 and 21).

d) A relatively long walking distance (Farm Nos. 11 and 21).

5.16 PECUNIARY ECONOMIES

On all farms in Groups II, III and IV and on the five farms in Group I where the herd numbers exceeded 150 cows, three questions concerning pecuniary economies were asked.

1) Contract Services

The first question was concerned with contract services. The question was "Do you feel you get preferential service from contractors over a one man farm (of 80 - 100 cows) in:

a) Getting the job done;
b) The rates you pay;

Of the thirty-four farmers who were asked the question, only three indicated that the rates they paid for contractural services differed from those they felt applied to a one man farm. Of the three, one (Farm No. 30) had been able to negotiate a ten per cent reduction in fertiliser spreading rates. Another (Farm No. 31) regularly called tenders for haymaking (i.e. mowing, raking, baling and carting) and by accepting the lowest tender, believed there was a price reduction of five cents per bale. The third (Farm No. 8) indicated that he, with two other farms, was able to collectively bargain for reductions in certain contractural services. Five farmers while answering the question commented that a more likely source of cost reductions for contractural services was from prompt payment. Thirteen of the thirty-four farmers indicated that they believed contractors gave them some preferential treatment, particularly topdressing and haybaling contractors. One farmer, who was also a haybaling contractor himself, indicated that he preferred to deal with larger clients.

It should be noted that the use made by contractors in general tended to decline from Group I to Group IV. In this context, seven farmers indicated that they seldom used contractors, and the work for which they employed contractors was usually of a non-urgent nature, such as hedge-cutting and drain cleaning and so preferential treatment from contractors was of little importance. Further, because a given farm is of a greater acreage, and carries a greater number of stock than a second farm, it does not necessarily follow that the amount of work for which contractors can be employed is greater on the first farm. The volume of work for which contractors can be employed will be influenced by additional factors such as the numbers of labour units and the farm's complement of machinery.

2) Stock

The second question was concerned with the purchasing and selling of stock. The question was "Do you feel size gives you any special bargaining powers over a one man farmer (milking 80 - 100 cows) with stock buyers or are there no special bargaining powers?".

Of the thirty-four farmers answering the question, sixteen indicated that there was some advantage due to size, four were unsure, while fourteen thought there was none. All sixteen who felt size gave them special bargaining powers indicated that such powers took the form of being able to dispose of cull stock when they wanted, rather than being able to buy cattle more cheaply or sell cattle at a higher price. Two of the sixteen farmers indicated that they bargained actively with stock firms in order to dispose of cull stock when they wished.

The overall impression obtained was that cost economies from this source are likely to be of little importance.

3) Acquisition of Inputs

The final question was concerned with the acquisition of all other farm inputs. The question was "Some people think that farms such as this are able to obtain discounts on some of the other farm inputs which are not available to a one man farmer (milking 80 - 100 cows). Do you think this is true or false?"

Of the thirty four farmers asked the question, two did not feel they could express an opinion, ten thought it was false and the remaining twenty-two indicated that it was true. (In the case of Farm No. 8, three farms collectively purchased inputs.)

Further questioning revealed that there appeared to be three main ways in which the latter group of farmers were able to obtain cost reductions from this source.

a) For certain inputs, they were able, because of the large quantity required, to deal directly with either manufacturers or wholesalers.

b) The retail cost per unit of some inputs declines as the quantity of these inputs purchased increases.

c) They were able to bargain with the sellers of certain inputs for cost reductions because of the large quantity required.

Only four of the twenty-two indicated that the cost reductions which could be obtained from this source were substantial. Of these, one claimed to have had success dealing with wholesalers and manufacturers and estimated that he had been able to reduce the cost of most of his farm inputs by twenty five per cent of the current retail prices. Two indicated that they were able to bargain on almost every input, one estimating that by such bargaining, he had been able to reduce the price of most inputs by ten per cent. The fourth, whose dairy farm was farmed in conjunction with two sheep farms, stated that a ten per cent reduction in price was obtained on most produce. All four farmers indicated they spent a considerable amount of their time engaged in obtaining such discounts. It was interesting to observe that two farmers described such bargaining as being unethical.

5.17 MANAGEMENT

1) General Comments

All farmers in Groups II, III and IV were asked the following question. "As the manager of a "x" man farm, how does your job differ if at all from that of a one man farm?" The procedure adopted was to initially ask the question, allow the farmers to answer, and if the farmers did not discuss the implications of employing labour and herd size, they were asked to do so by the use of prompts. (Preliminary discussions with Extension Officers had led the author to believe that these two subjects were likely to be of importance to the question.)

On fourteen farms, the managerial function [38] appeared to be the responsibility of two people. (The fourteen farms were numbers 18, 21, 26, 29, 31, 33, 34, 35, 36, 37, 38, 39, 40, 41.) On five of these farms (i.e Nos. 18, 21, 26, 29, 31), the two people in question, were also concerned with both the entrepreneurial decisions and with decisions concerning the day to day running of the farm. (That is managerial decisions in the co-ordination and supervision sense.) On the remaining nine, there appeared to be some division between the two functions. Typically, one person was concerned with the entrepreneurial decisions, while the other was concerned with the day to day running of the farm. (In only two cases, the person to whom the question was put was not concerned with the entrepreneurial function, the farms being Nos. 39 and 41.)

Of the twenty-six [39] farmers to whom the question on the employment of labour was relevant, twenty-three indicated that this was a factor which caused their role as a manager to differ from that of a one man farmer. Seventeen stated that the employment of labour necessitated some effort by management to evolve and apply strategies which gave rise to high labour productivity. Three farmers noted that the managerial function extended also to the maintenance of good relations between all employees. Extreme difficulties were encountered, it was stated, if ill-feeling existed between the various staff members. Five considered that in order to make the best use of employed labour it was necessary for the manager to spend some time deciding what jobs were to be done, when they were to be done, and by whom. Further this also meant some time had to be spent ensuring that the necessary resources for such work were available. Eighteen farmers while discussing labour commented on the supervision of labour. Twelve felt the time they devoted to supervising the labour was quite small. The other six expressed the opposite view. Further discussion led the author to the conclusion that the supervisory input is likely to depend on the number and type of labour units employed. Where a large number of inexperienced youths are employed, it seems likely

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38. The term managerial function as used in this context includes entrepreneurship co-ordination and supervision.
39. Farms Nos. 18, 21, and 26 were excluded as in all cases both labour units employed on such farms were concerned with the entrepreneurial decisions and decisions concerning the day to day running of the farm.

that a considerable amount of the manager's time will be spent supervising the labour force. Where one experienced man is employed, it seems likely that the supervisory input will be negligible.

Eleven farmers indicated that management differed because of herd size. The reasons given were:-

a) Detection of in-season cows for artificial breeding is more difficult in larger herds (seven farmers).

b) Large mobs of calves are more difficult to rear than small mobs (sixteen farmers).

c) There appears to be some effect of herd size on cow condition. Typically younger animals suffer (five farmers).

d) Judging whether a given area has sufficient feed for grazing, in any given time period, by a particular herd is more difficult with a larger herd (five farmers).

Three farmers felt that high stocking rates led to greater managerial problems than did herd size. It was interesting to note that the manager of Farm No. 39, who was also responsible for the management of a neighbouring farm of 130 surveyed acres stocked at 1.7 milking cows per surveyed acre, felt that this latter farm required a greater managerial input than Farm No. 39.

Six farmers believed that considerably more of a manager's time was involved in clerical work of some kind. 40/ In the case of stock records, this was due to:

i) Having a greater number of animals about which information had to be recorded.

ii) Recording more information about each animal because of the difficulty with large herd numbers in remembering detailed information about each animal.

The employment of labour also necessitated some clerical work which was not required on one man farms.

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40. It is interesting to note that nine of the Group IV farmers prepared budgets each year while in the other groups, the corresponding figures were Group III, seven, Group II, four and Group I, four.

Two farmers answering the question indicated that they spent a considerable amount of time pricing inputs from various sources and bargaining to obtain economies in the acquisition of such inputs. Both had enjoyed considerable success at this.

2) <u>Records</u>

All farmers but one (Farm No. 19) kept records of service dates and consequently of calving dates. (Nineteen recorded pre-mating heats. See Table A.12 of Appendix A)

All farmers but one kept some form of production records. In most cases these took the form of a cumulative total of the season's production based on the ten day period slips from the factory. Twenty-two farmers had additional information because of herd testing records.

Other records kept included stock parentage records, animal health records, paddock records, weather records. Diaries also contained, in some cases, a great deal of information but in most cases this was not in a readily available form.

The overall impression gained by the author was that the managers of the larger herds spent more time on record keeping than those of the smaller herds, but this was a reflection of the increasing number of entries needed for particular records rather than the keeping of a greater number of records.

3) <u>Problems Due to Distance</u>

As some authorities (9, p.12) consider that the increasing distances normally associated with increasing farm size give rise to managerial problems, all farmers were asked: "Do you feel the sheer distances involved in your travelling about a farm of this size are a problem?"

None of the forty-one farmers answering this question felt distances were a problem. However, thirty-four regularly used some means of transport. Of the thirty-four:

15 used a tractor;
14 used a motorbike;
5 used a bicycle;
4 used a car;
3 used a truck;

(The discrepancy between the total of the figures shown, and 34 is due to some farmers using more than one source of transport.) Four of the seven who indicated they normally used no means of transport were in Group I, two were in Group II and one in Group III.

5.18 RESULTS OF ADDITIONAL FARM SURVEYS

Additional surveys were conducted on four other farms in order to allow the author to study three further management systems which were considered to be pertinent to the study.

1) Farms where Two Separate Herds are Milked through the One Farm Dairy

One example of the above was visited where two farmers, although individually owning their own herds and farms and employing their own labour, milked their herds in the one farm dairy. The two farmers owned 180 and 200 acres respectively and in addition they both leased additional farms close by. In the 1969/70 milking season, the two farmers had collectively wintered approximately 530 cows to milk a maximum of approximately 500 cows. The farm dairy was a 32 aside highline single herringbone operated by four milkers. (Two milking units being supplied from both farms.) The procedure adopted was to milk one particular herd (the smallest) first. The milking machines and yards were then cleaned, and the second herd (the larger) was milked. Two reasons for adopting such an arrangement were given. First, the farm dairies on both farms were old and in need of replacement at the time the two farmers purchased their farms and it was felt cost economies could be achieved by building and utilising one new farm dairy. Second, both farmers had differing farming views and such an arrangement gave each farmer complete freedom in the adoption of the various farming practices he preferred. Such freedom it was considered was not available in a partnership agreement.

A farmer was also interviewed who in the 1969/70 milking season, had divided his 360 cow herd (run on a 250 acre property, plus a run-off) into two herds of approximately 180 cows each. One herd was made up mainly of older cows, while the other comprised younger cows and any other cows, which for various reasons appeared to be in poor condition or health. The herd in question, it was said, had in previous seasons been characterised by younger animals which produced disappointingly and often ended the lactation in poor condition. The reasons for this were not known exactly but as it had been suggested that this might be due to herd size per se, the herd had accordingly been divided into two.

Such a division, however, involved the labour force in additional work. For example, two labour units were required to bring the herd to the farm dairy for milking. Further, in order to prevent the length of the grazing rotation (and hence grazing pressure) from being halved, additional subdivision in the form of temporary electric fencing was required. 41/

The effect of such a system is extremely hard to evaluate, particularly as in the 1969/70 season (the first season it was adopted) the farm was seriously affected by a drought. However, despite the disadvantages earlier discussed the farmer in question intended to continue the system in the 1970/71 dairying season.

As a result of the suggestion noted above, that herd size per se has some effect on the productivity of the animals within a herd, the author interviewed Mr. R. Kilgour, a scientist conducting animal behaviour studies at the Ruakura Agriculture Research Centre. According to Mr. Kilgour (32, pp.102-104), the splitting of large herds into smaller ones may be justifiable because of social factors. Domestic animals (including cows), it is believed, tend to have a social organisation within their group, herd or flock. That is, a social hierarchy is established within a group of animals. A stable social group exists when every cow can recognise and maintain a known relationship with every other cow. The important point here being that socially subordinant cows can recognise and avoid socially dominant cows. If a herd becomes too big, it is felt that such recognition is no longer possible and stress within the herd, particularly on the subordinant cows, greatly increases with a consequent loss of production and disease resistance. Further research however is needed to establish what herd size constitutes a stable social group.

2) Contract Milking

One farm was visited where a contract milking agreement was in operation. In the 1969/70 season, the farmer in question 42/ milked approximately 175 cows upon 150 surveyed acres. In addition, he under-

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41 i.e. Each permanent paddock was divided into two with an electric fence.

42. The farmer will be referred to as the contract milker for the remainder of the discussion.

took to milk on a contract basis two neighbours' herds of approximately 110 and 140 cows respectively. A 20 aside highline single herringbone was used, operated by three milkers.

The agreement stipulates that the neighbours must guarantee for a seven year period to provide not less than a specified minimum number of cows each milking. The contract milker is required to provide all the necessary milking facilities, as well as the labour required for milking. Payment to the contract milker for his services is at a specified rate per pound of milkfat. Provision is made for the rates to be reviewed each year after taking into account such factors as the basic milkfat price, and the dairy farmers' index of costs. The contract milker is expected to meet all shed expenses, expenditure on antibiotics for mastitis control is however shared. The neighbours are entitled to remove from their respective milk vats for calf rearing, fifty-five gallons of milk per calf, up to a maximum number of calves which represents a twenty per cent replacement rate. [43]

The three herds are milked in a given order and immediately a milking is complete, they become again the responsibility of the two neighbours. Facilities are made available at the farm dairy, however, by the contract milker for bloat prevention and control and artificial breeding.

3) Farms Consisting of a Number of Distinct Units

One farm was visited which comprised four distinct dairying units. The farm consisted of 890 surveyed acres (865 effective acres) and in the 1968/69 season produced from a total of 935 cows, 305,000 pounds of milkfat[44] (the figure has been rounded to the nearest thousand pounds of milkfat). This represents 353 pounds of milkfat per acre and 326 pounds of milkfat per cow.

The area and cow numbers of each of the four farms is shown in Table 5.26.

The labour complements on each of the four farms was two permanent labour units. (A third labour unit was employed, however, on each farm

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43. i.e. For a herd of 100 cows, fifty-five gallons per calf could be removed for a maximum of 20 calves.
44. The total shown includes an estimate of the milkfat used for calf rearing.

over the spring months.) The four farms were not completely self contained as young stock from each farm were for varying periods grazed away from the farms. All hay and silage for each farm, however, was made upon the farm in question. The machinery complement of each farm comprised one tractor, one forage harvester, one trailer and one bloat spray outfit. A mower was shared between all four farms. Contractors were employed for topdressing and haymaking.

Table 5.26 Areas and Herd Sizes of the Four Farms

	Area (acres)	Effective Area (acres)	Cow Numbers
Farm 1	220	220	235
Farm 2	220	210	220
Farm 3	220	210	240
Farm 4	230	225	240

The day to day decisions concerning the running of each of the four farms as made by the senior staff member of each farm, in compliance with a farming policy formulated by the farm supervisor. (The farm supervisor was also the senior staff member of Farm 3.) Major decisions (of an entrepreneurial nature) were made by the farm manager after consultation with a management committee.

Increasing farm size by increasing the number of plants, rather than the size of an individual plant, according to the farm manager, has the following advantages:

a) Difficulties arising because of a large number of cows in one herd are avoided. (Such difficulties have been discussed earlier and include the detection of in-season cows and the detection of animal health problems.)

b) A spirit of competition exists between the staff of the four farms which induces the farm staff of each farm to make efforts to increase productivity.

5.19 SUMMARY

One of the most striking features of the farm survey was the extremely high ratio of cows per labour unit recorded by the farms of the upper subclasses of Group I and II. Such high ratios of cows per labour unit were achieved by the labour units making extensive use of contractors and casual labour and working extremely long hours, particularly in the spring. In terms of the ratio of cows per milking unit however, the differences between the four groups of farms were less marked. This was due to the Group I farms making extensive use of family labour (i.e. wives) for milking. Similarly, there was also a greater tendency for family labour to assist with other farm work on the Group I farms. Contractors and casual labour were used less extensively on the farms of Group III and IV and consequently, the labour units of such farms were engaged in a greater range of farm operations. A most noteable feature was that, with one exception, on all the Group III and IV farms, some provision was made for the milking units to have time off during the milking season. This contrasted with the situation on the Group I farms where such a provision was made on only one third of the farms.

Specialisation and division of labour was apparent to some extent on all the multi-labour unit farms. It appeared that work on the survey farms could be divided into three classes; first, jobs which were regarded as being extremely vital to the profitable organisation of the farm; second, jobs requiring special skills or experience; finally, jobs which were regarded as being less vital to the profitable organisation of the farm.

There were no marked differences between the four groups of survey farms in terms of the range of machinery used. There was a trend towards the number of tractors and of particular items of machinery which were used on the survey farms to increase from Group I to Group IV. As contractors were used less extensively on the farms of Group III and IV, there was a tendency for the farms of Group III and IV to own a greater range of the machinery used on the farm.

All farmers considered tractor sheds, implement sheds, farm dairies, some form of workshop and dwellings were buildings they could not do without. The ratio of cows to the number of houses required was extremely high on those farms of Group I where the ratio of cows per labour unit was high. Certain of the multi-labour unit farms were able to achieve high ratios because of the employment of married couples and single labour. With three exceptions, on all survey farms, a type of herringbone farm dairy was used. The most popular type of herringbone was the highline single.

The stocking rates on the survey farms were relatively high. The stocking rate of all the Group IV farms was greater than one milking cow per effective acre.

Milkfat production per cow and per acre varied considerably between and within the four groups of survey farms. There was a trend towards a decline in both the milkfat per cow and milkfat per acre on those farms of each group where the ratio of cows per labour unit was high. The output of milkfat per labour unit was extremely high on some of the Group I farms. In terms of output per milking unit, however, the differences between the four groups were less marked.

There were no obvious differences between the four groups of survey farms in terms of percentages of stock losses, and herd wastage, calving percentages and percentages of empty cows and heifers.

Of the forty-one farmers surveyed, twenty-two were in the 1969/70 season, herd testing, and forty were using artificial breeding. The predominant breed of dairy cattle was Jersey, although the Friesian breed appeared to be increasing in importance. Only sixteen of the forty-one farmers knew every animal in their herd individually and it appeared that it became increasingly difficult to know every cow individually as herd size increases.

Little can be said about the effect of herd size on animal health, in the absence of a careful study. The impression gained by the author was that the manager of a larger herd would have to pay more attention to calf rearing and the condition of stock (particularly the two year old heifers).

The data concerning the maximum distances of travel and time away from pasture indicated that although in general, the maximum distances the herds had to walk were greater on the farms of the larger herd sizes, the distances could on specific farms be relatively low due to a favourable farm layout. There was no trend towards the maximum time the herds were away from pasture being greater on the farms of the larger herd sizes.

Thirty-four farmers were asked to discuss the ways in which pecuniary economies could arise. Three indicated that they were able to obtain reductions in the rates for contractural services, sixteen considered that size gave them advantages in the disposal of cull stock and twenty-two believed that cost reductions could be obtained in the purchasing of some of the other farm inputs.

On fourteen of the multi-labour unit farms, the managerial function appeared to be the responsibility of two people, and on five of these farms, the two people in question were concerned with both the entrepreneurial decisions and with decisions concerning the day to day running of the farm. Twenty-three farmers indicated that the employment of labour was a factor which caused their role as a manager to differ from that of a one man farmer. Eleven farmers indicated that management differed because of herd size.

Two examples of farms where two herds were milked through the one farm dairy were visited. In the case of the first example, two reasons were given for the adoption of such an arrangement. First, the farmers in question considered that cost economies could be obtained by the building of one large farm dairy rather than two smaller ones, and second, the arrangement gave each farmer freedom in the adoption of those farming practises he preferred. In the case of the second example, the farmer divided his herd into two, as it had been suggested that the poor production of his herd (particularly the production of the younger stock) was due to herd size per se.

A farm where a contract milking agreement was in operation was also visited. The farmer in question undertook to milk in addition to his own herd, the herds of two neighbours.

One example of a farm consisting of a number of distinct units was visited. The advantages of increasing farm size by increasing the number of plants, rather than the output of a given plant were given as, first, the difficulties associated with a large number of animals in one herd are avoided, and second, a spirit of competition exists between the staff members of each of the individual units.

CHAPTER SIX

BASIC ASSUMPTIONS OF THE STUDY AND DETAILS OF THE ANALYTICAL PROCEDURE

6.1 INTRODUCTION

In this chapter, the basic assumptions of the analysis are presented and discussed and a description given of the analytical procedure. The chapter should be read in conjunction with Appendix B in which details of the assumptions made and cost data used are given.

The analytical procedure adopted in this study is the Economic-Engineering or Synthetic-Firm technique. Consequently the initial part of the chapter is concerned with a brief description of the method of constructing the short run average cost curves. The resources which constitute the fixed plant are indicated and the range of plant utilisations (herd sizes) relevant to each short run average cost curve are given.

The second part of the chapter is concerned with the assumptions made in order to attempt to eliminate all the sources of between farm variation, other than those due solely to farm size. For example, the district to which the results are applicable is indicated, the technology employed on the representative farms [1] is discussed and information concerning some of the assumed levels of prices and costs given.

The final part of the chapter is concerned with a detailed description of the assumptions made and the operations required for the development of the budgets (from which the cost revenue ratios are derived) of the representative farms. All possible sources of economies and diseconomies of size revealed by the farm survey, and by the compilation of the cost data are incorporated into these assumptions. This description is of considerable importance, in the author's opinion, because it does allow the reader to gain an insight into the ways in which economies and diseconomies of size arise.

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1. The meaning of the term "representative farm" is indicated later in the text. (See footnote 4.)

6.2 GENERAL DESCRIPTION OF THE CONSTRUCTION OF THE SHORT RUN AVERAGE COST CURVES

The procedure used to analyse economies of size in this study is the Economic-Engineering or Synthetic-Firm technique. This technique analyses economies of size in terms of short run and long run average cost curves.

The initial requirement of the Economic-Engineering technique, is that a resource (or group of resources) be identified as an item (or items) of fixed plant. In this study, labour [2] is initially recognised as the resource which is fixed in the short run. Five plant sizes are recognised, based upon multiples of adult male labour units. The five plant sizes are:

Farms with one permanent adult male labour unit	: Plant size one
Farms with two permanent adult male labour units	: Plant size two
Farms with three permanent adult male labour units	: Plant size three
Farms with four permanent adult male labour units	: Plant size four
Farms with five permanent adult male labour units	: Plant size five

Each plant size is divided into three subclasses according to the size (i.e. number of sets of cups) of farm dairy (herringbone) [3] employed. Details of the three subclasses associated with each plant size are shown in Table 6.1.

Fifteen short run average cost curves are produced by computing cost revenue ratios representing different degrees of plant utilisation. In this study, the variable degrees of plant utilisation, for each plant size, are represented by a series of varying ratios of cows per labour unit.

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2. Other resources besides labour are also regarded as items of fixed plant. These other resources are indicated later in the text.
3. The two terms 'farm dairy' and 'herringbone' are not synonymous in this discussion. The term 'herringbone' refers only to that part of the farm dairy where the actual milking process takes place The term 'farm dairy', however, is a collective term and includes such items as the milkroom, herringbone, circular yard, entry/exit draughting area etc.

Table 6.1 Sizes of (Herringbone) Farm Dairies according to Plant Size

Plant Size	Subclass (a)	Subclass (b)	Subclass (c)
Plant size one	6 aside	8 aside	10 aside
Plant size two	12 aside	14 aside	16 aside
Plant size three	18 aside	21 aside	24 aside
Plant size four	24 aside	28 aside	32 aside
Plant size five	30 aside	35 aside	40 aside

The procedure adopted for the construction of a short run average cost curve is to:

a) Set the herd size at the initial degree of plant utilisation for the plant size in question. In the case of plant size one farms, the initial degree of plant utilisation is represented by a herd size of sixty cows. (i.e. The ratio of cows per labour unit is sixty.)

b) For the initial degree of plant utilisation, construct a budget [4] and from such a budget determine a cost revenue ratio. The cost revenue ratio so determined represents the initial point on the short run average cost curve in question.

c) Increase the herd size by a factor [5] (i.e. increase the degree of plant utilisation), construct another budget and derive a new cost revenue ratio. This second cost revenue ratio represents a second point on the short run average

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4. Each budget can be viewed as representing a farm of a different 'size'. Such farms will be referred to in the discussion as 'representative farms'.

5. The factor by which herd size is increased varies between plant sizes. In the case of: i) Plant size one farms, the factor is 10 cows;
ii) Plant size two farms, " " " 15 cows;
iii) Plant size three farms," " " 20 cows;
iv) Plant size four farms " " " 30 cows;
v) Plant size five farms " " " 30 cows;

cost curve. In the case of plant size one farms, the factor by which herd size is increased is 10 cows. (A new budget and cost revenue ratio is therefore derived for a herd size of seventy cows - the ratio of cows per labour unit has increased to seventy.)

d) The procedure discussed above in c) is repeated up to and including the herd size representing the maximum degree of plant utilisation, for the particular subclass of the plant size in question. For plant size one farms utilising a six aside farm dairy (i.e. subclass (a)), this maximum degree of plant utilisation corresponds to a herd size of 105 cows. The cost revenue ratio derived from a budget for 105 cows represents the final point on this particular short run average cost curve.

The range of plant utilisations (herd sizes) over which cost revenue ratios are determined for each of the three subclasses, of each of the five plant sizes, is shown in Table 6.2.

An examination of Column (1) of Table 6.2 indicates that in all cases, the herd sizes representing the initial degrees of plant utilisation correspond to a ratio of sixty cows per labour unit. The data shown in Column (2) however, have been derived by determining for all subclasses, the maximum number of cows which can be milked 6/ in each of the associated farm dairies, if the average milking time (over the whole season) is assumed to be 1.75 hours. 7/ (An average milking time of 1.75 hours over the whole milking season is therefore considered to be the limit of the fixed resource, labour. The figure is based upon impressions obtained by the author from the farm survey.)

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6. On any given representative farm, the assumption is made that all milking cows are milked in a single herd. Consequently other organisations such as shift milking, and dividing a given herd into a number of smaller herds are ignored.
7. The figure of 1.75 hours does not include other chores such as cleaning the farm dairy and yards, etc. It refers only to the length of time the milking machines operate. The data upon which Column (2) of Table 6.2 is based are discussed on page 51 of Appendix B.

Table 6.2 Range of Plant Utilisations (Herd Sizes) According to Plant Size

Subclass (Size of Herring-bone)	Plant Size One (cows) Min. (1)	Max. (2)	Plant Size Two (cows) Min. (1)	Max. (2)	Plant Size Three (cows) Min. (1)	Max. (2)	Plant Size Four (cows) Min. (1)	Max. (2)	Plant Size Five (cows) Min. (1)	Max. (2)
(a)	60	105	120	210	180	315	240	420	300	525
(b)	60	120	120	226	180	339	240	452	300	565
(c)	60	136	120	240	180	360	240	480	300	600

NOTES: i) Column (1) shows for each of the five plant sizes, the herd size corresponding to the initial (minimum) degree of plant utilisation.

ii) Column (2) shows for each of the fifteen subclasses, the herd size corresponding to the maximum degree of plant utilisation.

The total number of cost revenue ratios derived (or representative farms constructed) for each plant size is:

Plant size one	:	22
Plant size two	:	25
Plant size three	:	27
Plant size four	:	25
Plant size five	:	30

Consequently in total, 129 cost revenue ratios (or representative farms) are involved in the derivation of a long run average cost curve.

6.3 BASIC REQUIREMENTS OF THE ECONOMIC-ENGINEERING TECHNIQUE

One important requirement of the Economic-Engineering technique is that all sources of between farm variation, other than those due solely to differences in farm size, be eliminated if possible. In order to comply with this requirement, a number of assumptions have been made; these are discussed in detail below.

The representative farms are located in the Awahuri district, eight miles west of Palmerston North. The soils of the district are described as gleyed and organic river flat soils, (33, p.19). Natural drainage is good, although with intensive winter stocking, pugging problems can arise. Natural soil fertility is high and consequently the fertiliser requirements of pastures are relatively low. Rainfall averages 37.5 to 40 inches per year and the rainfall is evenly distributed throughout the year, (33, p.5).

All the representative farms are seasonal supply dairy farms, are of the same shape (that is rectangular, the length being twice the width of the farms) and are stocked at 1.1 milking cows per surveyed acre. A stocking rate of 1.1 cows per surveyed acre is considered by local Extension Officers to be typical of the higher producing farms in the district.

The technology employed on the farms is that which is currently being recommended by local Extension Officers. A brief description of the technology employed follows. Pasture is the main feedstuff used. No forage crops are grown and no silage is made. The supplementary feed reserves consist entirely of hay. The farms are self-contained except for the replacement heifers (and replacement bulls), which are grazed away from the farm for a period of twelve months. Calves however, are retained on the farms. Rotational grazing is practised throughout the year and the farms are subdivided into approximately thirty paddocks. In winter the block grazing wintering system is used. During excessively wet periods in the winter, however, the stock are removed from the pastures and held on the farm race, in order to minimise pasture pugging. The predominant dairy breed is Jersey, although the Friesian breed is increasing in importance. Herd improvement practices include the use of artificial breeding and herd testing. Fertiliser requirements are relatively low, the annual application of fertiliser (to pastures) being four hundred weight of superphosphate. The major pasture pests are <u>Wiscana cervinata</u> (Porina moth) and <u>Costelytra zealandia</u> (grass grub). Annual applications of pesticides are made to eradicate the former. Weeds are of minor importance, the only weed requiring treatment with herbicides being <u>Hordeum murinum</u> (barley grass).

One important feature of the Economic-Engineering technique is that it provides opportunities for the researcher to standardise the management factor. Accordingly in this study, the assumption is made that all representative farms are farmed by operators of similar managerial ability, and all operators are considered to be of above average managerial ability.

All farm improvements [8] are new. The investment costs [9] of such improvements includes tradesmens' labour. The input prices are those pertaining to August 1970. Although a number of survey farmers indicated the existence of pecuniary economies in the acquisition of inputs, compilation of the cost data revealed only one (annual) input (electricity), where such an economy was considered to be significant. Consequently, with the exception of electricity, pecuniary economies in the acquisition of (annual) inputs have been ignored.

The prices of cull stock (i.e. cull cows, empty heifers, cull bulls and bobby calves) used, were decided upon after discussions with the representatives of a number of Manawatu stock firms. The prices are those which it is thought would be paid in the 1970/71 season. Milkfat price however is treated as a variable.

6.4 THE METHOD OF ANALYSIS

A single computer programme was written (by the author) to prepare for each of the five plant sizes, a series of budgets representing different degrees of plant utilisation. From these budgets, the cost revenue ratios are derived, from which the short run average cost curves are constructed. The preparation of each budget consists of the following five steps:

The calculation of a livestock reconciliation schedule;
The calculation of the farm investment requirements;

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8. The term 'farm improvements' refers to: fencing, farm races, water reticulation systems, farm dairies, dwellings, implement sheds, barns, pump sheds, milking equipment, effluent disposal systems, and electric power installation.
9. As such resources are of a capital nature (i.e. they are not exhausted over a single production time period) a number of different cost concepts can be associated with these resources. For example:
   i) The initial sum which must be outlayed to obtain the resource (e.g. the cost of a new dwelling is $8,000).
   ii) The annual cash costs which are associated with such resources (e.g. repairs and maintenance and insurance).
   iii) The annual non-cash costs associated with such resources (e.g. interest and depreciation.

   The term investment cost is used to indicate that the relevant cost concept in this case is i).

The calculation of the gross farm income;
The calculation of a series of cost figures;
The derivation of a series of net income figures;

The general procedure adopted by the author when writing the computer programme was to divide the data into two groups. The first group comprises data which are incorporated into the programme deck (of cards) of the computer programme, while the second group comprises data which are made available to the programme as data (input) cards. Details of the data of each group are as follows:

Group One consists of:

a) Resource data [10/] which within each subclass of each plant size, vary either continuously or discretely [11/] as herd size varies. For example, the investment costs of barns, water reticulation systems, effluent disposal units etc.

b) Resource data which over the complete range of plant sizes and herd sizes studied (i.e. from plant size one 60 cows, to plant size five, 600 cows), remain constant. For example, the investment cost of the pump shed.

c) Stock performance data and product prices, which are assumed to remain constant both between and within plant sizes. For example, stock losses, herd wastage, cull stock prices, etc.

Group Two consists of:

a) Resource data which within each subclass of each plant size remains constant as herd size varies. Data of this nature

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10. The term 'resource data' is a collective term and refers to the type, quantity and cost of resources.

11. The phrase 'varies continuously' means in this context, that a different value is associated with each herd size.

    The phrase 'varies discretely' is taken to mean that a given value remains constant over a range of herd sizes, and a change from one value to another is made at a particular herd size.

are therefore concerned with the resources which (within each subclass) are fixed in the short run. Such data includes:

i) The number of labour units and the wages of the employed labour units.

ii) The size and length of the herringbone.

iii) Building investment costs of certain buildings. For example, the investment cost of dwelling(s) and an 'initial' [12] value of the implement shed.

iv) The length of "drop-offs" from the main electrical service line to the various buildings;

v) The investment costs of certain items of machinery. For example, the investment costs of tractor(s), transport tray(s), trailer(s), haymower(s), hayrake, grader blade, hayloader and spray equipment.

vi) The investment costs of various items of equipment. For example, the investment costs of milking equipment, general farm equipment, and hand tools.

vii) The estimated economic lives of all assets which are to be depreciated.

viii) Sundry data required for the calculation of a number of expenditure items. For example, dairy shed expenses, electricity, insurance and repairs and maintenance.

b) The range of herd sizes over which cost revenue ratios are to be derived for the particular subclass in question, and the factor by which herd size is to be increased.

c) Certain parameters, the values of which it was considered might have a considerable influence on the results of the

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12. The meaning of the term 'initial' is indicated later in the text.

study. For example, milkfat price, rates of interest, and milkfat production per cow. 13/

6.5 OPERATIONS PERFORMED BY THE COMPUTER

After the second group of data have been made available to the programme by way of data input cards, the following operations are performed by the computer for the preparation of each budget.

1) Calculation of the Livestock Reconciliation Schedule, and Gross Farm Income

Initially a livestock reconciliation schedule for the herd size in question is computed. Such a schedule determines, first the number of replacement stock which must be saved annually to maintain stock numbers, and second, the number of cull stock which are available for sale each year.

From the data concerning the numbers of replacement stock required and the numbers of cull stock available, the income from cull stock sales and bobby calf sales is derived. This is added to the milkfat income to obtain the gross farm income.

2) Calculation of the Farm Investment Requirements

Land Investment

Initially, the area of the farm, the dimensions of the farm, the price per acre of the "bare" land (i.e. land exclusive of all improvements except pasture), and the total land investment are determined.

Farm Race Investment

Data concerning the dimensions of the farm are used to calculate the length of the farm race. The appropriate width and the appropriate cost per chain of the farm race are determined from data incorporated into the programme deck. This data, together with the data concerning

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13. Long run average cost curves are derived for two sets of assumptions concerning the level of milkfat production per cow attained by the representative farms.
    i) Long run average cost curves have been produced, for the assumption that the level of milkfat production per cow remains constant over the complete range of plant sizes and herd sizes studied.
    ii) Long run average cost curves have been produced, for the assumption that the level of milkfat production per cow is a function of both plant and herd size. For a fuller discussion, see page 25 of Appendix B.

the length of the farm race, allows the total cost of the farm race to be determined. Finally, the total race investment is derived by adding to the cost of the farm race, the cost of certain factors (e.g. tanker track, gate fillings and cattlestop), which remain constant over all plant sizes and herd sizes studied.

Fencing Investment

From the dimensions of the farm and farm race, the length of fencing required is calculated. This together with the cost data incorporated into the programme allows the total cost of fencing to be calculated. The total fence investment is obtained by adding to the total cost of fencing, the costs of those components which, either vary discretely with herd size, or remain constant over the complete range of plant and herd sizes studied (e.g. the costs of the various gates).

Investment Costs of Farm Dairies

The only data concerning the farm dairy which is made available to the programme by way of input data cards, are the size and length of the herringbone. (The remaining data required to calculate cost of the farm dairy are incorporated into the programme.) The farm dairy has been viewed as consisting of a number of components. The components are:

a) Herringbone;
b) Milk Room and vat stand;
c) Circular yard; 14/
d) Drenching race;
e) Entry/exit/draughting area;
f) Entry area;

The individual components of the farm dairy are shown in Figure 6.1. Within each subclass, all but one of these six components, the herringbone, varies as the herd size varies. 15/

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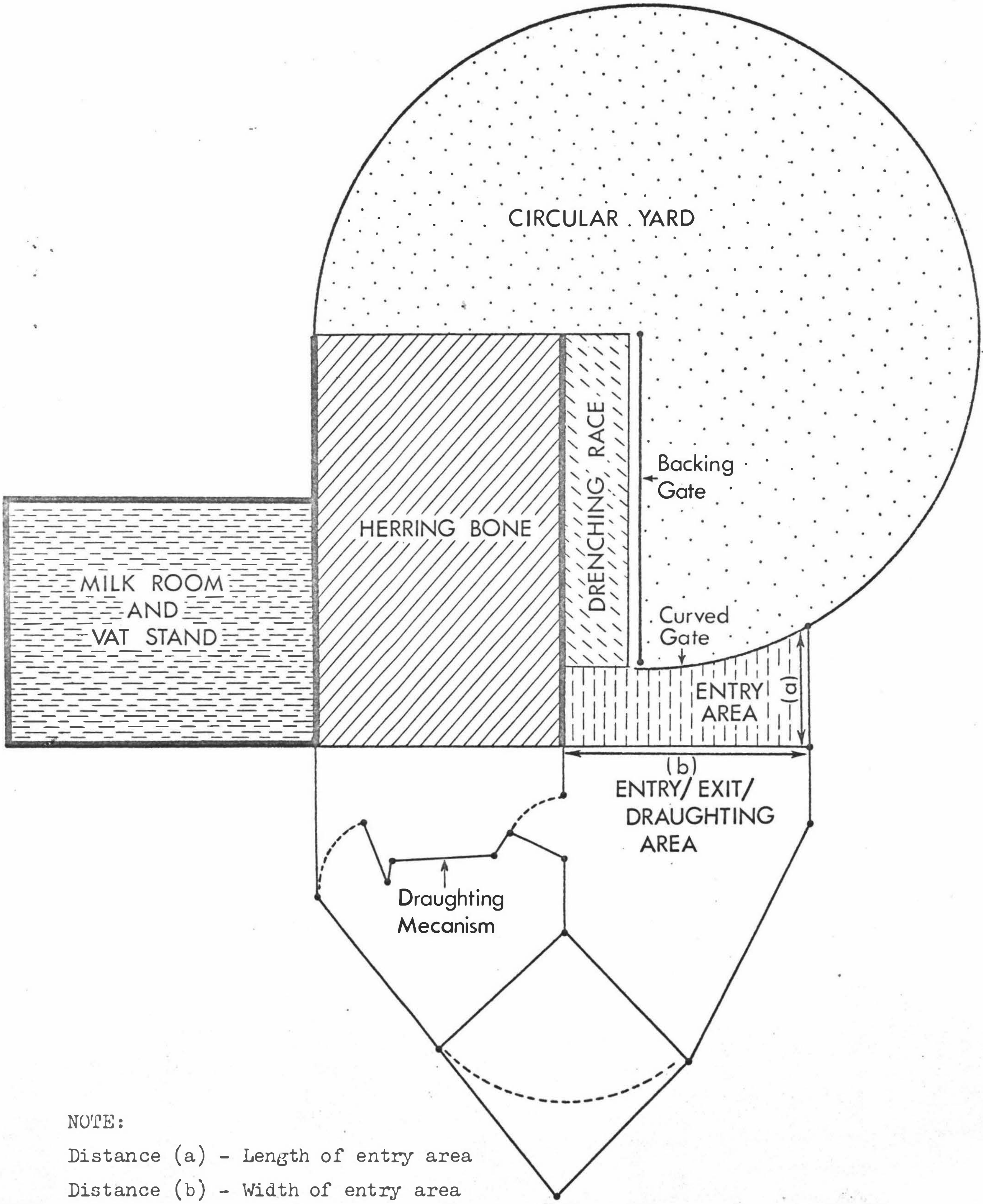
14. The circular yard can be further divided into:
    i) Concrete ground slab;
    ii) Backing gate and power unit;
    iii) Yard pipe work and kerbing;
15. The circular yard (and its components) vary continuously as herd size varies. The remaining components vary discretely with variations in herd size.

FIG. 6.1 COMPONENTS OF THE FARM DAIRY



NOTE:

Distance (a) - Length of entry area

Distance (b) - Width of entry area

Initially, the cost of the herringbone is determined; from the data concerning the herringbone length and the programmed cost data. The appropriate milk room and vat stand, and entry/exit/draughting area is then selected. From the selection of entry/exit/draughting area, the width of the entry area is specified. The physical dimensions and costs of the circular yard are then determined, including the dimensions and costs of the backing gate, circular yard pipe work and kerbing. A comparison between the length of the herringbone and the length of the backing gate allows the length of the drenching race and entry area to be calculated. The cost of these two components is then determined. Finally, the total cost of the farm dairy is found by summing the costs of the six individual components.

Barn and Implement Shed Investment Cost

The investment in barns varies discretely with variations in herd size. From the data incorporated into the programme, the appropriate barn investment is determined.

As discussed in section 6.4, an 'initial' value for the implement shed and data concerning the machinery investment are made available to the programme as input data. Provision is made in the programme, however, for such information to be modified in three situations. First, on all plant size one farms, where the herd size exceeds 120 cows, the assumption is made that contractors are employed for hay raking. Consequently, on such farms the cost of the hay rake is set to zero, and the value of the implement shed reduced by the value of the housing area required by the hay rake. In the case of plant sizes two, three, four and five, the total ownership [16] costs of a hay baler are computed and compared with the costs of employing a baling contractor. When the total ownership costs are less than total contract costs, a baler is added to the complement of machinery, and the value of the implement shed increased by the value of the housing area required by the baler. A similar procedure is adopted in the case of a fertiliser distributor. [17]

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16. The total ownership costs of a baler include:
    i) Baler costs: Interest, depreciation, repairs and maintenance, insurance and baling twine.
    ii) Tractor costs: Fuel and oil consumption and repairs and maintenance.
    iii) Housing costs: Interest, depreciation, insurance and repairs and maintenance.
17. The addition of a fertiliser distributor to the machinery complement is also accompanied by the addition of a front end loader to facilitate ease of handling of bulk fertiliser.

Machinery Investment Costs

The total machinery investment, is obtained by the summation of the costs of the individual items of machinery. Such a summation includes those items of machinery originally supplied as input data, plus those added (e.g. hay balers and fertiliser distributors), and those excluded (e.g. hay rakes) by the procedures discussed previously.

Investment Costs of Water Reticulation and Effluent Disposal Systems

The investment costs of both the water reticulation systems and effluent disposal systems are derived by the use of regression equations, which express the investment costs as a function of herd size.

Investment Costs of Electric Power Installation

From the dimensions of the farm, the length of the main electrical service line is calculated. This information, together with the cost data incorporated into the programme, allows the cost of the service line to be calculated. The total cost of electric power installation is obtained by adding to the cost of the main service line, the cost of the "drop-offs" to the various farm buildings.

Milking Equipment and General Equipment

The total cost of the milking equipment is derived as being the sum of the following five components:

a) Milking machines;
b) Farm Dairy buckets;
c) Herd testing (milk meter) brackets;
d) Teat washers;
e) Hot water cylinders;

In the case of plant sizes three, and four, however, the value of the hot water cylinder initially supplied as input data, is only relevant up to and including herd sizes of 265 cows. 18/ Thereafter, a new value is required. Provision is made in the programme for such a modification to be made.

From the dimensions of the farm, the length of electric fence wire required is calculated. The cost of such an item is calculated and

18. The reason for this modification is discussed on page 42 of Appendix B.

added to the value of the general equipment and handtools, to obtain the total value of the equipment.

Working Capital Requirements and Stock Investment

The working capital requirements are expressed as a function of herd size. The investment in stock, however, is determined from the data of the livestock reconciliation schedule and from data concerning the values of various classes of livestock, which is incorporated into the programme.

Total Farm Investment and "Market Value" of the Representative Farms

The total farm investment is determined by the summation of the individual investment costs of the components of two groups of resources.

Group One :	a)	Land;	
	b)	Buildings;	*
	c)	Fencing;	*
	d)	Farm race;	*
	e)	Water reticulation system;	*
	f)	Effluent disposal unit;	*
	g)	Milking equipment;	*
	h)	Electric power installation;	*
Group Two :	a)	Stock;	
	b)	Working capital	
	c)	Machinery;	*
	d)	Equipment;	*

An estimate of the "market value" of the farm is also made by reducing the value of those resources marked above by an asterisk by forty per cent. [19] The figure of forty per cent was chosen because preliminary investigations indicated that the total investment requirements of the representative farms were in excess of those expected to be required by farms of comparable plant sizes and herd sizes in the Awahuri district. It was felt that much of the discrepancy could be explained by the fact that all resources marked by an asterisk, were assumed to be new on the representative farms and further, the costs of such resources included tradesmen's labour. As it was considered that one could expect the resources marked by an asterisk to be forty per cent exhausted on farms of comparable plant and herd size in the Awahuri district, the values of such resources in the calculation of the "market value" of the farms are reduced by forty per cent.

19. The figure of forty per cent was decided upon by the author, after discussions with Mr. J. N. Hodgson, Reader in Farm Management, Massey University.

3) Calculation of the Cost Data

Casual and Contract Labour Costs

Provision is made in the programme for the calculation of casual and contract labour costs wherever relevant. Such calculations include:

a) On all farms of plant size one, a charge for hay baling and hayloading;

b) On all plant size one farms where the herd size exceeds 120 cows, a charge for casual labour for repairs and maintenance work;

c) On all farms of plant size one where the herd size lies between 121 and 130 cows, a charge for contract hay raking;

d) On all plant size one farms where the herd size exceeds 130 cows, a charge for contract hay raking and hay mowing;

e) On all farms of plant sizes two to five, where a hay baler has not been added to the complement of machinery, a charge for contract hay baling;

f) On all farms of plant sizes two and three, a charge for contract hay loading; 20/

g) On all plant size one farms and on all farms of plant sizes two to five where a fertiliser distributor has not been added to the complement of machinery, a charge for contract fertiliser application.

Animal Health Costs

Animal health costs consist of three components:

a) General herd costs; (including bloat costs)
b) Calf rearing costs;
c) Drench costs;

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20. The cost (per bale) for contractors is assumed to vary between the three plant sizes where contractors are employed. On farms of plant size one, it is assumed three contract labour units are employed. On plant size two farms, two contract labour units are employed. (The additional labour unit being supplied by the farm staff.) Similarly, on plant size three farms, one contract labour unit and two farm labour units are employed.

General herd costs are expressed as a function of herd size. Data from the livestock reconciliation schedule, together with cost data incorporated into the programme are used to derive the calf rearing and drench costs.

Breeding Expenses

The programme determines, for each herd size, the number of cows which must be artificially inseminated, in order that all herd replacements be artificially bred. The cost of inseminating the required number of cows is then calculated. Similarly for each herd size, the number of cows to be herd tested and the cost of herd testing is determined.

Dairy Shed Expenses

Dairy shed expenses consist of the following items:

a) Rubberware;
b) Rotary pump oil;
c) Detergent;
d) Dairy shed brushes;
e) Annual milking machine check;
f) Eartags (for stock identification);

From the data incorporated into the programme, the quantities and annual costs of items a), b), c) and f) are calculated. (Data from the livestock reconciliation schedule are also used in the calculation of item f).) The annual cost of dairy shed brushes is supplied to the programme as input data. As the cost of item e) remains constant over the complete range of herd and plant sizes studied, this cost has been incorporated into the programme.

Feed Costs

Feed costs include only grazing costs for the replacement yearling heifers and associated bulls. Data from the livestock reconciliation schedule are used in the calculation of such costs. No charge is made for feed for calf rearing purposes. It is assumed that calves are reared entirely on whole milk (i.e. nurse cows).

Fertiliser

The fertiliser cost per acre (and hence per cow) is assumed to remain constant over the complete range of plant and herd sizes studied. Such a cost therefore is expressed as a function of farm area (i.e. the number of acres).

Weed and Pest Control

Expenditure on weed and pest control consists of two components. First, pesticide for the control of porina moth and second, herbicide for the control of barley grass. Both components are expressed as a function of farm area and are assumed to remain constant over the complete range of plant and herd sizes studied.

Administration

This item of expenditure consists of two parts - accountancy fee and sundry items. The accountancy fee is derived by the use of a linear relationship, which expresses the accountancy fee as a function of herd size. The total administration cost is obtained by adding to the accountancy fee, the cost of a number of items (i.e. sundry items), which are assumed not to vary with changes in plant and herd size.

Rates

Rates are charged at a given rate per dollar of total unimproved value. The assumption is made that the unimproved value per acre declines continuously with increases in farm size. Such a value is obtained by the use of a linear expression, which describes the unimproved value (per acre) as a proportion of the original purchase price (per acre) of the bare land. Total unimproved value therefore is the product of the number of acres and the unimproved value per acre.

Freight

Provision is made in the programme for the calculation of freight on the following:

a) Livestock;
b) Fertiliser;
c) Sundry farm requisites;

Data from the livestock reconciliation schedule are used in the calculation of the cost of transporting the replacement heifers and associated bulls, to and from the place of outside grazing. The fertiliser freight costs are expressed as a function of farm area. Over the range of plant and herd sizes studied, this item of expenditure can assume two values, depending on whether or not, a contractor is used for the application of fertiliser. Two items are included in the category of sundry farm requisites, the two items are paraffin for bloat prevention and calcined magnesite for the prevention of metabolic disorders. In both cases, the programme calculates the quantities of these items required and the cost of their transportation.

Finally, freight charges on cull stock have been deducted from the price received for the products and freight on materials for repairs and maintenance purposes have been included in the cost of the materials.

Insurance

Insurance expenditure consists of two components; the first of which consists of those premiums which within a subclass, vary (either continuously or discretely) as herd size varies. Assets on which such premiums are charged include: buildings, machinery, equipment, milking equipment, supplementary feed reserves,[21] effluent disposal pump and water pump,[22] Premiums of this nature are computed from the data incorporated into the programme. The second component consists of those premiums which within a subclass are fixed for all degrees of plant utilisation. Such premiums include those for: workers' compensation, personal accident and sickness, Farmers' Public Liability and tractor insurance. The annual costs of these premiums are supplied to the programme as input data.

Vehicle Expenses

Included in this item of expenditure are: [23]

a) Tractor fuel and oil costs;

b) Tractor and trailer registration costs;

c) Baling twine on those farms where the complement of machinery includes a hay baler;

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21. Within each subclass, for each herd size, the total value of the required supplementary feed reserves is calculated.
22. Insurance, in the case of the water reticulation system and effluent disposal unit, is changed only on the value of the pumps. (Discussions with the representative of an insurance company indicated that the company was unwilling to insure the accessories such as pipelines, troughs and sprinklers.) From the programme instructions, the programme determines for each herd size, the appropriate values of the two pumps.
23. Unfortunately a charge for car expenses was overlooked during the compilation of the cost data. The consequences of this omission are discussed in section 7.4.

The procedure adopted to calculate the tractor fuel and oil consumption is to calculate the number of hours each of the implements operate. Trailers and transport trays are, however, excluded from this calculation. The hours of operation of each implement are then totalled and multiplied by a factor [24] to obtain an estimate of the total hours of tractor operation. From data incorporated into the programme, which specify the hourly consumption and costs per gallon of fuel and oil, the annual cost of these two items is obtained. Tractor and trailer registration costs are made available to the programme as input data. The cost of baling twine is incorporated into the programme expressed as a function of herd size.

Electricity

Electricity expenditure includes charges for the following:

a) Waterpumps;
b) Milking machines;
c) Farm dairy electric lights;
d) In place (bulk milk vat) cleaning devices;
e) Effluent disposal units;
f) Hot water cylinders;
g) Teat washers;
h) Refrigeration units;

A description of the derivation of the costs of the electrical consumption of the above items follows.

The daily requirements of electrical energy for water pumping are obtained by the use of a regression equation which expresses the required input of electrical units [25] as a function of herd size. Significant pecuniary economies were found to exist in the purchase of electricity. The procedure adopted by the authorities is to total the number of units used per period [26] per switchboard [27] to charge the initial 600 units

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24. For a full discussion of this factor, see page 65 of Appendix B.
25. The terms 'electrical units', 'units' and 'kilowatt-hours' (kwh) are synonymous. They are used interchangeably in this discussion.
26. A period in this context means two months.
27. The assumption is made that two switchboards are included in the electrical installations of the representative farms. One is concerned solely with the water pump, the other with the farm dairy electrical equipment.

at one rate and the remainder at a lower rate. [28] Consequently, a calculation is made in the programme of the number of units used per period for water pumping and the differential system of costing applied.

Four electrical devices (e.g. milking machines, farm dairy electric lights, in place cleaning devices and effluent disposal systems), are assumed to be connected to one switchboard. The electrical costs of these four devices are obtained by summing the number of units used by each device per period and applying the differential system of charging discussed earlier.

A description of the procedures used for determining the number of units used by each of the above four devices per period follows. The hourly input of electrical energy required to power the milking machines is made available to the programme as input data. This, together with data detailing the number of hours the milking machines operate per period allows the number of units consumed by the milking machines per period to be determined.

From data incorporated into the programme, the number of electric lights in each size of herringbone and the number of hours per period, the electric lights operate are calculated. Such information, together with data specifying the voltage of the electric lights, gives the total number of units used by the lights per period.

Provision is made in the programme for in place cleaning devices to be added to the complement of electrical equipment, when herd sizes exceed 176 cows. [29] For herds of 176 cows or less, no charge is made for such a device. For herds in excess of 176 cows, the daily input of units required by such a device is incorporated into the programme. The total number of units used per period is obtained by multiplying the number of days (in any given period), by the daily requirement of units.

The daily input of electrical energy required by the effluent disposal system is obtained by the use of a regression equation, which expresses the input of units as a function of herd size. The number of units used per period is obtained by a procedure similar to that used for the in place cleaning device.

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28. Such a system of charging is not adopted for all electrical appliances. The systems of charging are discussed in detail on pages 55 - 62 of Appendix B.
29. Data obtained from the manufacturers indicated that such devices are at present only fitted to the larger bulk milk vats.

The total number of units required annually for hot water heating is supplied as input data at the time the programme is executed. It should be realised, however, that in the case of plant sizes three and four, such a quantity varies discretely with herd size. Provision is therefore made in the programme for the quantity to be altered at the appropriate herd size. In the case of hot water heating, the system of charging adopted by the authorities is such that no pecuniary economies can be realised. The appropriate rate of charging (per unit) is incorporated into the programme.

The annual requirement of units by the teat washers is considered to consist of two components. First, the total number of units required to initially heat the contents of the teat washer cylinder at the commencement of each milking. Second, the total number of units required to heat the necessary volume of water during the milking for the herd size in question.

The first component is defined as input data at the time of programme execution, while the second component which varies continuously with herd size, is computed. The total annual cost is obtained by adding the two components together and applying to this total the appropriate cost factor.

Provision is made in the programme for refrigeration units to be added to the complement of electrical equipment when herd size exceeds 176 cows. [30] The derivation of the total number of units required annually for refrigeration purposes is obtained by the use of an expression which expresses the required number of units as a function of:

i) The average volume of milk per milking;
ii) The average reduction in temperature;
iii) The dimensions of the appropriate bulk milk vat;

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30. The present policy of the Manawatu Co-operative Dairy Company is to install refrigeration units on bulk milk vats which are of a capacity of 720 gallons or more. A bulk milk vat of 720 gallons is required when herd size exceeds 176 cows. Further it should be noted that although the investment and installation costs of the refrigeration units and the in place cleaning devices are met by the Dairy Company, the farmer is expected to meet the electricity costs of such devices.

Consequently, for each herd size (above 176 cows), the average volume of milk produced per milking is determined and the appropriate bulk milk vat selected. Data concerning the average reduction in milk temperature and the dimensions of the various bulk milk vats are incorporated into the programme. The total annual electrical costs of the refrigeration units are then obtained by multiplying the total annual requirement of units by the appropriate cost factor.

Repairs and Maintenance

Repairs and maintenance expenditure includes expenditure on the following items:

a) Buildings;
b) Fences;
c) Races;
d) Milking equipment;
e) Water reticulation systems;
f) Effluent disposal systems;
g) Machinery;
h) General equipment;

In the case of buildings, milkingequipment, water reticulation systems, effluent disposal systems and general equipment, the repairs and maintenance cost is assessed as a percentage of the original investment cost.

A slightly modified procedure is adopted, however, in the derivation of the sum required for repairs and maintenance to fencing and the farm race. In the case of fencing, the expenditure required for the fence lines is assessed as a given sum per chain of fence length, while that required for gates is assessed as a percentage of the original cost of the materials. In the case of the farm race, however, initial calculations indicated that as herd size increases (both between and within plant sizes), the length of race per cow decreases. As the width of the race varies discretely with herd size, it follows that within farms of the same race width, the race stocking rate [31] must increase as herd size increases. Such an increase in race stocking rate, should, in the author's opinion, be accompanied by an increase in the repairs and maintenance expenditure per chain of race. To facilitate such an increase, the repairs and maintenance cost per chain is set as five per cent of the

31. Race stocking rate is expressed in terms of cows per square chain of race.

original material costs (including freight) on the farms of minimum race stocking rate. 32/ For all other herd sizes, the race stocking rate is calculated and divided by the minimum stocking rate. (i.e. The stocking rate at which the cost factor is set as five per cent of the original material costs.) The product of the resulting quotient and five per cent, (i.e. the value on the 60 cow farm) gives for the herd size in question, the appropriate repairs and maintenance cost factor. The repairs and maintenance costs for gate fillings is similarly determined. The sum required for the tanker track, however, is assessed as a percentage of the original investment costs of the materials.

Machinery repairs and maintenance costs are assessed on an hourly basis. The total hours of operation of each machine are calculated and the appropriate cost factors (i.e. costs per hour), applied to obtain the costs for each machine. The total machinery repairs and maintenance cost is obtained by summing the expenditures of the individual machines. The hourly repairs and maintenance cost factors are with three exceptions, incorporated into the programme. The three exceptions are those relating to tractor(s), trailer(s) and transport tray(s). The reason for this is that in plant sizes three to five, multiples of these machines are included in the complements of machinery. In such cases where the machinery complement includes a number of a particular type of machine, the individual machines making up such a number are not necessarily similar. The individual machines (making up a number) differ in size 33/ and associated with each machine of a particular size, is a particular repairs and maintenance cost factor. Consequently the cost factor which is used in the programme, for that type of machine, differs from plant size to plant size, depending on the combination of individual machine sizes chosen.

Depreciation

Depreciation is calculated by using the sinking fund method. 34/

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32. i.e. Farms with a herd size of 60 cows.
33. For example, the machinery complement of plant size five includes three tractors. They are not of the same size as they are of different rated horsepower capacities. Similarly the machinery complement of plant size five includes two trailers. These are not of the same size as the physical dimensions of the trays differ.
34. After studying a number of discourses on depreciation, the author decided to use the sinking fund method, primarily because it recognises the time value of money.

For a particular asset, the annual payment to the depreciation fund is given by the expression:

$$SFP = (P - S) \frac{i}{(1 + i)^{n} - 1}$$

where: SFP is the annual payment to the depreciation fund;
P is the initial investment cost of the asset in question;
S is the salvage value of the asset;
i is the rate of interest;
n is the estimated economic life of the asset;

The resources of a capital nature are divided into two groups. From Group One, depreciation is charged on the following:

a) All buildings;
b) Milking equipment;
c) The pumps of the water reticulation and effluent disposal systems;

Further, such resources are considered to have a zero salvage value.

In the case of Group Two, depreciation is charged on all the individual items of machinery. A salvage value of ten per cent is allowed for such resources. The programming procedure adopted is to supply as input data, only the estimated economic lives of the assets to be depreciated. All other relevant data (including the derivation of the appropriate sinking fund factors and salvage values)are computed from data incorporated into the programme.

Interest

As a consequence of the method of depreciation (34, p.35) used, interest is charged on the total value of the resources of Group One and Group Two. Two rates of interest are used; one for the Group One resources and another for those of Group Two.

Operator's Labour Reward

The opportunity cost of the operator's labour in all cases is assumed to be 3,000 dollars per annum. A sum of 3,000 dollars per annum is assessed as the opportunity cost of the farm operator's labour, as discussions with local Extension Officers indicated that such a sum was being earned by experienced farm employees in the Manawatu district.

Operator's Managerial Reward

The opportunity cost of the operator's managerial input is assessed as six per cent of the gross farm income in all cases. A rate of six per cent on gross farm income is used for assessing the opportunity cost of the farm operator's managerial input as this sum, when added to 3,000 dollars (for the operator's labour), approximated the salary being paid to employed managers on some of the Group IV survey farms.

4) Derivation of the Net Income Figures

Five total cost concepts are derived, the details of which are:

Total cost A	=	Total cash costs;
Total cost B	=	Total cost A + depreciation;
Total cost C	=	Total cost B + interest on investment;
Total cost D	=	Total cost C + opportunity cost of operator's labour;
Total cost E	=	Total cost D + opportunity cost of operator's managerial input.

Five net income figures are derived by subtracting each of the five cost concepts from the gross farm income. The five net income figures so derived are therefore:

Net cash income	=	Gross farm income - Total cost A
Net farm income	=	Gross farm income - Total cost B
Operator labour and management income	=	Gross farm income - Total cost C
Operator management income	=	Gross farm income - Total cost D
Entrepreneurial income	=	Gross farm income - Total cost E

6.6 DERIVATION OF THE COST REVENUE RATIOS AND SUNDRY DATA

For each representative farm, five cost revenue ratios are derived by dividing each of the five cost concepts discussed earlier by the gross farm income. The five cost revenue ratios are therefore:

$$\text{Cost Revenue Ratio 1} = \frac{\text{Total Cost A}}{\text{Gross Farm Income}}$$

$$\text{Cost Revenue Ratio 2} = \frac{\text{Total Cost B}}{\text{Gross Farm Income}}$$

$$\text{Cost Revenue Ratio 3} = \frac{\text{Total Cost C}}{\text{Gross Farm Income}}$$

Cost Revenue Ratio 4 = $\frac{\text{Total Cost D}}{\text{Gross Farm Income}}$

Cost Revenue Ratio 5 = $\frac{\text{Total Cost E}}{\text{Gross Farm Income}}$

Finally for each representative farm, the output of milkfat per labour unit and the average (seasonal) milking time is calculated.

6.7 TAXATION CONSIDERATIONS

The effect of taxation is not considered in this study. As taxation is a complex matter and is dependent on a number of factors,[35] other than the income generating capacity of a farm, taxation is considered to be outside the scope of the study.

6.8 SUMMARY

In this chapter, a detailed account is given of the basic assumptions of the analysis and a careful and thorough description given of the operations required for the construction of the short run average cost curves.

A careful study of this chapter plus the information contained in Appendix B (Volume II) will enable the reader to gain an understanding of the factors which (in this study) give rise to economies and diseconomies of size. Further a detailed knowledge of the assumptions made and of the cost data is required if the results of the analysis are to be assessed critically.

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35. Some of the factors which influence the taxation liability of a farmer are:

i) The personal situation of the farm operator (e.g. marital status, number of dependents, etc.).

ii) Form of ownership of the farm.

iii) The level of equity.

iv) The extent to which the various farming taxation exemptions are taken advantage of.

CHAPTER SEVEN

PER UNIT COST AND INCOME DATA

7.1 INTRODUCTION

In this chapter, a detailed account is given of the way in which the cost and gross farm income data varies according to plant and herd size.

The first part of the chapter is concerned with the way in which the per unit[1] investment costs of the various capital resources vary with plant and herd size. The total investment requirements and estimated "market values" of the representative farms are then presented. In the third part of the chapter, the relationship between plant and herd size and the per unit costs of the various annual cash and non cash costs are discussed. Finally the manner in which each of the five total cost concepts and gross farm income varies with plant and herd size is indicated.

This chapter is not essential to the thesis but has been included as, in the author's opinion, it does enable the reader to gain a clear understanding of the factors which are responsible for economies and diseconomies of size. The chapter should be read in conjunction with the series of per unit cost (and income) curves [2] presented in Appendix C of Volume II.

7.2 PER UNIT COSTS OF CAPITAL RESOURCES

Land

The per unit investment cost of land falls continuously over the complete range of herd sizes studied. The per unit investment cost, therefore, falls from a maximum of 478.51 dollars in the case of the 60 cow farms, to 259.91 dollars in the case of farms with a herd size of 600 cows.

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1. The phrase "per unit cost" is synonymous with the phrase "per cow cost".
2. A per unit cost curve shows the relationship between a given item of cost data and herd and plant size.

Curve AA' of Figure 7.1 shows the relationship between herd size and the per unit investment cost of land. From Figure 7.1, it can be seen that the curve is made up of two straight line segments which intersect at B. 3/ It is important to note that the (negative) gradient of the initial segment of the curve (i.e. segment AB) is less than that of the second segment (i.e. segment BA'). Consequently relatively large cost reductions are obtained over the initial segment of the curve. For example, increasing herd size from 60 to 110 cows results in a per unit cost reduction of 137.61 dollars. At the other extreme, however, a fifty cow increase from 550 to 600 cows results in a per unit cost reduction of only 9.27 dollars. Land can, therefore, be recognised as one resource which might give rise to pecuniary economies. 4/

Farm Race

The relationship between herd size and per unit race investment costs is shown in Figure 7.2 by the curve AA'. The segmented nature of the curve is due to the assumption that race width varies discretely with herd size. Figure 7.2 shows that within farms of a given race width, the per unit investment cost decreases as herd size increases. The reasons for such decreases in the per unit investment costs are:

a) Certain components of the total race cost are fixed over the complete range of herd sizes studied, (e.g. the costs of the cattle stop, gate fillings and tanker track).

b) Within farms of a given race width, the cost of the race to the farm dairy is fixed.

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3. The two segments have been derived from the use of two linear functions.

4. The data upon which Figure 7.1 is based refers to the price per acre which would have to be paid if the area in question was purchased as a single "parcel of land". In practice, however, it may not be possible to purchase the required area in a single "parcel". Consequently pecuniary economies may not be realised. For example, in order to acquire 300 acres, it may be necessary to purchase three "parcels" of 100 acres each. The purchase price per acre of the 300 acres will therefore not differ from that of a single "parcel" of 100 acres and consequently no pecuniary economies are realised.

c) Over the complete range of herd sizes studied, although the length of the farm race increases continuously with increases in herd size, such increases occur at a decreasing rate, (i.e. the per unit length of race required declines continuously as herd size increases).

All three sources of cost reductions noted above can be described as arising from proportionality relationships. The relationships discussed in a), b) and c) also, between farms of different race widths, tend to give cost advantages to farms of the largest herd size (i.e. 600 cow farms). These advantages, however, are reduced by the increased cost per chain of the races required by the larger herd sizes. Consequently the lowest per unit investment cost is not associated with the largest herd size studied but is recorded at a herd size of 399 cows.

Fencing

The relationship between herd size and the per unit investment cost of fencing is shown by the curve AA' of Figure 7.3. Curve AA' shows that over the complete range of herd sizes studied, the per unit costs of fencing decline continuously as herd size increases. Such cost reductions are due to:

a) The continuous decline in the per unit length of fencing (and hence cost of fences), which is associated with increases in herd size.

b) Any minor disturbances [5] in the overall trend towards a continuous decline in the per unit cost of gates with increases in herd size being offset by the continuous decline in the per unit cost of fences noted above.

Again such cost reductions can be described as arising from proportionality relationships. Consequently, the maximum per unit cost is

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5. As the total cost of gates varies discretely with herd size, the trend towards a continuous decline in the per unit cost of gates, with increases in herd size, is interrupted over specific ranges of herd sizes. For example, the per unit cost of gates declines continuously up to and including a herd size of 199 cows. Over the range of 200 - 202 cows, the per unit cost is greater than the per unit cost associated with 199 cows. A minor disturbance is therefore said to occur over the range of 200 - 202 cows.

recorded on the 60 cow farms (i.e. 58.21 dollars) and the minimum (i.e. 16.75 dollars), is recorded on the 600 cow farms.

Water Reticulation Systems

The per unit investment costs of the water reticulation systems for the representative farms are shown in Figure 7.4 by the curve AA'. Figure 7.4 shows the curve AA' as consisting of two segments. The first segment (i.e. AB is constructed from the first regression equation; [6] the second segment (i.e. B'A') from the second regression equation. [6] Within the first segment, the investment costs fall from 32.19 dollars per cow in the case of 60 cow farms to 8.17 dollars per cow in the case of farms with a herd size of 399 cows. Investment costs then rise slightly to 8.60 dollars per cow for a herd size of 400 cows (due to the number of troughs being increased to forty-five), and thereafter decline steadily to reach a minimum of 7.50 dollars per cow at a herd size of 600 cows.

The relationships shown in Figure 7.4 are due to:

a) The continuous decline in the per unit length of the main pipeline which is associated with increases in herd sizes. (Such an advantage is to some extent offset by the necessity to increase the diameter of the pipeline for the larger herd sizes).

b) Certain components of the cost of the water reticulation systems remaining fixed over the complete range of herd sizes studied (e.g. the installation costs of the water bore).

c) Certain components of the cost of the water reticulation systems remaining constant over specific ranges of herd sizes (e.g. the cost of pumps, trough leads, troughs, trough fittings and pipe fittings).

As in the case of fencing and race investment costs, proportionality relationships give rise to the three sources of cost reductions just noted.

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6. The two regression equations are discussed fully on page 37 of Appendix B.

Electric Power Installations

Figure 7.5 shows the electric power installation costs, according to plant size and herd size. In the case of plant sizes one to three, the relationship is represented by the curves AA', BB' and CC' respectively. [7] Curves D_1D_1' and D_2D_2' represent the relationship in the case of plant size four, while the relevant curves for plant size five are E_1E_1' and E_2E_2'. [8] Within each plant size (and in the case of plant sizes four and five, each subclass), the per unit installation costs decrease as herd size increases. The reasons for such decreases are:

a) The continuous decline in the per unit length of the main service line which is associated with increases in herd size.

b) The cost of "drop-offs" from the main service line to the various farm buildings, remaining constant over all degrees of plant utilisation.

Again proportionality relationships are responsible for such cost reductions. A third factor is also of interest however. No charge is made by the authorities for the initial sixty feet of service line. Such a concession, favours farms of the smallest herd size, as the effect of the

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7. For the remainder of this discussion, the symbols AA', BB', CC', DD' and EE' are used to denote the per unit cost curves of plant sizes one to five respectively. In the case where three per unit cost curves are associated with each plant size (i.e. each per unit cost curve corresponds to one of the three subclasses), the per unit cost curves corresponding to the three subclasses are denoted by the subscripts 1, 2, 3. Hence in the case of plant size one, the per unit cost curve of:

   i) Subclass (a) is denoted by A_1A_1'
   ii) Subclass (b) is denoted by A_2A_2'
   iii) Subclass (c) is denoted by A_3A_3'

8. Two curves are required in the case of plant sizes four and five as within both plant sizes, depending on the size of herringbone used, two expressions are used to calculate the length of the main service line. See page 36 of Appendix B.

concession is diluted, as the length of main service line increases. However, within each plant size (and in the case of plant sizes four and five, each subclass) such an effect is not of sufficient magnitude to offset the cost reductions discussed in a) and b) and the per unit cost declines continuously as herd size increases.

In the case of resources of this nature,[9] the per unit investment costs are a function of both plant size and herd size. Although continuous cost reductions occur within a plant size as herd sizes increase, continuous cost reductions do not occur between plant sizes as herd size increases. For example, in the case of plant size one farms, the per unit cost declines continously as herd size increases from 60 - 136 cows. (At the cut-off [10] point of plant size one subclass (c) the per unit cost is 3.75 dollars.) Moving to a herd size of 137 cows (which necessitates using plant size two), results in the per unit cost increasing to 4.20 dollars. The reasons for such an increase are as follows. Although the increase in herd size (i.e. from 136 to 137 cows) is accompanied by a decline in the per unit cost of the main service line, this is more than offset by the increased per unit cost of the "drop-offs". As herd size is increased still further, the per unit investment cost declines, but does not become equal to or less than 3.75 dollars until a herd size of 163 cows is reached. Thereafter the per unit cost declines steadily up to a herd size of 240 cows (i.e. the cut-off point of plant size two subclass (c)).

Therefore if a horizontal line is constructed from point A' to curve BB', the line A'P results. Such a line can be used to indicate the range of herd sizes, over which (in the case of plant size one and two farms), continuous cost reductions occur, that is over the range of 60 - 136 cows (curve AA') and 163 - 240 cows (segment PB' of curve BB'). Alternatively the line can be used to show that cost advantages accrue to the plant size two farms (relative to the cut-off point of plant size one subclass c)), only over specific ranges of herd sizes. In this case, cost advantages accrue to the plant size two farms, only over the range of 163 to 240 cows, (i.e. segment PB').

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9. Other resources of this nature are farm dairies, milking equipment, implement sheds, machinery and equipment.
10. The term "cut-off point" is synonymous with the term "maximum degree of plant utilisation." The cut-off points of each of the fifteen subclasses are shown in Column (2) of Table 6.2.

Similar lines can be constructed through the cut-off points of the other plant sizes (and subclasses), enabling the interplant cost advantages to be determined. An examination of Figure 7.5 indicates that relative to the representative farms of plant size one, cost advantages accrue to all representative farms of plant sizes three to five. In the case of plant size two farms, however, as noted earlier, cost advantages accrue only over specific ranges of herd sizes.

Figure 7.5 shows that between plant sizes two to five, for comparable subclasses and degrees of plant utilisation [11] the per unit cost declines as one moves from plant size two to plant size five. Consequently the lowest per unit cost is recorded at the cut-off point of plant size five subclass (c). It should be realised that at this herd size, the per unit cost of the "drop-offs" is not at a minimum. (The per unit costs of the "drop-offs" is a minimum at the cut-off point of plant size one subclass (c).) The minimum total per unit cost on this plant size five farm results from the continuous reduction in the per unit cost of the main service line, which accompanies increases in herd size being of sufficient magnitude to offset the slightly higher per unit cost of the "drop-offs".

Farm Dairy Costs

Figure 7.6 shows the per unit farm dairy costs, according to plant size and herd size.

Figure 7.6 shows that within each of the three subclasses of each plant size, the overall trend [12] is for the per unit investment costs to decline as herd size increases. This decrease in per unit investment cost is explained by:

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11. i.e. Representative farms with the same number of cows per labour unit, and utilising a herringbone with the same number of sets of cups per milker.
12. In the case of the three subclasses associated with plant size one, the per unit costs of the farm dairies decline continuously as herd size increases. In the case of each of the three subclasses associated with each of the other four plant sizes, such a decline is interrupted over specific ranges of herd sizes because of changes in the costs of entry/exit/draughting area and changes in the cost of the milk room and vat stand.

a) The cost of the herringbone portion of the farm dairy, remains constant over the complete range of herd sizes relevant to the subclass in question.

b) Certain components of the cost of the farm dairy vary continuously with herd size, the increases however occur at a decreasing rate, (e.g. the cost of the circular yard backing gate and the cost of the circular yard pipe work and kerbing.)

c) Certain components of the cost of the farm dairy are assumed to be fixed over the complete range of herd sizes studied (e.g. the cost of electrical installations to the backing gate and the entry and exit gates to the drenching race.)

d) Certain components of the cost of the farm dairy vary discretely with herd size (e.g. the cost of the entry/exit/ draughting area, the milk room and vat stand and the entry gate.)

All four sources of cost reductions noted above can be described a arising from proportionality relationships. Hence it seems likely that pecuniary economies will be realised in the construction of farm dairies.

It should be noted that within each plant size, the per unit investment cost at the three cut-off points conforms to one of two patterns.

i) In the case of plant size one, the per unit cost decreases from the first to the third cut-off point.

ii) In the case of plant sizes two to five, the per unit cost increases from the first to the third cut-off point. 13/

If the procedure discussed on page 136 is adopted, and a series of horizontal lines drawn through the various cut-off points, the nature of the between plant cost reductions can be examined. Relative to the plant size one (i.e. the cut-off point of subclass (c) - the plant size one farm with the lowest per unit cost), with the exception of plant size five, cost reductions accrue over specific ranges of herd sizes to all subclasses of the other four plant sizes. In the case of plant size five the per unit cost of all representative farms of subclass (a) is less than that at the cut-off point of plant size one subclass (c).

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13. For plant sizes two to five when moving from the first to the third cut-off points, increases in the per unit cost of the herringbone outweight the per unit cost decreases from all other sources. For plant size one, however, the opposite applies.

It should be noted that within plant sizes two to five, the lowest per unit cost in each case is recorded at the cut-off point of subclass (a). Further as one moves from plant size two to plant size five, (for comparable subclasses and degrees of plant utilisation), the magnitude of the cost reductions increases. Consequently, the lowest per unit cost is obtained at the cut-off point of plant size five, subclass (a), (i.e. 525 cows, 30 aside herringbone).

Barn Investment Costs

Curve AA' of Figure 7.7 shows the per unit investment cost of barns according to herd size. The segmented nature of the curve is due to the fact that barn costs vary discretely with herd size. Consequently, a series of cost reductions are obtained over the length of the curve, by the fuller utilisation of the capacity of each barn. Per unit investment costs decline from a maximum of 7.55 dollars in the case of the 67 cow farms to a minimum of 3.81 dollars in the case of farms with a herd size of 533 cows.

As the barns in question are kitset barns,[14] the cost reductions shown in Figure 7.7 from a farm operator's point of view can be regarded as of a pecuniary nature. However, in the first instance, it is likely that such reductions arise from proportionality relationships (i.e. the per unit quantity of materials required declines as herd size increases).

Pump Shed Costs

As the pump shed cost remains constant over the complete range of herd sizes studied, the per unit investment cost declines continuously as herd size increases. The maximum value of 2.41 dollars per cow is recorded on the farms with a herd size of 60 cows and the minimum value of 0.24 dollars per cow on the farms of 600 cows.

Dwellings

Within each subclass dwellings are regarded as items of fixed plant. Consequently, cost reductions are obtained as the degree of plant utilisation increases. Between plant sizes, however, a cost advantage accrues to those farms of plant size one, where the ratio of cows per labour unit exceeds 120.

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14. The costs which are incorporated into the programme include all the costs which are associated with a barn (e.g. materials, cartage, painting and erection costs).

Implement Sheds

Figure 7.8 shows the per unit investment costs of implement sheds, according to plant size and herd size. The vertical lines FF', GG' and HH' of Figure 7.8 indicate the herd sizes at which, for particular plant sizes, the complement of machinery is altered, necessitating a change in the total cost of the implement shed. Line FF' applies only to plant size one farms and indicates the herd size at which the hay rake is excluded from the complement of machinery, and the total cost of the implement shed decreased. Line GG' indicates the herd size at which a fertiliser distributor is added to the complement of machinery and the total cost of the implement shed increased, in order to accomodate the fertiliser distributor. Similarly, line HH' indicates the herd size at which a hay baler is added to the complement of machinery, necessitating an increase in the total cost of the implement shed.

Within each plant size, if minor variations [15] which occur in some plant sizes over a small range of herd sizes are ignored, the overall trend is for cost reductions to be realised as the degree of plant utilisation increases. Relative to the cut-off point of plant size one, cost reductions accrue to the other four plant sizes over specific ranges of herd sizes. The minimum per unit cost occurs at the cut-off point of plant size five, subclass (c).

Milking Equipment

Figure 7.9 depicts the manner in which the per unit cost of milking equipment varies according to plant and herd size.

Within each of the three subclasses associated with each plant size, cost reductions result as the degree of plant utilisation increases. [16] Within a plant size, the cut-off points of the three subclasses conform to one of two patterns. In the case of plant size one farms, the lowest per unit cost is recorded at the cut-off point of subclass (b), while in the case of plant sizes two to five, the per unit costs increase as one moves from the first to the third cut-off point.

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15. Such variations occur in plant sizes two to five and are due to the increase in the area of the implement shed, in order to accomodate a fertiliser distributor and/or a hay baler.
16. Minor disturbances due to alterations in the cost of hot water cylinders do, in some cases, interrupt this trend. See Table B.15 of Appendix B.

Relative to plant size one (i.e. the cut-off point of subclass (b)) over specific ranges of herd sizes, cost reductions accrue to all subclasses of the larger plant sizes. The magnitude of such cost reductions, for comparable subclasses and degrees of plant utilisation, increases as one moves from plant size two to plant size five. Within each of these four plant sizes, the lowest per unit costs are recorded at the cut-off point of subclass (a). Thus over the complete range of plant and herd sizes studied, the per unit cost declines from 34.31 dollars at the start point 17/ of plant size one subclass (c) to 9.86 dollars at the cut-off point of plant size five subclass (c).

Within each subclass, the cost reductions noted in Figure 7.9, arise from proportionality relationships due to the fuller utilisation of the items of fixed plant. 18/ For comparable subclasses, and degrees of plant utilisation, the between plant differences may from a farm operator's view be regarded as of a pecuniary nature. However in the first instance, it seems likely that such cost reductions arise from proportionality relationships. 19/

Effluent Disposal Systems

Curve AA' of Figure 7.10 shows the relationship between herd size and the per unit investment cost of the effluent disposal systems. Curve AA' consists of three segments, each segment being derived from a regression equation. If minor variations such as those which occur over the range of 121 to 145 cows and 351 to 437 cows are ignored, 20/ the overall trend is for the per unit cost to decline as herd sizes increase.

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17. The term 'start point' is synonymous with the term 'the initial degree of plant utilisation'. The start points of each of the 15 subclasses are shown in Column (1) of Table 6.2.
18. e.g. The costs of milking machines and teat washers and in some cases costs of hot water cylinders (for a particular subclass) remain constant over all degrees of plant utilisation.
19. e.g. Certain components of the cost of the milking machines remain constant over a range of milking machine sizes. For example, the costs of electric motors, vacuum pumps, teat washer cylinders. In addition, certain components of the cost remain constant over the complete range of milking machine sizes studied, e.g. fittings for the water supply to cooler.
20. These variations are due to the introduction of different effluent disposal systems (and hence the use of different regression equations), when herd sizes reach 121 and 351 cows. The regression equations are discussed fully on page 38 of Appendix B.

Machinery

The relationships between the per unit costs of machinery and plant and herd size are shown in Figure 7.11. The vertical line FF' in Figure 7.11 indicates the herd size at which a hay rake is excluded from the complement of machinery of plant size one farms. Line GG' applies to plant sizes two to five and shows the herd size at which a fertiliser distributor is added to the machinery complements. Similarly line HH' applies to plant sizes three to five and shows the herd size at which a hay baler is added to the machinery complements.

In the case of plant size one, continuous cost reductions occur as the degree of plant utilisation increases. For plant sizes two to five, however, this trend is interrupted (over specific ranges of herd sizes) by the addition of fertiliser distributors and hay balers to the machinery complements.

Between plant sizes, however, relative to the plant size one farms, with the exception of plant size three, cost advantages accrue over specific ranges of herd sizes to the other plant sizes. It is interesting to note that the lowest figure is recorded at the cut-off point of plant size two subclass (c), being 20.64 dollars per cow. Comparable figures for the other plant sizes are:

Plant size one	:	27.38 dollars
Plant size three	:	27.65 dollars
Plant size four	:	26.86 dollars
Plant size five	:	21.40 dollars

This can be explained by:

a) The relatively high ratio of cows to certain items of machinery on the plant size two farms (e.g. tractors, trailers and transport trays).

b) The absence of certain items of machinery from the machinery complement of the plant size two farms, (e.g. hay balers and hay loaders).

Equipment

The per unit costs of equipment according to plant and herd size are shown in Figure 7.12.

Within a plant size, cost reductions are obtained as the degree of plant utilisation increases. Between plant sizes, relative to plant size one, cost advantages accrue to all representative farms of plant sizes three to five. In the case of plant size two, however, cost advantages are realised only over a specific range of herd sizes. Again the minimum per unit cost is obtained at the cut-off point of plant size five, subclass (c).

Within a plant size, the cost reductions result from:

a) The fuller utilisation of those components of the equipment cost, which remain fixed over all degrees of plant utilisation, (e.g. the cost of hand tools and general equipment).

b) The decrease in the per unit cost of electric fencing wire which is associated with increases in herd size.

Between plant sizes, the cost reductions arise from:

i) The costs of certain items of equipment, which do not vary over the complete range of herd sizes studied, (e.g. crescent spanners, grease gun, hydraulic jack, diesel tank).

ii) A more favourable ratio of cows to certain items of equipment which characterises the larger plant sizes (e.g. certain tools including axes, saws, hayforks, drench guns, etc.).

iii) The decline in the per unit electric fence wire requirement, noted above.

Therefore both between and within plant sizes, proportionality relationships are responsible for the cost reductions.

7.3 PER UNIT TOTAL INVESTMENT REQUIREMENTS AND ESTIMATED "MARKET VALUE" OF THE REPRESENTATIVE FARMS

Figures 7.13 and 7.14 show the per unit total investment requirements and the per unit estimated "market values" of the representative farms.

Within each subclass, the per unit investment requirements and estimated "market values" decline continuously as the degree of plant utilisation increases.

In both cases, relative to plant size one, cost advantages accrue to all other plant sizes, over specific ranges of herd sizes. Further, (in both cases), for plant sizes two to five, for comparable subclasses and degrees of plant utilisation, the magnitude of the cost reductions increase as one moves from plant size two to plant size five. The maximum per unit investment requirement is therefore recorded at the start point of plant size one subclass (c), being 1,094 dollars and the minimum per unit investment requirement corresponds to the cut-off point of plant size five subclass (c), being 542 dollars. Similarly, the maximum per unit estimated "market value" is observed at the start point of plant size one, subclass (c), being 890 dollars, and the minimum, 471 dollars, is recorded at the cut-off point of plant size five subclass (c).

7.4 PER UNIT ANNUAL CASH COSTS

The per unit annual cash costs are divided into three categories:

a) Category I : Cash costs which remain constant over the complete range of herd sizes studied.

b) Category II : Cash costs which are a function of herd size.

c) Category III : Cash costs which are a function of both plant and herd size.

Category I

Included in Category I are the following items of expenditure:

a) Animal health;
b) Feed;
c) Weed and pest control;
d) Fertiliser;

In the case of animal health costs and feed costs, minor variations do occur (between herd sizes), because of slight variations in the proportions of young stock required for replacement purposes. These variations arise because the numbers of young stock required (as calculated in the livestock reconciliation schedule) are expressed as integers. In the case of weed and pest control costs and fertiliser costs, no such variations are evidenced, as the expenditure is expressed as a function of the number of acres. The per unit costs of animal health and feed therefore approximate 4.25 and 5.50 dollars respectively. The per unit costs of weed and pest control and fertiliser are 0.18 dollars and 3.66 dollars respectively.

Category II

Included in Category II are the following items of expenditure:

a) Breeding expenses;

b) Administration;

c) Rates;

Breeding Expenses

Curve AA' and Curve BB' of Figure 7.15 show the per unit costs of artificial breeding and herd testing respectively according to herd size. The per unit costs of artificial breeding decline as herd size increases from 1.17 dollars per cow when the herd size is 60 cows to 0.96 dollars per cow when a herd size of 600 cows is reached. The decline, however, is not continuous [21] as particular values apply to specific ranges of herd sizes. The cost reductions indicated by Curve AA' are a consequence of the graduated system of charging employed. Similarly, the per unit costs of herd testing decline by 0.20 dollars over the complete range of herd sizes studied. Such a cost reduction results because of the charging of a herd fee which remains constant irrespective of herd size.

Administration

The relationship between the per unit costs of administration and herd size are shown by the Curve AA' of Figure 7.16. Curve AA' shows that over the complete range of herd sizes studied, the per unit cost declines continuously as herd size increases from a maximum value of 3.05 dollars (60 cows) to a minimum of 0.47 dollars (600 cows). Such a continuous decline in the per unit cost is due to:

a) The decrease in the per unit accountancy fee which is

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21. The per unit costs do not decline continuously:
    i) Because of slight variations in the proportion of cows artificially inseminated, due to the number of cows to be inseminated being expressed as integers.
    ii) The per unit costs are only taken to two decimal places.

associated with increases in herd size. 22/

b) Certain components of the administration cost remain constant over the complete range of herd sizes studied (e.g. rural delivery fee, journal subscriptions, postages and tolls).

Rates

The relationship between herd size and the per unit expenditure on rates is shown by the curve AA' of Figure 7.17. Over the range of herd sizes studied, the per unit cost declines continuously from 2.62 dollars to 0.93 dollars. Such a decline is due to:

a) The continuous decline in the per unit price of land, which accompanies increases in herd size.

b) The continuous decline in the ratio of the unimproved value per acre, to the purchase price of land, which accompanies increases in herd size.

Category III

Included in Category III are the following items of expenditure:

a) Casual and contract labour;
b) Permanent labour (wages);
c) Vehicle expenses;
d) Freight;
e) Insurance;
f) Dairy shed expenses;
g) Electricity;
h) Repairs and maintenance;

Casual and Contract Labour

The per unit costs of casual and contract labour, according to plant and herd size are shown in Figure 7.18.

From Curve AA' it can be seen that in the case of plant size one, over the initial range of herd sizes (i.e. 60 - 120 cows), the per unit cost remains constant at 3.13 dollars per cow. Over this range of herd

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22. Such decreases in per unit costs are due to accountancy fees being expressed by a linear function, $y = ax + b$, where y = accountancy fee, x = herd size and a and b are constants.

sizes, charges are made for hay baling, hay loading and contract fertiliser application. For herd sizes in excess of 120 cows, the per unit costs increase because of the employment of additional hay contractors [23] and casual labour for repairs and maintenance work. The segmented nature of Curve AA' over the range of 120 - 136 cows, results from the (total) cost of casual labour, varying discretely with herd size.

Curve BB' representing plant size two consists of two straight line segments. Up to and including a herd size of 188 cows, the per unit cost is 2.97 dollars. For herds of 189 cows or more, the per unit cost is 2.36 dollars. The difference in the per unit costs of the two segments is due to the inclusion in the costs of the first segment, of the cost of contract fertiliser application. (Both segments include the costs of hay baling and hay loading.)

Curve CC' representing plant size three, consists of three straight line segments. The initial segment (i.e. 180 - 188 cows) includes the costs of hay baling, hay loading and contract fertiliser application. The second segment (i.e. 189 - 300 cows) includes the costs of hay baling and hay loading, while the third segment, includes the cost of hay loading only. Plant sizes four and five are represented by the curves DD' and EE' respectively. In both cases, the only cost of relevance is the cost of hay baling. Such a cost is relevant only up to and including a herd size of 300 cows.

<u>Permanent Labour (Wages)</u>

Figure 7.19 shows the relationship between the per unit costs of wages and plant and herd size. [24] Figure 7.19 shows that between plant sizes for comparable degrees of plant utilisation, cost advantages accrue to the smallest plant size (i.e. plant size two).

For example, when the ratio of cows per labour unit is 60, the per unit costs of wages for the four plant sizes are:

Plant size two	:	25.00 dollars
Plant size three	:	33.33 dollars

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23. i.e. For herd sizes of 121 cows or more, hay raking is performed by contractors and for herds of 131 cows or more, contractors are employed for hay mowing.
24. It should be noted that such an expense is not relevant to plant size one.

Plant size four : 37.50 dollars

Plant size five : 40.00 dollars

Similarly when the ratio of cows per labour unit is 120, the per unit cost of wages are:

Plant size two : 12.50 dollars

Plant size three : 16.66 dollars

Plant size four : 18.75 dollars

Plant size five : 20.00 dollars

The increasing per unit cost of wages, for comparable degrees of plant utilisation, as one moves from plant size two to plant size five, is a reflection of the fact that the per unit opportunity cost of the farm operator's labour declines from plant size two to plant size five. The per unit total labour cost [25/] is for comparable degrees of plant utilisation constant between the four plant sizes. Consequently, for any given degree of plant utilisation, the per unit cost of wages increases from plant size two to plant size five.

Vehicle Expenses

The per unit costs of vehicle expenses according to plant size and herd size are shown in Figure 7.20. For all plant sizes, the curve describing the relationship consists of two or more segments. Within each of the segments comprising a curve, the per unit cost declines as herd size increases.

In the case of plant size one, the per unit cost declines steadily until a herd size of 120 cows is reached. Thereafter it declines rapidly, reaching a minimum at a herd size of 136 cows. The rapid decline is due to contractors being employed for certain haymaking operations.

The per unit costs of the plant size two farms decline from an initial 0.79 dollars per cow (120 cows) to 0.75 dollars at a herd size of 188 cows. At a herd size of 189 cows, the cost increases to 0.80 dollars per cow due to the introduction of a fertiliser distributor, and thereafter declines slightly to 0.79 dollars per cow when a herd size of 240 cows is reached.

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25. The term 'total labour cost' in this context means that the total cash cost for wages be considered in conjunction with the imputed opportunity cost of the farm operator's labour.

Curve CC' which represents plant size three consists of three segments. The initial segment (180 - 188 cows) applies to those farms, the machinery complement of which does not include a fertiliser distributor, nor a hay baler. The second segment (189 - 300 cows) applies to those farms, the machinery complement of which includes a fertiliser distributor but does not include a hay baler. The third segment (301 - 360 cows) applies to those farms, the machinery complements of which, contain both a fertiliser distributor and a hay baler. The lowest per unit cost of the plant size three farms is recorded at a herd size of 188 cows. The effect of adding additional implements to the complements of machinery is to cause the per unit costs of herd sizes of 189 cows or more to be greater than those pertaining to herd sizes of 180 cows - 188 cows.

Similarly curves DD' and EE' representing plant sizes four and five respectively, consist of two segments. In both cases, the initial segment applies to those farms, the machinery complement of which, does not include a hay baler and the second segment applies to those farms, the machinery complement of which does include a hay baler. In both cases, the lowest per unit costs are recorded by those farms with a herd size of 300 cows. [26]

Within each segment of each curve, the decline in the per unit cost with increases in herd size, is due to the registration costs of the vehicles (for the plant size in question) remaining constant over the range of herd sizes relevant to segment in question. Between plant sizes, Figure 7.20 shows that relative to all other representative farms, cost advantages accrue to those plant size one farms, where the number of cows exceed 120. Further, for comparable degrees of plant utilisation, the per unit costs are higher on the plant size four and five farms, than on farms of the three smaller plant sizes. The reasons for the higher per unit costs on the plant size four and five farms are:

a) The per unit hours of tractor operation, increase on the

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26. The author omitted a charge for car expenses. If it is assumed that 100 dollars per annum is allowed for car expenses on each of the representative farms, then the relationships shown in Figure 7.20 are markedly altered. In this case, the highest per unit cost occurs at the start point of the plant size one farms (2.53 dollars per cow) and the lowest on the plant size three farms with a herd size of 300 cows (1.14 dollars per cow).

farms of the larger plant sizes, because the farm tractors are used for spreading fertiliser, hay loading and hay baling.

b) The addition of a hay baler to the machinery complement, not only increases the per unit hours of tractor operation but also increases the hourly cost of tractor operation. This is because the hourly fuel and oil consumption of a tractor when operating a baler is greater than that required when operating all other implements. Further the per unit costs also increase because of the addition of the cost of baling twine.

c) The increase in per unit hours of tractor operation due to the introduction of hay balers, fertiliser distributors and hay loaders is also accompanied by an increase in the per unit hours tractors are used for transportation purposes (i.e. "hacking").

Freight

The per unit cost of freight takes on two values over the range of plant and herd sizes studied. Up to and including farms of herd size of 188 cows, the freight cost approximates [27] 0.72 dollars per cow, while on farms with a herd size of 189 cows or more, the freight cost is about 0.67 dollars per cow. The variation is due to a slight difference in the cost (per ton) of transporting fertiliser. (The charge made for transporting fertiliser by bulk fertiliser contractors is slightly greater than the charge made by transport contractors.)

Insurance

The per unit insurance costs according to plant and herd size are shown in Figure 7.21.

Within each of the three subclasses associated with each plant size, the per unit cost of insurance decreases as the degree of plant utilisation increases. Although the decreases in per unit costs are shown in Figure 7.21 as occurring continuously, in fact, such a trend is interrupted over specific ranges of herd sizes, due to alterations in those premiums which

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27. Slight variations do occur between herd sizes in the per unit costs of transporting stock to and from the place of grazing. This as noted earlier is due to slight variations between herd sizes in the proportions of young stock required, resulting from expressing the numbers of young stock required as integers.

vary discretely with herd size. Data concerning such variations was not obtained due to the excessive amount of computing time required to obtain it.

Such decreases arise from proportionality relationships. For example:

a) The insurance premiums paid for certain resources, remain constant over the complete range of herd sizes pertaining to each subclass (e.g. premiums of dwelling(s), tractor(s), pump shed).

b) Certain premiums increase continuously as herd size increases but such increases occur at a decreasing rate, (e.g. premiums for general equipment and in some cases, farm dairies.)

c) The premiums paid for certain resources vary discretely with herd size. Although minor variations do occur over specific ranges of herd sizes, the overall trend is for these per unit insurance costs to fall as herd size increases, (e.g. premiums for barns and implement sheds).

Between plant sizes over the complete range of herd sizes studied, the maximum per unit cost is recorded at the start point of plant size one, subclass (c), where the per unit cost is 2.23 dollars. The minimum value is recorded at the cut-off point of plant size five, subclass (c), where the per unit cost is 0.85 dollars. It should be noted that relative to the cut-off point of plant size one subclass (c), with one exception, [28] cost reductions over specific ranges of herd sizes accrue only to particular subclasses of each of the four (larger) plant sizes. [29] Further the magnitude of such cost reductions is small. For example, the per unit cost at the cut-off point of plant size five subclass (c) is 0.85 dollars, while at the cut-off point of plant size one, subclass (c), the per unit cost is 0.99 dollars, a difference of 0.14 dollars per cow. In this context, it should be realised that although the proportionality relationships previously discussed tend to give cost advantages to the larger plant and herd sizes, these are offset to some extent, by the necessity for the farms of plant sizes two to five to pay a workers' compensation insurance premium. For comparable degrees of plant utilisation, between plant sizes two to five, the per unit cost of this premium

28. The exception is plant size five.

29. i.e. Subclasses (b) and (c) of plant sizes two, three and four.
Subclasses (a), (b) and (c) of plant size five.

increases as one moves from plant size two to plant size five due to the per unit increase in the cost of wages.

Dairy Shed Expenses

Figure 7.22 shows the way in which the per unit dairy shed expenses vary according to plant size and herd size.

Figure 7.22 shows that within each of the three subclasses associated with each plant size, the trend is for the per unit costs of dairy shed expenses to decrease as herd size increases. In only four cases do the per unit costs decline continuously as herd size increases. [30] In the case of the other per unit cost curves, the trend towards a continuous decline in the per unit cost with increases in herd size, is interrupted over specific ranges of herd sizes for the following reasons. First, in the case of the five subclass (a) per unit cost curves, and the four subclass (b) per unit cost curves, (i.e. of plant sizes two to five), the total cost of inflations varies discretely with herd size. Second, the "interruption" in the trend towards a continuous decline in per unit costs with increases in herd size, of all the per unit cost curves of plant sizes three and four is due to the total cost of detergent varying discretely with herd size.

The nature of the per unit cost curves is due to:

a) Within each subclass of each plant size, the costs of claw rubbers, milk and air droppers, and dairy shed brushes remains constant over all degrees of plant utilisation.

b) Within certain subclasses, the costs of detergent and inflations remains constant over all degrees of plant utilisation. In the other subclasses where the costs of detergent and inflations vary discretely with herd size, the per unit costs of detergent and inflations are lower at the cut-off point, than at the start point despite the discrete variation.

30. The four cases are the per unit cost curves of:

i) Plant size one subclass (b);

ii) Plant size one subclass (c);

iii) Plant size two subclass (c);

iv) Plant size five subclass (c);

c) The cost of an annual milking machine check remains constant over the complete range of herd sizes studied.

d) As it is assumed within each subclass, that the time the milking machines are operated for cleaning purposes, does not vary according to herd size, the quantity (and hence cost) of the rotary pump oil consumed for this purpose remains constant over all degrees of plant utilisation.

All four sources of cost reductions can be described as arising from proportionality relationships. Further, within each plant size, the per unit costs at the cut-off points increase as one moves from subclass (a) to subclass (c). Relative to the plant size one farms, cost reductions accrue over specific ranges of herd sizes, to all three subclasses of each of the four larger plant sizes. In the case of plant sizes two to five, for comparable subclasses and degrees of plant utilisation, the general trend is for the magnitude of the per unit cost reduction to increase from plant size two to plant size five. Consequently the lowest per unit cost is recorded at the cut-off point of plant size five subclass (a).

Electricity

The per unit costs of electricity according to plant size and herd size are shown in Figure 7.23.

Within each of the three subclasses associated with each plant size, the overall trend is for the per unit cost to decline as the degree of plant utilisation increases. Minor disturbances over specific ranges of herd sizes do occur in some per unit cost curves, due to the introduction of refrigeration units, in place cleaning devices and an increase in the quantity of hot water required for cleaning the bulk milk vats.

Within each subclass, the following proportionality relationships contribute to the trend towards a decline in the per unit cost with increases in herd size.

a) In the case of plant sizes one, two and five, the number (and hence cost) of units required for hot water heating remains constant over the complete range of herd sizes. The number (and hence cost) of units required for hot water heating for plant sizes three and four, varies discretely with herd size. The effect of this discrete variation is to interrupt the continuous decline in the per unit kwh requirements over a small range of herd sizes. Advantages arising from proportionality relationships still accrue to the larger herd sizes of each subclass, however.

b) Similarly, the number of and cost of units, required to initially heat the contents of the teat washer cylinders, remains constant over all degrees of plant utilisation.

c) For plant sizes three to five, the number of units required annually to operate the in place cleaning devices, remains constant over all degrees of plant utilisation. In place cleaning devices are added to the complement of electrical equipment of plant size two farms when the herd size exceeds 176 cows. Over the range of 177 - 240 cows, cost reductions arise from proportionality relationships because the annual requirement of units by the in place cleaning devices is assumed to remain constant.

d) The expression which is used to derive the number of units required by the refrigeration units expresses the required number of units as a function of the volume of milk produced per milking, the required reduction in temperature, and the dimensions of the bulk milk vat. As the size of bulk milk vat varies discretely with herd size, it follows that within herd sizes of a given vat size, cost reductions will result as herd size increases.

e) Within each subclass, the number of units required annually to operate the milking machines for cleaning purposes, remains constant over all degrees of plant utilisation.

Within each subclass, pecuniary economies are also responsible for the trend towards a decline in the per unit cost of electricity as herd size increases. As herd size increases within a subclass, proportionately more [31] of the total units used for water pumping, lighting, operating milking machines, effluent disposal units and in place cleaning devices are charged at the lower rate. It should also be realised that proportionality relationships exist which give rise to per unit cost increases within a subclass, as herd size increases. Regression

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31. This assumes of course that the total number of units used per period by these appliances initially (i.e. at the start point of the subclass in question), is such that the differential system of charging can be employed.

equations are used to determine the number of units required for water pumping and for the disposal of farm dairy effluent. The regression equations are such [32] that the per unit requirements of kwh for water pumping and for the disposal of effluents, increase continuously with increases in herd size. However, the magnitude of such increases is small and is outweighed by the cost reductions arising from the proportionality relationships and the pecuniary economies discussed earlier.

Between plant sizes relative to plant size one, with two exceptions, cost reductions accrue to all the subclasses of the other plant sizes over specific ranges of herd sizes despite the fact that the electricity costs of the farms of plant sizes two to five include additional charges for refrigeration units and in place cleaning devices. The two exceptions are plant sizes four and five subclass (a) where cost reductions accrue over the complete range of herd sizes relevant to each subclass. Within each plant size, the lowest per unit cost is recorded at the cut-off point of subclass (a). For comparable cut-off points [33] the per unit cost declines as one moves from plant size one to plant size five. Consequently the lowest per unit cost is recorded at the cut-off point of plant size five subclass (a). Proportionality relationships are also responsible for the trend towards lower per unit costs in the larger plant sizes. For example:

i) The quantity of hot water required per milking for the milk room is 10 gallons, irrespective of farm dairy (and milking machine) size. The per unit quantity of hot water (for the milk room) is therefore a minimum at a herd size of 600 cows.

ii) The daily requirement of the in place cleaning devices, is set at 0.0465 kwh per day irrespective of herd size. Such an assumption also favours the farms with a herd size of 600 cows.

iii) The quantity of hot water required for cleaning the bulk milk vat varies discretely with herd size. This again favours farms of the largest herd size, as at this herd size, the per unit quantity of hot water required for vat cleaning is a minimum.

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32. The regression equations are of the form: $y = ax - b$, where y = number of units (i.e. kwh), x = herd size and a and b are constants.
33. There are three series of comparable cut-off points. They are the five subclass (a) cut-off points, the five subclass (b) cut-off points and the five subclass (c) cut-off points.

iv) Cost reductions accrue to the larger plant sizes in certain circumstances [34] because as the size of milking machines is increased, the number of units require to operate the milking machine per set of cups, falls.

v) The number of units required to initially heat the contents of the teat washer cylinder varies discretely with the size of farm dairy (i.e. subclass). Therefore within farms of the same teat washer cylinder size, cost reductions accrue to the farms of largest herd size.

vi) As the size of farm dairy increases, the ratio of the number of electric lights to the number of sets of cups falls. This relationship arises because the number of lights installed in the milk room and vat stand, entry/exit/draughting area and circular yard remain constant irrespective of farm dairy size.

vii) The expression for deriving the number of kwh required by the refrigeration units expresses the number of kwh as a function of the volume of milk produced per milking, the required decline in temperature and the dimensions of the bulk milk vat. Further as vat size varies discretely with herd size, that part of the expression which is a function of the dimensions of the vat, also varies discretely with herd size. Cost advantages do accrue, because of a general trend for that part of expression which is a function of the dimensions of the milk vat, when expressed on a per cow basis, to decline as herd size increases.

viii) In the case of water pumping and the disposal of effluent wastes, the per unit requirements of kwh increase continuously as herd size increases. This, as discussed earlier is due to the use of regression equations.

Finally pecuniary economies are also realised which give cost advantages to the largest plant sizes and herd sizes.

Repairs and Maintenance

The per unit repairs and maintenance costs according to plant and herd size are shown in Figure 7.24.

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34. Advantages accrue up to and including a 30 aside herringbone.

Within each of the three subclasses of each plant size, the per unit repairs and maintenance cost decreases as herd size increases. Although the per unit cost curves shown in Figure 7.24 show the per unit costs as decreasing continuously with increases in plant utilisation, in fact, the continuous cost reductions are interrupted over specific ranges of herd sizes due to the introduction of fertiliser distributors and hay balers, and changes in such factors such as the width of farm races, the area of implement sheds and the cost of certain components of the farm dairy, at specific herd sizes. Data concerning such interruptions were not obtained, however, due to the excessive amount of computing time required to obtain it.

Within each subclass, the decline in the per unit cost is due to the repairs and maintenance cost of a number of resources [35] being assessed as a percentage of the original investment cost. Consequently for these resources, the per unit repairs and maintenance cost, parallels the original per unit investment costs shown in Figure 7.13.

The per unit machinery repairs and maintenance costs, however, vary discretely with herd size. Over the range of herd sizes appropriate to plant size one, three values are relevant. Comparable figures for the other plant sizes are: plant sizes two, four and five - two values, plant size three - three values. Only in the case of plant size one do the per unit costs decline as herd size increases. In the case of plant sizes two to five, the increases in the per unit costs are small and are outweighed by the decreases from those resources, the repairs and maintenance cost of which, parallels the original per unit investment cost.

The effect of compensating for the increased race stocking rate, which accompanies increases in herd size, is to cause the per unit repairs and maintenance cost (of farm races) to remain constant over the complete range of herd sizes studied.

Relative to plant size one, cost reductions accrue to all subclasses of the other plant sizes over specific ranges of herd sizes. Between plant sizes two to five for comparable subclasses and degrees of plant utilisation, the per unit cost decreases from plant size two to plant size five. The lowest per unit cost is recorded at the cut-off point of plant size five subclass (c).

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35. e.g. Buildings, water reticulation systems, effluent disposal systems.

7.5 PER UNIT ANNUAL NON-CASH COSTS

Depreciation Costs

Figure 7.25 shows the per unit depreciation costs according to plant and herd size.

Within each subclass, the general trend is for the per unit costs to decline as herd size increases. However, the declines in the per unit cost do not occur continuously as herd size increases. "Minor variations" occur due to:

a) The initial investment cost of certain resources varies discretely with herd size, (e.g. barns, implement sheds, milking equipment, effluent disposal pumps, water pumps, etc.)

b) The introduction at specific herd sizes of fertiliser distributors and hay balers.

c) The trend towards the per unit cost of farm dairies declining continuously with herd size being interrupted over specific herd sizes.

As in the case of repairs and maintenance and insurance costs, data concerning the herd sizes and ranges of herd sizes over which variations due to the reasons noted above occur, were not collected due to the excessive amount of computing time required to obtain it. It is interesting to note that the per unit cost curve of plant size five, subclass (a) lies below that of plant size four subclass (c), over the entire range of herd sizes common to both subclasses. For a given herd size, this is due to the decrease in the per unit costs of the farm dairy and milking equipment of plant size five subclass (a), being of sufficient magnitude to offset the slightly lower per unit costs of machinery, implement shed and dwellings of plant size four subclass (c). [36]

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36. e.g. At a herd size of 300 cows, the per unit depreciation cost for dwellings is:
    i) Plant size four subclass (c) : 0.30 dollars;
    ii) Plant size five subclass (a) : 0.35 dollars;

    The per unit depreciation costs for farm dairies and milking equipment are
    i) Plant size four subclass (c) : 1.29 dollars;
    ii) Plant size five subclass (a) : 1.22 dollars;

    The per unit machinery depreciation cost of plant size five subclass (a) is 0.14 cents greater than that of plant size four subclass (c). Similarly, the per unit implement shed depreciation cost for plant size five is 0.11 cents greater than that of plant size four.

Relative to the plant size one farms, cost advantages are realised over specific ranges of herd sizes by all other subclasses. The minimum value is recorded at the cut-off point of plant size five subclass (c).

Interest

Figure 7.26 shows the per unit interest costs [37] according to plant size and herd size. As the interest cost has been assessed as a percentage of the total investment costs of the two groups of resources, [38] Figure 7.26 parallels Figure 7.13. From Figure 7.26, it can be seen that:

a) Relative to the farms of plant size one, cost advantages accrue to all other subclasses over specific ranges of herd sizes.

b) In the case of plant sizes two to five, for comparable subclasses and degrees of plant utilisation, the magnitude of the cost reduction increases from plant size two to plant size five.

c) The maximum per unit cost is recorded at the start point of plant size one subclass (c) and the minimum at the cut-off point of plant size five subclass (c).

Farm Operator's Labour

The opportunity cost of the farm operator's labour is assessed as 3,000 dollars per annum over the complete range of herd sizes studied. The per unit cost of the farm operator's labour, therefore, declines continuously with increases in herd size, from a maximum of 50 dollars in the case of a 60 cow herd, to five dollars when a herd size of 600 cows is reached.

Farm Operator's Management

The opportunity cost of the farm operator's management is assessed as six per cent of the gross farm income.

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37. The interest rates used in the assessment of the interest charges are:
    Group One resources : 6 per cent;
    Group Two resources : 7 per cent;
38. These two interest rates were decided upon by the author after discussions with the representatives of a number of credit agencies. The two rates approximate the interest rates a farm operator would have to pay, if credit was used to purchase the two groups of resources in question.

Figures 7.27 and 7.28 show the total opportunity cost of the farm operator's management, according to plant and herd size when the milkfat price is 33 cents per pound. Figure 7.27 shows the relationships when the level of milkfat production per cow remains constant over the complete range of herd sizes studied, while Figure 7.28 shows the relationships when the level of milkfat production per cow is a function of plant and herd size.

Figures 7.27 and 7.28 show that within each subclass, the opportunity cost of the farm operator's management rises as the degree of plant utilisation increases and so the maximum value is recorded at the cut-off point. Within each plant size, the maximum value is recorded at cut-off point of subclass (c). For comparable cut-off points, the opportunity cost increases from plant size one to plant size five. Consequently the highest opportunity cost is recorded at the cut-off point of plant size five subclass (c).

7.6 PER UNIT COSTS OF THE FIVE TOTAL COST CONCEPTS

Total Cost (A)

Figure 7.29 shows the per unit costs of Total Cost (A) [39] according to plant and herd size.

With the exception of the per unit cost curve of plant size one subclass (c), within each subclass, the per unit costs of Total Cost (A) decline as the degree of plant utilisation increases. In the case of the per unit cost curve of plant size one subclass (c), the minimum per unit cost is recorded at a herd size of 120 cows - the per unit cost curve is therefore "u" shaped. [40] Between plant sizes, for comparable cut-off points, the per unit cost increases as one moves from plant size one to plant size five. This is due to the per unit cost of wages (at comparable cut-off points) increasing as one moves from plant size one to plant size five and being of sufficient magnitude to offset all other cash cost decreases.

For example, the total per unit cash costs (excluding labour) at the cut-off point of plant size one subclass (c) are 36.46 dollars. The

39. i.e. Total cash costs.
40. The "u" shape is due to the increase in the per unit costs of casual and contract labour at a herd size of 136 cows (relative to a herd size of 120 cows), being of sufficient magnitude to offset the per unit decreases in the other cash costs.

per unit cost of employed labour is zero. Therefore the total per unit cash costs are 36.46 dollars. Comparable figures for the other plant sizes are:

Plant size two subclass (c):	Per unit cash costs excluding labour	32.20	dollars
	Per unit employed labour costs	12.50	dollars
	Per unit Total Cost (A)	44.70	dollars
Plant size three subclass (c):	Per unit cash costs excluding labour	29.98	dollars
	Per unit employed labour costs	16.66	dollars
	Per unit Total Cost (A)	46.64	dollars
Plant size four subclass (c):	Per unit cash costs excluding labour	28.58	dollars
	Per unit employed labour costs	18.75	dollars
	Per Unit Total Cost (A)	47.33	dollars
Plant size five subclass (c):	Per unit cash costs excluding labour	27.94	dollars
	Per unit employed labour costs	20.00	dollars
	Per unit Total Cost (A)	47.94	dollars

Total Cost (B)

Figure 7.30 shows the per unit costs of Total Cost (B) according to plant and herd size.

With the exception of the per unit cost curve of plant size one subclass (c), within all subclasses, the per unit cost declines as the degree of plant utilisation increases. The per unit cost curve of plant size one subclass (c) is again "u" shaped, the lowest per unit cost being recorded at a herd size of 130 cows.

A comparison of the data relating to comparable cut-off points, indicates that the per unit costs increase as one moves from plant size one to plant size five. The reason for this is that relative to plant size one, for comparable cut-off points, lower per unit depreciation costs are recorded at the cut-off points of plant sizes two to five. Such declines, however, are not of sufficient magnitude to offset the increasing per unit cash costs discussed earlier.

For example at the cut-off point of plant size one subclass (c), the per unit cash costs are 36.46 dollars. The per unit depreciation costs are 3.26 dollars. The per unit Total Cost (B) costs are therefore 39.72 dollars.

Comparable figures for the other plant sizes are:

Plant size two subclass (c) :	Per unit Total Cost (A)	:	44.70 dollars
	Per unit depreciation cost	:	2.60 dollars
	Per unit Total Cost (B)	:	47.30 dollars
Plant size three subclass (c):	Per unit Total Cost (A)	:	46.64 dollars
	Per unit depreciation cost	:	2.95 dollars
	Per unit Total Cost (B)	:	49.59 dollars
Plant size four subclass (c) :	Per unit Total Cost (A)	:	47.33 dollars
	Per unit depreciation cost	:	2.79 dollars
	Per unit Total Cost (B)	:	50.12 dollars
Plant size five subclass (c) :	Per unit Total Cost (A)	:	47.94 dollars
	Per unit depreciation cost	:	2.40 dollars
	Per unit Total Cost (B)	:	50.34 dollars

Total Cost (C)

Figure 7.31 shows the per unit costs of Total Cost (C) according to plant size and herd size.

Figure 7.31 shows that within each subclass the per unit cost declines as the degree of plant utilisation increases. Between plant sizes, a comparison of the per unit costs of comparable cut-off points indicates that the per unit costs increase from plant size one to plant size three and then decline slightly as one moves from plant size three to plant size five.

The reason for this is that as one moves from plant size one to plant size five (for comparable cut-off points), the per unit interest cost declines. In the case of plant sizes two and three (relative to plant size one), such declines are not of sufficient magnitude to offset the increased per unit costs of Total Cost (B) discussed earlier and consequently, the per unit costs of Total Cost (C) increase. However, in the case of plant sizes four and five (relative to plant size three), the declines are of sufficient magnitude to offset the increases in the per unit costs of Total Cost (B) and hence the per unit costs of Total Cost (C) decline.

For example, the per unit cost of Total Cost (B) at the cut-off point of plant size one, subclass (c) is 39.72 dollars. The per unit interest cost is 42.63 dollars. The per unit cost of Total Cost (C) is therefore 82.35 dollars. Comparable figures for the other plant sizes are:

Plant size two subclass (c) :	Per unit Total Cost (B)	:	47.30 dollars
	Per unit interest cost	:	39.30 dollars
	Per unit Total Cost (C)	:	86.60 dollars
Plant size three subclass (c) :	Per unit Total Cost (B)	:	49.59 dollars
	Per unit interest cost	:	37.54 dollars
	Per unit Total Cost (C)	:	87.13 dollars
Plant size four subclass (c) :	Per unit Total Cost (B)	:	50.12 dollars
	Per unit interest cost	:	35.86 dollars
	Per unit Total Cost (C)	:	85.98 dollars
Plant size five subclass (c) :	Per unit Total Cost (B)	:	50.34 dollars
	Per unit interest cost	:	33.79 dollars
	Per unit Total Cost (C)	:	84.13 dollars

Total Cost (D)

Figure 7.32 shows the per unit costs of Total Cost (D) according to plant and herd size.

Within each subclass, the per unit cost declines as the degree of plant utilisation increases. Between plant sizes, the per unit costs of comparable cut-off points decline as one moves from plant size one to plant size five. This is due to the inclusion in Total Cost (D) of the opportunity cost of the farm operator's labour. Such a cost as discussed in section 7.5 declines continuously as herd size increases, and the declines are of sufficient magnitude to cause the per unit costs of Total Cost (D), for comparable cut-off points, to fall as one moves from plant size one to plant size five.

For example, the per unit cost of Total Cost (C) at the cut-off point of plant size one subclass (c) is 82.35 dollars. The per unit opportunity cost of the operator's labour is 22.06 dollars. The per unit cost of Total Cost (D) is therefore 104.41 dollars. Comparable figures for the other plant sizes are:

Plant size two subclass (c) :	Per unit Total Cost (C)	:	86.60 dollars
	Per unit cost of operator's labour	:	12.50 dollars
	Per unit Total Cost (D)	:	99.10 dollars
Plant size three subclass (c):	Per unit Total Cost (C)	:	87.13 dollars
	Per unit cost of operator's labour	:	8.33 dollars
	Per unit Total Cost (D)	:	95.46 dollars
Plant size four subclass (c) :	Per unit Total Cost (C)	:	85.98 dollars
	Per unit cost of operator's labour	:	6.25 dollars
	Per unit Total Cost (D)	:	92.23 dollars
Plant size five subclass (c) :	Per unit Total Cost (C)	:	84.13 dollars
	Per unit cost of operator's labour	:	5.00 dollars
	Per unit Total Cost (D)	:	89.13 dollars

Total Cost (E)

Figures 7.33 and 7.34 show the per unit costs of Total Cost (E) according to plant and herd size.

Figure 7.33 shows the relationships when the level of milkfat production per cow is constant over the complete range of herd and plant sizes studied, while Figure 7.34 shows the relationships when the level of milkfat production per cow is a function of plant size and herd size.

Figures 7.33 and 7.34 show that the pattern of the per unit cost curves is similar to those shown in Figure 7.32 (i.e. the per unit cost curves of Total Cost (D)). That is:

a) Within each subclass, the per unit cost decreases as the degree of plant utilisation increases;

b) Between plant sizes, the per unit costs of comparable cut-off points decrease as one moves from plant size one to plant size five.

As the opportunity cost of the farm operator's management is assessed at a percentage of gross farm income, it follows that when the level of milkfat production per cow remains constant over the complete range of herd sizes studied, the per unit opportunity cost of the operator's management remains constant. 41/ Consequently, between plant sizes, for comparable cut-off points, the per unit costs decrease as one moves from plant size one to plant size five, because the per unit costs are obtained by adding a constant sum to the per unit costs of Total Cost (D). Hence the pattern of the per unit cost curves is similar to that of Figure 7.32.

When the level of milkfat production per cow varies with plant and herd size, the per unit opportunity cost of the farm operator's management, for comparable cut-off points, decreases as one moves from plant size one to plant size five. Consequently in this case, the trend noted in Figure 7.32 of declines in the per unit costs (i.e. Total Cost (D))for comparable cut-off points, as one moves from plant size one to plant size five is accentuated. 42/ This is due to the per unit costs, for comparable cut-off points, as one moves from plant size one to plant size five, being obtained by adding a decreasing sum to the per unit costs of Total Cost (D).

7.7 PER UNIT GROSS FARM INCOME

Gross Farm Income

Constant Milkfat Production per Cow (33 cents per pound of milkfat)

When the level of milkfat production per cow is constant over the complete range of herd sizes studied, the per unit gross farm income

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41. Minor variations do occur, however, due to the number of cull stock sold being expressed as integers.
42. i.e. Between plant sizes, for comparable cut-off points, the absolute difference in the per unit costs increase when the per unit costs are expressed in terms of Total Cost (E). For example, the absolute difference in the per unit costs of plant size one subclass (c) and plant size five subclass (c) when expressed in terms of Total Cost (D) is 15.29 dollars. When expressed in terms of Total Cost (E) the difference is 15.60 dollars.

approximates 118 dollars per cow. (Minor variations between herd sizes do occur due to the number of cull stock sold being expressed as integers.)

Variable Milkfat Production per Cow (33 cents per pound of milkfat).

Figure 7.35 shows the per unit gross farm income, according to plant size and herd size, when milkfat production per cow is a function of plant size and herd size. Within each plant size, due to the level of milkfat production per cow being expressed in terms of a linear function,[43] the per unit income declines as herd size increases. The five per unit gross farm income curves are not straight lines, due to minor variations between herd sizes in the proportions of cull stock sold. The per unit gross farm income falls from a maximum of 148.60 dollars in the case of 60 cow herds (plant size one) to 113.40 dollars per cow in the case of 600 cow herds (plant size five).

7.8 SUMMARY

In this chapter, a detailed account has been given of the way in which the per unit costs of the various resources vary with changes in plant and herd size. The magnitude of the cost variations is indicated and the manner in which the variations arise discussed. The results show that with few exceptions, cost advantages accrue to the farms of the larger plant and herd sizes, relative to plant size one farms, because of lower per unit resource costs. In most instances, the cost advantages arise because of proportionality relationships.

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43. The linear functions are of the nature

$$y = b - ax$$

where y is the level of milkfat production per cow
x is the herd size
a and b are constants.

CHAPTER EIGHT

THE COST-SIZE AND PROFIT-SIZE RELATIONSHIPS

8.1 INTRODUCTION

In this chapter, the nature of the cost-size and profit-size relationships are discussed.

In the first part of the chapter, ten series [1] of short run average cost curves and the corresponding long run average curves are discussed. Both within and between subclasses, the ranges of herd sizes and gross farm incomes, over which continuous reductions in the total cost per dollar of gross income occur, are indicated. The cost-size relationships are further examined when the output per labour unit data of the representative farms, approximates those of corresponding survey farms.

The second part of the chapter presents for each of the series of short run average cost curves, the corresponding series [2] of short run net income curves; and for each of the ten long run average cost curves, the corresponding long run net income curve. The nature of the profit-size relationships are discussed and the minimum herd size and milkfat production required, for the entrepreneurial income of each subclass to be positive indicated.

Finally, in the third part of the chapter, a breakeven analysis of the results is presented which allows the effect of changes in the assumptions of the analysis, upon the shape of the long run average cost curves, to be studied.

The diagrams showing the series of cost and income curves discussed in this chapter are shown in Appendix D of Volume II.

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1. A series of short run average cost curves is the fifteen short run average curves (one for each subclass) derived from one of the five cost revenue ratios.

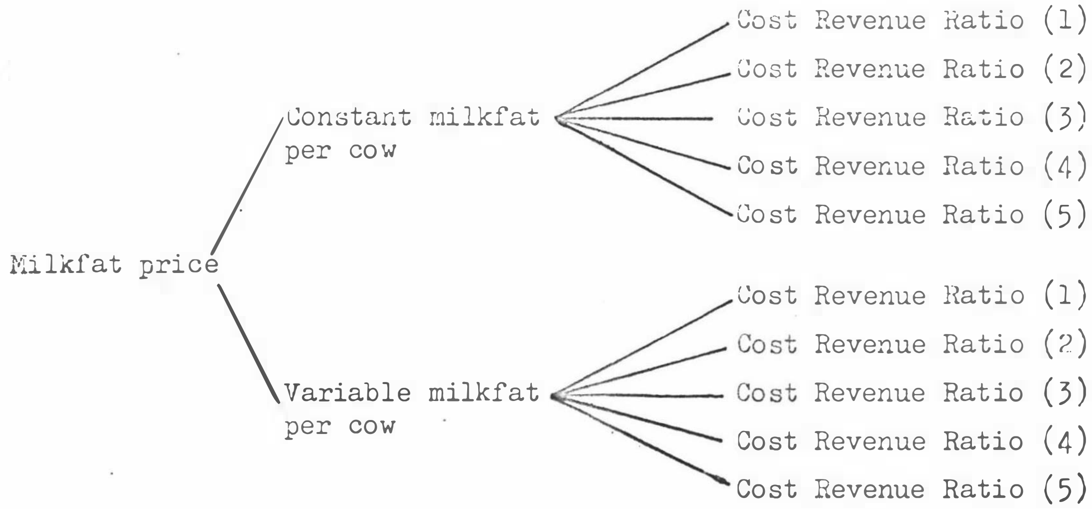
2. A series of short run net income curves is the fifteen short run net income curves derived from one of the five net income figures.

8.2 SHORT RUN AND LONG RUN AVERAGE COST CURVES

Introductory Comments

Short run and long run average cost curves are derived for five [3] levels of milkfat price. For any given level of milkfat price, cost curves are constructed for two levels of milkfat production per cow. First, cost curves are developed for the assumption that the level of milkfat production per cow remains constant irrespective of plant and herd size, and second, cost curves are developed for the assumption that the level of milkfat production per cow varies with changes in plant and herd size. Finally, for any given milkfat price and level of milkfat production per cow, five series of cost revenue ratios (and hence five series of cost curves) are produced. Consequently for any given level of milkfat price, ten series of short run average cost curves and ten long run average cost curves are derived. A diagrammatic representation of the ten long run average cost curves associated with any given level of milkfat price is shown in Figure 8.1.

Figure 8.1 Diagrammatic Representation of the ten L.R.A.C Curves associated with each milkfat price



For simplicity, details of the ten long run average cost curves are presented for only one level of milkfat price; 33 cents per pound of milkfat.[4] This price is chosen as it is thought to approximate the

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3. The five levels of milkfat price are: 25, 27.5, 30, 33 and 35 cents per pound of milkfat.
4. Data concerning the long run average cost curves for the other four levels of milkfat price (i.e. as mentioned above) are lodged in the Farm Management Department, Massey University and are available on request.

price which would be paid to dairy farmers in the Manawatu, in the 1970/71 dairying season. All cost curves presented in this chapter, are based upon an interest rate for the Group One resources of six per cent and an interest rate of seven per cent for the Group Two resources.

8.3 SHORT RUN AND LONG RUN AVERAGE COST CURVES - CONSTANT MILKFAT PER COW

1) Cost Curves derived from the First Series of Cost Revenue Ratios

Figure 8.2 shows the fifteen short run average cost curves and the long run average cost curve constructed from the first series of cost revenue ratios.

With one exception,[5] the cost revenue ratios of all short run average cost curves, decline continuously as gross farm income increases. Consequently, with one exception, the lowest cost revenue of each subclass is recorded at the cut-off point.

Further, for comparable cut-off points, the cost revenue ratios increase as one moves from plant size one to plant size five. This is due to the increase in the per unit costs of Total Cost (A) as one moves from plant size one to plant size five and the fact that per unit gross farm income approximates 118 dollars per cow, over the complete range of plant and herd sizes studied. As discussed in section 7.6, the increase in the per unit costs of Total Cost (A) is due to the increase in the per unit cost of employed labour being of sufficient magnitude to offset all other cash cost decreases.

In the case of plant sizes two to five, within each of the three subclasses of each plant size, the cost revenue ratios decline as one moves from the cut-off point of subclass (a) to the cut-off point of subclass (c). Such a reduction is due to the decrease in the per unit costs of Total Cost (A). In the case of plant size one, however, the lowest cost revenue ratio is recorded at the cut-off point of subclass (b). In the case of plant size one subclass (c), the per unit increase in the costs of casual and contract labour on farms of herd size in excess of 120 cows, is of sufficient magnitude to offset all other cash cost decreases and consequently the cost revenue ratio at the cut-off point is greater than that at the cut-off point of subclass (b).

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5. The exception is the short run average cost curve of plant size one subclass (c). The lowest cost revenue ratio of this particular short run average cost curve is recorded at a herd size of 120 cows.

As the resources which comprise the fixed plant are not continuously divisible, the long run average cost curve is segmented. It is important to note that the long run average cost curve comprises segments of all fifteen [6] short run average cost curves. Thus each subclass of each plant size, represents the least cost way and hence most profitable way of producing particular ranges of gross farm income. Although it is not possible to draw an envelope curve tangent to the short run average cost curves, the nature of the long run average cost curve can be examined by:

a) Drawing a line which is tangent to the short run average cost curve of plant size one subclass (a).

b) Extending such a line through the cut-off points of comparable subclasses. [7]

A line of this nature, will for the remainder of the discussion, be termed a trace curve. In Figure 8.2, the trace curve is drawn through the cut-off points of subclass (c) and is represented by the line TC - TC'. The trace curve in Figure 8.2 is "u" shaped. The initial point is the start point of the short run average cost curve of plant size one, subclass (a), [8] the low point is the low point of the short run average cost curve of plant size one subclass (c) and the final point is the cut-off point of plant size five subclass (c).

2) Cost Curves Derived from the Second Series of Cost Revenue Ratios

Figure 8.3 shows the short run average cost curves and the long run average cost curve constructed from the second series of cost revenue ratios.

Again with the exception of the short run average cost curve of plant size one subclass (c), the cost revenue ratios of all short run

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6. For each of the ten L.R.A.C. curves which can be drawn for each level of milkfat price, the L.R.A.C. curve is segmented and comprises segments of all fifteen S.R.A.C. curves. Further in all cases, the L.R.A.C. includes the entire S.R.A.C. curve of plant size one subclass (a).
7. In circumstances when a S.R.A.C. curve is "u" shaped, the line should be drawn tangent to the low point of the S.R.A.C. curve in question rather than through the cut-off point. The line should be such that it traces out the shortest distance between comparable cut-off points.
8. For all trace curves, the initial point is the start point of plant size one, subclass (a).

average cost curves, decline continuously as gross farm income increases.

A comparison of the data relating to comparable cut-off points indicates that the cost revenue ratios increase as one moves from plant size one to plant size five. The reason for the increase is that although the per unit depreciation costs (for comparable cut-off points) decline as one moves from plant size one to plant size five, such decreases are not of sufficient magnitude, to offset the per unit increases in Total Cost (A). Consequently the per unit costs of Total Cost (B) increase as one moves from plant size one to plant size five.

Again for plant sizes two to five, the cost revenue ratios decline as one moves from subclass (a) to subclass (c). (This is due to the decrease in the per unit costs of Total Cost (B).) In the case of plant size one, however, the lowest per unit cost is recorded at a herd size of 130 cows, on the short run average cost curve of subclass (c).

The trace curve is again "u" shaped, the lowest point being the low point of the short run average cost curve of plant size one subclass (c), and the final point being the cut-off point of plant size five subclass (c).

3) Cost Curves Derived from the Third Series of Cost Revenue Ratios

The short run average cost curves and the long run average cost curve based upon the third series of cost revenue ratios are shown in Figure 8.4.

For all fifteen short run average cost curves, the cost revenue ratios decline continuously as gross farm income increases, and the lowest point of each of the fifteen short run average cost curves corresponds to the cut-off point. [9]

A comparison of the cost revenue ratios relating to comparable cut-off points reveals that the cost revenue ratios, increase as one moves from plant size one to plant size three but then decline slightly, as one moves from plant size three to plant size five. This is explained by the fact that as one moves from plant size one to plant size five,

9. The short run average cost curves constructed from the fourth and fifth series of cost revenue ratios are of a similar nature. That is, for all short run average cost curves, the cost revenue ratios decline continuously as the degree of plant utilisation increases.

the per unit interest costs for comparable cut-off points declines. In the case of plant sizes two and three, relative to plant size one, such declines are not of sufficient magnitude, to offset the per unit increases in Total Cost (B). However, in the case of plant sizes four and five, the decreases in the per unit interest costs, relative to plant size three, are of sufficient magnitude, to cause the per unit costs of Total Cost (C) to decline as one moves from plant size three to plant size five.

All three cut-off points of each plant size conform to the same pattern. That is the cost revenue ratios decline as one moves from subclass (a) to subclass (c).[10] (This is due to the per unit decline in the Total Cost (C) as one moves from subclass (a) to subclass (c).)

The trace curve is in this case "s"[11] shaped. The lowest point is the cut-off point of plant size one subclass (c) and the highest point, the cut-off point of plant size three subclass (c).

With three exceptions,[12] cost revenue ratios in excess of 1.0 are recorded over the initial degrees of plant utilisation of all short run average cost curves. Such a ratio indicates that on such representative farms, losses are recorded.

4) Cost Curves Derived from the Fourth Series of Cost Revenue Ratios

Figure 8.5 shows the short run average cost curves and the long run average cost curve constructed from the fourth series of cost revenue ratios.

A comparison of the cost revenue ratios relating to comparable cut-off points for this series of cost curves indicates that the cost

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10. The short run average cost curves derived from the fourth and fifth series of cost revenue ratios are similar, in that for both plant sizes, the cost revenue ratios decrease as one moves from subclass (a) to subclass (c).

11. The trace curve is similar to the letter "s" in shape, turned upon its side, i.e.

12. The three exceptions are:
    Plant size one, subclass (a);
    Plant size two, subclasses (a) and (b);

revenue ratios decline as one moves from plant size one to plant size five. This is due to the inclusion in the total costs, from which the cost revenue ratios are derived, of the opportunity cost of the farm operator's labour. The per unit cost of the farm operator's labour declines continuously as herd size increases and the declines are of sufficient magnitude to cause the per unit costs of Total Cost (D) to fall as one moves from plant size one to plant size five.

The trace curve is in this case "L" shaped with the final point and the lowest point being the cut-off point of plant size five, subclass (c).

For all fifteen subclasses, cost revenue ratios greater than 1.0 are recorded by representative farms corresponding to the initial degrees of plant utilisation.

5) Cost Curves Derived from the Fifth Series of Cost Revenue Ratios

Figure 8.6 shows the fifteen short run average cost curves and the long run average cost curve constructed from the fifth series of cost revenue ratios.

In this case, the cost revenue ratios of comparable cut-off points also decrease as one moves from plant size one to plant size five. As the opportunity cost of the operator's managerial input is in all cases assessed as six per cent of the gross farm income and as the per unit gross farm income over the complete range of plant and herd sizes studied, approximates 118 dollars per cow, it follows that the per unit cost of the operator's managerial input approximates seven dollars per cow over the complete range of plant and herd sizes studied. The inclusion of the opportunity cost of the operator's managerial input, therefore, does not alter the pattern of the short run average cost curves noted in Figure 8.5. Hence the trace curve is again "L" shaped with the final and lowest point being the cut-off point of plant size five subclass (c).

Again for all fifteen plant sizes, cost revenue ratios greater than 1.0 are recorded by the representative farms, corresponding to the initial degrees of plant utilisation. Proportionately more of the representative farms, however, record cost revenue ratios in excess of 1.0, when the cost curves are derived from the fifth series of cost revenue ratios. For example, of the 129 representative farms from which a long run average cost curve is constructed, when the long run average cost curve is constructed from the third series of short run average cost curves, 12 representative farms record a cost revenue ratio greater than 1.0.

When the long run average cost curve is derived from the fourth series of short run average cost curves, the cost revenue ratios of 47 representative farms are greater than 1.0 and when the curve is constructed from the fifth series of cost curves, cost revenue ratios greater than 1.0 are observed on 72 representative farms.

8.4 SHORT RUN AND LONG RUN AVERAGE COST CURVES - VARIABLE MILKFAT PER COW

1) Cost Curves Derived from the First Series of Cost Revenue Ratios

The short run average cost curves and long run average cost curve derived from the first series of cost revenue ratios are shown in Figure 8.7.

In the case of plant sizes two to five, the cost revenue ratios of all short run average cost curves decline continuously as the gross farm income increases and consequently the lowest cost revenue ratio in each case is recorded at the cut-off point. The short run average cost curves of plant size one subclasses (b) and (c), however, are "u" shaped.[13] The short run average cost curve of subclass (a) is similar to those of plant sizes two to five.

For comparable cut-off points, the cost revenue ratios increase as one moves from plant size one to plant size five. This is due to the fact that for comparable cut-off points, as one moves from plant size one to plant size five, the per unit cash costs increase and further, the per unit gross farm income decreases.

For plant sizes two to five, within each plant size, the cost revenue ratios at the cut-off points decrease as one moves from subclass (a) to subclass (c). This is due to the decrease in the per unit cash costs being of sufficient magnitude to offset the effect of the decrease in the per unit gross farm income. In the case of plant size one, however, the cost revenue ratios at the cut-off points increase as one moves from

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13. The short run average cost curve of plant size one subclass (c) is "u" shaped because of:

    i) The increase in the per unit cash costs of herds of over 120 cows.
    ii) The decline in the per unit gross farm income which accompanies increases in herd size.

    The short run average cost curve of plant size one subclass (b) is "u" shaped because over the range of 110 - 120 cows, the decline in per unit gross farm income is of sufficient magnitude to offset the effect of the decline in the per unit cash costs.

subclass (a) to subclass (c). [14]

A trace curve drawn through the cut-off points of subclass (c) is again "u" shaped. The lowest point is the cut-off point of plant size one subclass (a) and the final point is the cut-off point of plant size five subclass (c).

2) Cost Curves Derived from the Second Series of Cost Revenue Ratios

The short run average cost curves and long run average cost curve derived from the second series of cost revenue ratios are shown in Figure 8.8.

The short run average cost curves of plant sizes two to five are again characterised by a continuous decline in the cost revenue ratios as gross farm income increases. In the case of plant size one, the short run average cost curve of subclass (c) is again "u" shaped. The short run average cost curvesof subclasses (a) and (b), however, are similar to those of plant sizes two to five. [15]

For comparable cut-off points, the cost revenue ratios increase as one moves from plant size one to plant size five. This is due to the per unit costs of Total Cost (B) increasing and the per unit gross farm income decreasing as one moves from plant size one to plant size five.

The cost revenue ratios at the cut-off points of the three subclasses of each plant size again conform to one of two patterns. The cost revenue ratios of plant sizes two to five decrease as one moves from subclass (a) to subclass (c). The cost revenue ratios of plant size one, however, increase as one moves from subclass (a) to subclass (c).

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14. In the case of subclass (c), this is due to the increase in the per unit cash costs and the decrease in the per unit gross farm income, while for subclass (b) this is due to decrease in the per unit gross farm income being of sufficient magnitude to offset the effect of the slightly lower per unit cash costs.
15. The short run average cost curves constructed from the third, fourth and fifth series of cost revenue ratios also conform to this pattern. That is, the cost revenue ratios of all short run average curves, with the exception of that of plant size one subclass (c), decline continuously as the degree of plant utilisation increases.

The trace curve is "u" shaped with the low point occurring at the cut-off point of plant size one subclass (a) and the final point is the cut-off point of plant size five subclass (c).

3) <u>Cost Curves Derived from the Third Series of Cost Revenue Ratios</u>

The short run average cost curves and long run average cost curve derived from the third series of cost revenue ratios are shown in Figure 8.9.

A comparison of the cost revenue ratios of comparable cut-off points indicates that first, the cost revenue ratios of subclasses (a) and (b) increase as one moves from plant size one to plant size five. Second, the cost revenue ratios at the cut-off points of subclass (c) increase from plant size one to plant size four and then decline slightly as one moves from plant size four to plant size five.

The decline in the cost revenue ratio at the cut-off point of plant size five subclass (c) is due to the decrease in the per unit costs of Total Cost (C) being of sufficient magnitude to offset the effect of the decline in the per unit gross farm income.

The cost revenue ratios at the cut-off points of plant sizes three to five decrease as one moves from subclass (a) to subclass (c). The lowest cost revenue ratios of plant sizes one and two, however, are recorded at the cut-off point of subclass (b).

Trace curves constructed through the subclass (a) and subclass (b) cut-off points are therefore "u" shaped. For both trace curves, the low point corresponds to the respective plant size one cut-off point. The final point is corresponding cut-off point of plant size five. A trace curve constructed through the subclass (c) cut-off points is, however, "S" shaped. The lowest point being the low point of the short run average cost curve of plant size one subclass (c) and the highest point being the cut-off point of plant size four subclass (c).

4) <u>Cost Curves Derived from the Fourth Series of Cost Revenue Ratios</u>

Figure 8.10 shows the short run average cost curves and the long run average curve derived from the fourth series of cost revenue ratios.

For comparable cut-off points, the cost revenue ratios decline as one moves from plant size one to plant size five. This is due to the decreases in the per unit costs of Total Cost (D) being of sufficient magnitude to offset the per unit decrease in gross farm income.

For all plant sizes, the cost revenue ratios at the cut-off points decrease as one moves from subclass (a) to subclass (c). 16/ Trace curves constructed through the cut-off points of all three subclasses are "L" shaped. The lowest point of such curves is the cut-off point of a plant size five subclass.

For all fifteen subclasses, cost revenue ratios of greater than 1.0 result over the initial degrees of plant utilisation. Of the 129 representative farms from which a long run average cost curve is derived, the cost revenue ratios of 18 farms is greater than 1.0.

5) Cost Curves Derived from the Fifth Series of Cost Revenue Ratios

Cost curves derived from the fifth series of cost revenue ratios are shown in Figure 8.11. For comparable cut-off points, the cost revenue ratios decline as one moves from plant size one to plant size five due to the decrease in the per unit costs of Total Cost (E) being of sufficient magnitude to offset the decreases in the per unit gross farm income. Trace curves are in this case "L" shaped with the low point occurring at the cut-off point of a plant size five subclass.

For all fifteen subclasses, cost revenue ratios greater than 1.0 are recorded over the initial degrees of plant utilisation. Of the 129 representative farms from which the long run average cost curve is derived, the cost revenue ratios of 39 farms is greater than 1.0. 17/

16. Such a pattern is also discernible in the cost curves derived from the fifth series of cost revenue ratios. That is for all plant sizes, the cost revenue ratios decrease as one moves from subclass (a) to subclass (c).

17. As indicated in section 6.5 the author omitted a charge for car expenses. If it is assumed that such a charge remains constant at 100 dollars per annum irrespective of plant and herd size, the inclusion of such a charge does not markedly alter the shape of the long run average cost curve. For example, if such a sum is included in the Total Cost (E) data, the cost revenue ratios at the low points of the five subclass (c) short run average cost curves are increased by:

a) Plant size one : 0.0060 dollars per dollar of gross income;
b) Plant size two : 0.0034 dollars per dollar of gross income;
c) Plant size three : 0.0025 dollars per dollar of gross income;
d) Plant size four : 0.0018 dollars per dollar of gross income;
e) Plant size five : 0.0015 dollars per dollar of gross income;

8.5 SHORT RUN AND LONG RUN AVERAGE COST CURVES - DISCUSSION

1) Introductory Comments

In this study, the cost curves derived from the fifth series of cost revenue ratios are used to discuss the nature of the cost-size relationships, as the total cost data from which the cost revenue ratios are derived, includes an allowance for all resources used in the production process The two long run average cost curves of interest are therefore those shown in Figures 8.6 and 8.11.

The two figures indicate that both when milkfat production per cow varies and remains constant with changes in plant and herd size, the long run average cost curve:

a) Consists of segments of all fifteen short run average cost curves. Hence each subclass represents the least cost way and hence most profitable way of producing particular ranges of gross farm income.

b) Includes the entire short run average cost curve of plant size one subclass (a). In the case of the other fourteen short run average cost curves, only segments of each curve are included in the long run average cost curve.

c) Because the resources which constitute the fixed plant are not continuously divisible is segmented.

2) Economies of Size arising from Increasing the Degree of Plant Utilisation

In both cases, within each subclass, reductions in the total cost per dollar of gross income are realised as the degree of plant utilisation increases. That is, within each subclass, economies of size are realised. With one exception, such reductions occur over the complete length of the short run average cost curves. The one exception is the short run average cost curve of plant size one subclass (c) when the per cow milkfat production varies with plant and herd size. This short run average cost curve, as discussed earlier, is "u" shaped. Consequently reductions in the total cost per dollar of gross income are realised only over the range of 60 - 130 cows.

3) Economies of Size arising from Changing Plant Size

Between subclasses, continuous reductions in the total cost per dollar of gross income occur only over specific ranges of herd sizes and gross farm incomes. The ranges of gross farm income over which such between plant reductions occur are shown in Figures 8.12 and 8.13 by the curve TT'.

The short run average cost curves of Figure 8.6 are reproduced in Figure 8.12. The heavy sections of the curve TT' in Figure 8.12 show the range of gross farm incomes over which continuous between sub-class reductions in the cost revenue ratio occur, when the level of milk-fat production per cow remains constant irrespective of plant and herd size.

Conversely, the horizontal dotted sections of curve TT' indicate the ranges of gross farm incomes over which continuous between subclass reductions in the cost revenue ratio do not occur. For example, the cost revenue ratio, when plant size one subclass (a) is utilised, declines as gross farm income increases over the range corresponding to 60 - 105 cows. This is shown by the segment TX_1 of the curve TT'. In the case of a herd size of 106 cows, utilising plant size one subclass (b), the cost revenue ratio is greater than that recorded at the cut-off point of plant size one subclass (a). The horizontal segment marks the range of gross farm incomes over which the trend towards continuous between subclass reductions in the cost revenue ratio is interrupted. Over the range of 107 to 120 cows, however, continuous between subclass reductions in the cost revenue ratio are realised. This is shown by the segment $X_2 - X_3$ of curve TT'. The heavy segments of the curve TT' therefore, demarcate the portions 18/ of the long run average cost curve over which continuous reductions in the cost revenue ratio are obtained, and hence economies of size are realised by changing (increasing) plant size.

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18. The heavy segments of the curve TT' show:

   i) The subclasses over which continuous reductions in the cost revenue ratio occur.

   ii) For each relevant subclass, the corresponding ranges of gross farm income.

Curve TT' of Figure 8.12 shows that economies of size resulting from changes in plant size [19] are realised over segments [20] of all short run average cost curves of plant size one. However, in the case of plant sizes two to five, economies of size resulting from changes in plant size are realised only over segments of the short run average cost curves of subclasses (b) and (c).

Data concerning the ranges of herd sizes and gross farm incomes, over which continuous between subclass reductions in the cost revenue ratio occur are shown in detail in Table 8.1.

From Figure 8.12 and Table 8.1, it can be seen that over the initial segment of the long run average cost curve (i.e. that segment corresponding to the short run average cost curve of plant size one subclass (a)), the cost revenue ratio declines rapidly. However, over the complete length of this segment, the cost revenue ratio is greater than 1.0. Consequently, although economies of size are realised over this portion of the long run average cost curve, losses are recorded by the representative farms which correspond to this segment. In the cases of plant size one farms, a cost revenue ratio of less than 1.0 is not recorded until a herd size of 115 cows is encountered on that part of the long run average cost curve which corresponds to the short run average cost curve of subclass (b).

Further, Figure 8.12 and Table 8.1 indicate that the most efficient [21] farm is the plant size five farm with a herd size of 600 cows and that over the complete range of plant and herd sizes studied, the total cost per dollar of gross income is reduced by 0.6571 dollars. However, it should be noted that the difference between the cost revenue ratios of the most efficient plant size one farm and the most efficient farm is only 0.1281 dollars. Comparable figures for the other plant sizes are:

Plant size two : 0.0834 dollars;
Plant size three : 0.0535 dollars;
Plant size four : 0.0258 dollars;

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19. The phrase "economies of size resulting from changes in plant size" is synonymous with the phrase "continuous between subclass reductions in the cost revenue ratio".
20. In the case of plant size one subclass (a), economies of size are realised over the complete length of the short run average curve.
21. i.e. The farm with the lowest cost revenue ratio.

Table 8.1 Ranges of Herd Sizes (and Gross Farm Incomes) over which continuous between Subclass Reductions in the Cost Revenue Ratio occur (Constant Milkfat Production per Cow).

Range of Gross Farm Incomes (Dollars) (1)	Range of Herd Sizes (2)	Subclass (3)	Cost Revenue Ratio (4)
7,138 - 12,384	60 - 105	Plant size one (a)	1.4727 - 1.0453
12,600 - 14,224	107 - 120	Plant size one (b)	1.0416 - 0.9801
14,587 - 17,012	123 - 136	Plant size one (c)	0.9771 - 0.9437
25,218 - 26,699	213 - 226	Plant size two (b)	0.9436 - 0.9194
27,071 - 28,346	229 - 240	Plant size two (c)	0.9185 - 0.8990
39,192 - 40,035	332 - 339	Plant size three (b)	0.8985 - 0.8898
40,515 - 42,477	343 - 360	Plant size three (c)	0.8885 - 0.8691
52,420 - 53,305	444 - 452	Plant size four (b)	0.8688 - 0.8620
54,050 - 56,643	458 - 480	Plant size four (c)	0.8616 - 0.8414
66,071 - 66,650	560 - 565	Plant size five (b)	0.8407 - 0.8369
67,390 - 70,774	571 - 600	Plant size five (c)	0.8363 - 0.8156

NOTES:

i) The range of gross farm incomes and herd sizes over which continuous between subclass reductions in the cost revenue ratio occur are shown in Columns (1) and (2) respectively.

ii) The subclasses over which such continuous reductions occur are shown in Column (3).

iii) The cost revenue ratios corresponding to the range of gross farm incomes and herd sizes over which such continuous reductions occur are shown in Column (4).

The short run average cost curves of Figure 8.11 are reproduced in Figure 8.13. The heavy sections of the curve TT' in Figure 8.13 show the range of gross farm incomes over which continuous between subclass reductions in the cost revenue ratio occur, when the level of milkfat production per cow varies with plant and herd size. Curve TT' shows that when the level of milkfat production varies with plant and herd size, economies of size from changing plant size are realised over segments of all the short run average cost curves of plant sizes one[20] and two and over segments of the short run average cost curves of subclasses (b) and (c) in the case of plant sizes three to five.

Table 8.2 is similar to Table 8.1 and presents detailed data concerning the ranges of herd sizes and gross farm incomes over which continuous between subclass reductions in the cost revenue ratio occur when the level of milkfat production per cow varies with plant and herd size.

From Table 8.2 and Figure 8.13, it can be seen that the cost revenue ratio again drops rapidly over that portion of the long run average cost curve corresponding to the short run average cost curve of plant size one subclass (a). However, in this case, only the cost revenue ratios corresponding to the initial degrees of plant utilisation are greater than 1.0. A cost revenue ratio of less than 1.0 is recorded when herd size reaches 88 cows. The most efficient farm is again the plant size five farm with a herd size of 600 cows.

Over the complete range of plant and herd sizes studied, however, the reduction in the total cost per dollar of gross income is only 0.3446 dollars. Further the difference between the most efficient farm of plant size one and the most efficient farm is reduced to 0.0478 dollars. Comparable figures for the other plant sizes are:

Plant size two : 0.0341 dollars;
Plant size three : 0.0242 dollars;
Plant size four : 0.0133 dollars;

4) Milkfat Output per Labour Unit on the Representative and Survey Farms

The ranges of milkfat output per labour unit which correspond to the data shown in Columns (1) and (2) of Table 8.2 are shown in Table 8.3. (Table 8.3 therefore shows the ranges of milkfat output per labour unit over which continuous between subclass reductions in the cost revenue ratio occur, when the level of milkfat per cow varies with plant and herd size.)

Table 8.2 Ranges of Herd Sizes (and Gross Farm Incomes) over which continuous between Subclass Reductions in the Cost Revenue Ratio occur (Variable Milkfat Production per Cow).

Range of Gross Farm Income (Dollars) (1)	Range of Herd Sizes (2)	Subclass (3)	Cost Revenue Ratio (4)
8,920 - 14,088	60 - 105	Plant size one (a)	1.1905 - 0.9262
14,496 - 15,631	108 - 120	Plant size one (b)	0.9195 - 0.8973
16,162 - 16,517	126 - 130	Plant size one (c)	0.8966 - 0.8937
26,330 - 26,491	208 - 210	Plant size two (a)	0.8917 - 0.8901
27,013 - 27,856	216 - 226	Plant size two (b)	0.8899 - 0.8837
28,467 - 29,005	233 - 240	Plant size two (c)	0.8836 - 0.8800
40,173 - 40,693	333 - 339	Plant size three (b)	0.8792 - 0.8764
41,269 - 42,423	346 - 360	Plant size three (c)	0.8763 - 0.8701
52,460 - 52,949	446 - 452	Plant size four (b)	0.8696 - 0.8674
53,939 - 55,389	463 - 480	Plant size four (c)	0.8671 - 0.8592
64,549 - 64,985	560 - 565	Plant size five (b)	0.8591 - 0.8568
65,826 - 68,045	574 - 600	Plant size five (c)	0.8567 - 0.8459

NOTES: i) The range of gross farm incomes and herd sizes over which continuous between subclass reductions in the cost revenue ratio occur are shown in Columns (1) and (2) respectively.

ii) The subclasses over which such continuous reductions occur are shown in Column (3).

iii) The cost revenue ratios corresponding to the range of gross farm incomes and herd sizes, over which such continuous reductions occur are shown in Column (4).

An examination of such data reveals that the output per labour unit (of farms of each plant size with the lowest cost revenue ratio), declines as one moves from plant size one to plant size five. If such data is compared with that of the farm survey, the following points are of interest. First, there are examples of Group I and II survey farms where the output per labour unit exceeds that of the corresponding [22] representative farm marked in Table 8.3 by an asterisk. For example, the output per labour unit of the following Group I survey farms exceeds that of the corresponding representative farms.

1968/69 season - Farm Nos. 7, 8, 9, 10 and 11;
1969/70 season - Farm Nos. 7, 8, 9, 10, 11 and 12. [23]

Similarly on Farm No. 21, both in the 1968/69 and 1969/70 season, the output per labour unit exceeded that of the corresponding representative farm. Second, there is only one example of a Group III or IV farm on which the output per labour unit exceeds that of the corresponding plant size shown in Table 8.3. This farm in question is Farm No. 22, the output per labour unit on which was greater than that shown in Table 8.3 in both seasons. In both seasons, however, on this farm, a married couple was employed. Consequently, the data concerning the output per milking unit of Farm No. 22 indicates that the figure in both seasons is less than that shown in Column (3) of Table 8.3.

A new series of cost revenue ratios [24] can be computed for plant sizes two to five so that the output per labour unit data of the (four) representative farms approximates the maximum figure recorded by a comparable survey farm. This data is presented in Table 8.4.

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22. i.e. Farms with the same number of labour units.
23. It should be noted, however, that in the 1968/69 season, Farm Nos. 7, 8 and 10 employed two milking units and in the 1969/70 season, Farm Nos. 8, 9, 10 and 12 employed two milking units.
24. A further cost revenue ratio was also computed for plant size two. As noted earlier, there is only one example of a survey farm, where the output per labour unit exceeds that of a corresponding representative farm. As on the farm in question (i.e. Farm No. 21) both labour units were concerned with the entrepreneurial function, and hence no "employed" labour was involved, the output data from Farm No. 21 has been ignored.

Table 8.3 Ranges of Output per Labour Unit over which continuous between Subclass Reductions in the Cost Revenue Ratio occur (Variable Milkfat Production per Cow).

Range of Herd Sizes (1)	Subclass (2)	Output per Labour Unit (pounds of milkfat) (3)
60 - 105	Plant size one (a)	23,400 - 36,660
108 - 120	Plant size one (b)	37,414 - 40,264
126 - 130	Plant size one (c)	41,590 - 42,439 *
208 - 210	Plant size two (a)	33,775 - 33,992
216 - 226	Plant size two (b)	34,630 - 35,653
233 - 240	Plant size two (c)	36,338 - 36,997 *
333 - 339	Plant size three (b)	34,153 - 34,564
346 - 360	Plant size three (c)	35,034 - 35,945 *
446 - 452	Plant size four (b)	33,316 - 33,630
463 - 480	Plant size four (c)	34,196 - 35,046 *
560 - 565	Plant size five (b)	32,667 - 32,900
574 - 600	Plant size five (c)	33,271 - 34,346 *

NOTES: i) Columns (1) and (2) of Table 8.3 are reproduced from Table 8.2 and show the ranges of herd sizes and the corresponding subclasses over which continuous between subclass reductions in the cost revenue ratio occur.

ii) Column (3) shows for each of the subclasses over which such cost reductions occur, the corresponding ranges of milkfat output per labour unit. The output per labour unit figures marked by an asterisk in Column (3) are those which correspond to the representative farm of each plant size, with the lowest cost revenue ratio.

Table 8.4 Modified Cost Revenue Ratios and Output per Labour Unit Data for Plant Sizes Two, Three, Four and Five. 25/

Plant Size (1)	Modified Cost Revenue Ratio (2)	Modified Output per Labour Unit data (pounds of milkfat) (3)	Herd Size (4)	Sub-Class (5)	Average Milking Time (Hours) (6)
(2)	0.8899	34,630	216	(b)	1.675
(3)	0.8834	33,735	327	(b)	1.690
(4)	0.9090	29,333	375	(a)	1.575
(5)	0.8756	30,694	515	(a)	1.710

NOTES:

i) Column (2) shows the cost revenue ratios of the (four) representative farms when the output per labour unit approximates the maximum figure recorded by a comparable survey farm.

ii) Column (3) shows the relevant milkfat output per labour unit data of the (four) representative farms.

iii) Column (4) shows for each of the (four) representative farms, the herd size which should be milked in order that the appropriate output per labour figure shown in Column (3) be obtained.

iv) Column (5) shows for each of the (four) representative farms, the subclass (i.e. size of herringbone) which should be used, if the herd size is to be that shown in Column (4). (The phrase "should be used" means the subclass which for the herd size (and hence output per labour unit in question) gives the lowest cost revenue ratio.)

v) Column (6) shows for the herd size and subclass shown in Columns (4) and (5), respectively, the corresponding average milking time.

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25. Table 8.4 is based upon the assumption that the level of milkfat production per cow varies with plant and herd size.

The cost revenue ratio of the plant size one farm with the highest output per labour unit is 0.8948 (i.e. plant size one subclass (c) 136 cows). From Table 8.4, it can be seen that the cost revenue ratios of the representative farms of plant sizes two, three and five (the output per labour unit data of which approximates the maximum recorded by a comparable survey farm) are lower than that of the plant size one representative farm discussed above. In the case of plant size four, the "modified" cost revenue ratio as shown in Table 8.4 is greater than that of the plant size one farm.

It should be noted, however, that the differences between the cost revenue ratios of the plant size one farm (with the highest output per labour unit) and those of the representative farms of plant sizes two to five as shown in Table 8.4 are not great. For example, the difference between the cost revenue ratio of the plant size one farm (with the highest output per labour unit) and that of the plant size two farm, shown in Table 8.4 is 0.0049 dollars per dollar of gross income. Comparable figures for the other plant sizes are:

Plant size three	:	0.0114	dollars	per	dollar	of	gross	income;
Plant size four	:	- 0.0142	"	"	"	"	"	"
Plant size five	:	0.0192	"	"	"	"	"	"

However, it is important to note that the average milking time of the plant size one farm in question is greater than the average milking time of the representative farms of plant sizes two to five as shown in Column (6) of Table 8.4. The average milking time of the plant size one farm is 1.75 hours. It seems likely, therefore, that plant size one farms can achieve a cost revenue ratio which is comparable to those of the farms of the larger plant sizes and hence between plant sizes, constant returns to size are realised. However, it would seem probable that in order for constant returns to size to be realised, the hours of work of the labour units of the plant size one farms would have to be greater than those of the labour units of the farms of the larger plant sizes, (i.e. the degree of plant utilisation of the plant size one farms would need to be greater than that of the farms of the larger plant sizes.)

In this context, if a new cost revenue ratio is computed for plant size one, so that the output per labour unit of the representative farm approximates that of survey farm No. 11 in the 1968/69 season, the resulting cost revenue ratio is 0.8239. Such a cost revenue ratio is:

a) Lower than the cost revenue ratios of all representative farms of Table 8.4.

b) Lower than the cost revenue ratios of all 129 representative farms from which the long run average cost curve of Figure 8.11 is derived (i.e. L.R.A.C. curve, variable milkfat production per cow).

c) With one exception,[26] lower than the cost revenue ratios of all 129 representative farms from which the long run average cost curve of Figure 8.6 is derived (i.e. L.R.A.C. curve, constant milkfat production per cow).

However, it is important to realise that the average milking time of the plant size one farm, with a cost revenue of 0.8239, is 2.76 hours.

8.6 NET INCOME CURVES - INTRODUCTORY COMMENTS

As discussed earlier, for each representative farm, five net income figures are calculated. The five net income figures are:

a) Net cash income;
b) Net farm income;
c) Operator labour and management income;
d) Operator management income;
e) Entrepreneurial income;

Therefore for each of the ten series of short run average cost curves, which can be drawn for a given level of milkfat price, a corresponding series of short run net income curves can be drawn. Such curves show for any given subclass, the net income (or net loss), resulting from producing a given level of gross farm income, with the subclass in question.

From a series of short run net income curves, another curve can be constructed, which shows the most profitable way of producing any given level of gross farm income. Such a curve may be termed a long run net income curve. In this section, ten long run net income curves are presented, each corresponding to one of the long run average curves discussed earlier.

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26. The one exception is the cost revenue ratio of the representative farm corresponding to the cut-off point of plant size five subclass (c) (i.e. 600 cows). The cost revenue ratio of this farm is 0.8156.

8.7 SHORT RUN AND LONG RUN NET INCOME CURVES - CONSTANT MILKFAT PER COW

1) Net Cash Income Curves

The short run and long run net cash income curves are shown in Figure 8.14.

For all fifteen subclasses, the net income (i.e. net cash income) increases as the degree of plant utilisation increases. Consequently the highest net cash income in all cases is recorded at the cut-off point.

Although the short run average cost curve of plant size one subclass (c) is "u" shaped, the net cash income increases as the degree of plant utilisation increases. This indicates that insufficient variable resources have been added to the fixed plant to cause profit (i.e. net cash income) to fall. The plant is therefore being operated at a degree of plant utilisation which either coincides with, or is slightly less than, the degree of plant utilisation at which profit is maximised.

For comparable cut-off points, the net income increases as one moves from plant size one to plant size five. Further, within each plant size, the net income increases as one moves from the cut-off point of subclass (a) to the cut-off point of subclass (c). The highest net cash income is therefore recorded at the cut-off point of plant size five subclass (c).

The long run net income curve comprises segments [27] of all fifteen short run net income curves, indicating that each subclass represents the most profitable way of producing particular ranges of gross farm income. The long run net income curve is segmented because the resources which comprise the fixed plant are not continuously divisible. [28]

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27. In all cases, the long run net income curve includes the complete net income curve of plant size one subclass (a).
28. The comments made in the second, fourth and fifth paragraphs also apply to the net income curves derived from the other four net income figures. That is:
    i) For all fifteen subclasses, the net income increases as the degree of plant utilisation increases.
    ii) For comparable cut-off points, the net income increases as one moves from plant size one to plant size five. Within each plant size, the net income increases as one moves from the cut-off point of subclass (a) to the cut-off point of subclass (c).
    iii) The long run net income curve comprises segments of all fifteen short run net income curves.

The net cash income of all 129 farms (from which the long run net income curve is derived) is positive.

2) Net Farm Income Curves

The short run and long run net farm income curves are shown in Figure 8.15.

Again, although the short run average cost curve of plant size one, subclass (c) is "u" shaped, the net farm income increases as the degree of plant utilisation increases. This, as discussed earlier, is due to insufficient variable resources being added to the fixed plant to cause the net income (i.e. net farm income) to fall.

The net farm income of all 129 representative farms is again positive. This is of particular interest, for as long as this sum is positive, the farm operator can remain solvent. The minimum net farm income is recorded at the start point of plant size one subclass (c), the sum in question being 3,879 dollars.

3) Operator Labour and Management Income Curves

The short run and long run operator labour and management income curves are shown in Figure 8.16.

In this case, with three exceptions,[29] losses are recorded over the initial degrees of plant utilisation of all fifteen subclasses. (i.e. The cost revenue ratios of such representative farms are greater than 1.0.)

4) Operator Management Income Curves

The short run and long run operator management income curves are shown in Figure 8.17. Figure 8.17 shows that in all cases, losses are recorded over the initial degrees of plant utilisation of each subclass, and further compared with the operator labour and management income curves, proportionately more of the representative farms record losses. For example, when the net income curves are derived from the operator labour and management income data, on twelve of the 129 representative farms, losses are recorded. When the net income curves are derived

29. The three exceptions are:

Plant size one, subclass (a);

Plant size two, subclasses (a) and (b).

from the operator management income data on 47 of the 129 representative farms, losses are recorded.

5) Entrepreneurial Income Curves

The short run and long run entrepreneurial income curves are shown in Figure 8.18.

In this case, on 72 of the 129 representative farms, losses are observed. Further, it should be noted that on all representative farms of plant size one subclass (a), losses are recorded.

6) Minimum Herd Size and Milkfat Output required for Entrepreneurial Income to be Positive

Table 8.5 shows for each subclass, the minimum herd size and corresponding output and cows per labour unit data required for the entrepreneurial income to be positive.

From Table 8.5, it is apparent that for comparable subclasses, the minimum ratio of cows per labour unit and output per labour unit, required for the entrepreneurial income to be positive declines as one moves from plant size one to plant size five. With the exception of plant size one, [30] within each plant size, the minimum herd size required (and hence cows per labour unit and output per labour unit) is recorded by subclass (a). Consequently, over the complete range of plant and herd sizes studied, the minimum ratio of cows per labour unit required declines from 115.0 in the case of plant size one subclass (b) to 79.4 in the case of plant size five subclass (a). The associated output per labo[illegible] figures are 34,500 pounds, plant size one subclass (b), and 23,820 pounds, plant size five subclass (a).

8.8 SHORT RUN AND LONG RUN NET INCOME CURVES - VARIABLE MILKFAT PER COW

1) The Short Run and Long Run Net Income Curves

The five series of short run and long run net income curves are shown in Figures 8.19, 8.20, 8.21, 8.22 and 8.23. From Figures 8.19 - 8.23, when the level of milkfat production per cow varies with plant and herd size, the following points are of interest.

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30. In the case of plant size one subclass (a), the entrepreneurial income is negative for all degrees of plant utilisation.

Table 8.5 Minimum Herd Size, Cows per Labour Unit, Output per Labour Unit required for the Entrepreneurial Income to be Positive (Constant Milkfat per Cow)

Subclass (1)		Minimum Herd Size (2)	Cows per Labour Unit (3)	Output per Labour Unit (Pounds of Milkfat) (4)
(a)	Plant Size one	-	-	-
(b)		115	115	34,500
(c)		118	118	35,400
(a)	Plant Size two	187	93.5	28,050
(b)		189	94.5	28,350
(c)		192	96.0	28,800
(a)	Plant Size three	263	87.66	26,300
(b)		268	89.33	26,800
(c)		271	90.33	27,100
(a)	Plant Size four	333	83.25	24,975
(b)		338	84.50	25,350
(c)		342	85.50	25,650
(a)	Plant Size five	397	79.40	23,820
(b)		405	81.00	24,300
(c)		409	81.80	24,540

NOTES:

i) Column (2) shows for each of the fifteen subclasses, the minimum herd size required for the entrepreneurial income to be positive.

ii) Column (3) shows the corresponding ratio of cows per labour unit.

iii) Column (4) shows the corresponding milkfat production per labour unit.

In all five cases, [31] as the degree of plant utilisation of each of the fifteen subclasses increases, the appropriate net income figures increase. Consequently, the highest net income figures for each subclass are recorded at the cut-off point.

Of particular interest are the five short run net income curves of plant size one subclass (c) and one [32] net income curve of plant size one subclass (b). Although the corresponding short run average cost curves of these net income curves are "u" shaped, the net income figures increase as the degree of plant utilisation increases. This, as noted earlier, is due to insufficient variable resources being added to the fixed plant to cause net income to fall.

In all five cases, for comparable cut-off points, the net income increases as one moves from plant size one to plant size five; within each plant size, the net income figures increase as one moves from the cut-off point of subclass (a) to the cut-off point of subclass (c). The highest net income in all five cases is recorded at the cut-off point of plant size five subclass (c).

The long run net income curve in all cases is segmented, due to the resources which comprise the fixed plant not being continuously divisible.

As one moves from the first to the fifth series of net income curves, there is a trend towards losses being recorded on proportionately more of the representative farms. For example, when the net income curves are derived from the net cash income data, on none of the 129 representative farms (from which the long run net income curve is derived) is the net income (i.e. net cash income) negative. Comparable figures for the four other series of net income curves are:

Series Two	: Net Farm Income	:	Losses are recorded on 0 of the 129 farms;
Series Three	: Operator Labour and Management Income	:	Losses are recorded on 0 of the 129 farms;
Series Four	: Operator Management Income	:	Losses are recorded on 18 of the 129 farms;
Series Five	: Entrepreneurial Income	:	Losses are recorded on 39 of the 129 farms;

31. i.e. For each of the five series of net income curves.

32. i.e. The net income curve derived from the net cash income data.

2) Minimum Herd Size and Milkfat Output required for Entrepreneurial Income to be Positive

Table 8.6 shows for each subclass, the minimum herd size and corresponding output and cows per labour unit data required for the entrepreneurial income to be positive, when the level of milkfat production per cow varies with plant and herd size.

Column (3) shows that when the level of milkfat production per cow varies with plant and herd size, for comparable subclasses, the differences between the five plant sizes in terms of the minimum ratio of cows per labour unit required are much reduced. Within each plant size, the minimum herd size required is recorded by subclass (a). Column (4) shows that for comparable subclasses, the output per labour unit required decreases from plant size one to plant size five and within each plant size, the minimum output per labour unit required is recorded by subclass (a). Consequently over the complete range of plant and herd sizes studied, the minimum ratio of cows per labour unit required declines from 88.0 in the case of plant size one subclass (a) to 72.8 in the case of plant size five subclass (a). The corresponding output per labour unit figures are 32,083 pounds in the case of plant size one subclass (a) and 23,218 pounds in the case of plant size five subclass (a).

8.9 BREAKEVEN ANALYSIS

1) Milkfat Production per Cow

One of the most critical assumptions of the analysis is the assumption concerning the level of milkfat production per cow pertaining to each of the 129 representative farms, from which the long run average cost curves are constructed.

As discussed earlier in this study, long run average cost curves are presented:

a) Under the assumption that the level of milkfat production per cow remains constant over the complete range of herd sizes studied.

b) Under the assumption that milkfat production per cow is a function of plant and herd size.

Figures 8.6 and 8.11 show that in both cases, the low point of the long run average cost curve is represented by the cut-off point of plant size five subclass (c).

Table 8.6 Minimum Herd Size, Cows per Labour Unit, Output per Labour Unit required for the Entrepreneurial Income to be Positive (Variable Milkfat per cow).

Subclass (1)		Minimum Herd Size (2)	Cows per Labour Unit (3)	Output per Labour Unit (Pounds of Milkfat) (4)
(a)	Plant Size 1	88	88.0	32,083
(b)		90	90.0	32,649
(c)		92	92.0	33,207
(a)	Plant Size 2	140	70.0	25,180
(b)		142	71.0	25,467
(c)		145	72.5	25,893
(a)	Plant Size 3	214	71.33	24,508
(b)		219	73.00	24,971
(c)		222	74.00	25,246
(a)	Plant Size 4	292	73.00	24,043
(b)		296	74.00	24,313
(c)		302	75.50	24,716
(a)	Plant Size 5	364	72.80	23,218
(b)		371	74.20	23,592
(c)		376	75.20	23,858

NOTES:

i) Column (2) shows for each of the fifteen subclasses, the minimum herd size required for entrepreneurial income to be positive.

ii) Column (3) shows the corresponding ratio of cows per labour unit.

iii) Column (4) shows the corresponding milkfat production per labour unit.

If milkfat production per cow is assumed not to vary with plant and herd size, the selection of another level of milkfat production per cow, will not alter the shape of the long run average cost curves. If it is considered that milkfat production per cow is a function of herd and plant size (and in the author's opinion, this is more likely), then altering the five linear functions which express milkfat production per cow as a function of herd and plant size, could alter the shape of the long run average cost curves. Further, it should be remembered the data which was used in the derivation of the five linear functions was arbitrarily decided upon by the author after a study of the farm survey data.

Rather than derive a number of long run average cost curves based upon a series of assumptions concerning the levels of milkfat production per cow, the effect of varying levels of milkfat production per cow on the shape of the long run average cost curves is studied in the following way. For each of the 129 representative farms (from which a long run average cost curve is derived), the level of milkfat production per cow required for the cost revenue ratio of the farm in question to be equal to that of the low point of the long run average cost curve is determined.

Readers are therefore invited to form their own opinions concerning the relationship between milkfat production per cow and plant and herd size and to examine Figures 8.24 and 8.25 to determine whether their opinions are such that the low point and hence shape of the long run average cost curves will alter.

Figure 8.24 shows the level of milkfat production per cow which must be attained by each of the representative farms if the cost revenue ratio 33/ of each farm is to equal that of the low point of the long run average cost shown in Figure 8.6. Similarly Figure 8.25 shows the level of milkfat production per cow which must be attained by each of the representative farms if the cost revenue ratio of each farm is to be equal to that of the low point of the long run average cost curve shown in Figure 8.11. 34/ The curves AA', BB', CC', DD' and EE' of Figure 8.25 show the relationship between milkfat production per cow and plant and herd

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33. The cost revenue ratios in question are those of the fifth series of cost revenue ratios i.e. $\frac{\text{Total cost (E)}}{\text{Gross farm income}}$

34. A second computer programme was used for the determination of the data shown in Figures 8.24 and 8.25.

size, resulting from the use of the five linear functions described in section B.2 of Appendix B.

An examination of Figures 8.24 and 8.25 indicates that in both cases, the level of milkfat production per cow which must be attained by the farms representing the initial degrees of plant utilisation, of the fifteen subclasses is relatively high. For example, for each of the three subclasses associated with each plant size, both when the level of milkfat production varies and remains constant, with changes in plant size and herd size, in order that the cost revenue ratios be equal to that of the low point of the long run average cost curve, the milkfat production per cow of those farms corresponding to the initial degrees of plant utilisation must exceed 400 pounds. Discussions with Manawatu Extension Officers led the author to the conclusion that such output levels are extremely unlikely to be attained, particularly as stocking rate remains constant irrespective of plant and herd size. Conversely, in both cases, for each of the fifteen subclasses over the latter degrees of plant utilisation, the levels of milkfat production per cow required by the representative farms to equalise the lowest cost revenue ratio of the long run average curve appear to be more likely.

Table 8.7 presents data concerning the level of milkfat production per cow required by the representative farms corresponding to the low points of the five subclass (c) short run average cost curves in order that the cost revenue ratios of such farms be equal to those of the low point of the long run average cost curves. From the data presented in Table 8.7, it can be seen that relatively small increases in milkfat production per cow are required for the cost revenue ratios of the four representative farms to be equal to those of the low points of the long run average cost curves. Discussions with Manawatu Extension Officers leadthe author to the conclusion that such increases are feasible, in which case between plant sizes, constant returns to size would exist.

Finally, if the reader should disagree with the level of milkfat production per cow of the representative farms which correspond to the low points of the long run average cost curves, the data presented in Figures 8.24 and 8.25 are no longer applicable. In such circumstances,

Table 8.7 Milkfat Production per cow required for the Cost Revenue Ratios of Representative Farms to be equal to those of the Low Point of the Long Run Average Cost Curves

Plant Size (1)	Constant Milkfat per Cow		Variable Milkfat per Cow	
	Milkfat/ Cow (Pounds) (2)	Difference (Pounds of Milkfat) (3)	Milkfat/ Cow (Pounds) (4)	Difference (Pounds of Milkfat) (5)
1	365.95	65.95	349.86	28.86
2	339.45	39.45	324.20	15.89
3	325.24	25.24	310.55	11.01
4	312.17	12.17	297.98	5.93
5	300.00	0.00	286.22	0.00

NOTES:

i) Column (2) shows the level of milkfat production per cow required by each of the five representative farms, in order that the cost revenue ratios of the representative farms be equal to that of the low point of the long run average cost curve shown in Figure 8.6.

ii) Column (3) shows for each of the representative farms, the required increase in the per cow production.

iii) Column (4) shows for each of the representative farms, the level of milkfat production per cow required in order that the cost revenue ratios of the representative farms be equal to that of the low point of the long run average cost curve shown in Figure 8.11.

iv) Column (5) shows for each of the representative farms, the required increase in per cow production.

the effect of varying levels of milkfat production per cow on the shape of the long run average cost curves can be determined by recalculating the cost revenue ratios from the data shown in Figures 7.33, 7.34 and 7.35. by the use of the following procedure.

For example, if the reader should decide that the level of milkfat production per cow at the cut-off point of plant size five subclass (c) should be 290 pounds and at the cut-off point of plant size four sub-class (c) 305 pounds, the modified cost revenue ratios can be obtained as follows:

i) From Figure 8.25 it can be seen that the level of milkfat production per cow has increased by:

Approximately 13 pounds per cow in the case of the plant size four farm;

Approximately 4 pounds in the case of the plant size five farm;

ii) The per unit gross farm income data is shown in Figure 7.35. From Figure 7.35, it can be seen that the per unit gross farm income is:

In the case of the plant size four farm, approximately 115 dollars per cow;

In the case of the plant size five farm, approximately 113 dollars per cow;

iii) The modified per unit gross farm income figures are therefore:

Plant size four farm, \$115 + \$4.29 = \$119.29
Plant size five farm, \$113 + \$1.32 = \$114.32

iv) The per unit costs of total cost (E) are shown in Figure 7.34. The per unit costs are:

Approximately \$99 per cow in the case of the plant size four farm;

Approximately \$96 per cow in the case of the plant size five farm;

v) The modified per unit costs of total cost (E) therefore become: (The per unit opportunity cost of the operator's management is increased.)

Plant size four farm, \$99.00 + \$0.26 = \$99.26

Plant size five farm, \$96.00 + \$0.08 = \$96.08

vi) The modified cost revenue ratios therefore become:

Plant size four farm, $\frac{99.26}{119.29}$ = 0.8320

Plant size five farm, $\frac{96.08}{114.32}$ = 0.8404

2) Cost Data

Similarly, the reader may also disagree with some of the assumptions made in the study, and with certain details of the cost data. For this reason, for each of the 129 farms from which a long run average cost curve is constructed, the sum by which the Total Cost (E) must be reduced in order that the cost revenue ratio be equal to that of the low point of the long run average cost curve is determined. [35] As the Total Cost (E) consists of five separate components, alterations in the assumptions made, or cost data used, in the computation of each of the five components, will cause variations in the (fifth) cost revenue ratio.

Figure 8.26 shows the reductions in the per unit cost of Total Cost (E), required for the cost revenue ratios of each of the representative farms, to be equal to that of the low point of the long run average cost curve, when the level of milkfat production per cow remains constant over the complete range of herd sizes studied.

Similarly Figure 8.27 shows the reductions required in the per unit cost of Total Cost (E) when the level of milkfat production per cow varies with plant and herd size.

Figures 8.26 and 8.27 show that for each of the fifteen plant sizes, when the degree of plant utilisation is low, the magnitude of the cost reductions required is relatively high. This indicates that major alterations (i.e. in excess of 30 dollars per cow) in the assumptions made or in the cost data used, are required if the cost revenue ratios of such farms are to be equal to those of the low points of the long run average cost curves. Such reductions in the per unit costs of Total Cost (E) are, in the author's opinion, extremely unlikely to be attained. Conversely over the latter degrees of plant utilisation, particularly in the case of the larger plant sizes, the magnitude of cost reductions required

35. A computer programme was written to determine these sums.

is relatively low. Consequently, on such farms, minor alterations in the assumptions made, or cost data used, could alter the shape of the long run average cost curves.

Consequently, if readers disagree with any of the assumptions made, or with certain details of cost data used, (other than the assumptions made or cost data used, for the calculation of the cost revenue ratios of the representative farms corresponding to the low points of the long run average cost curves), they are invited to recalculate the per unit costs of Total Cost (E), (based upon their own assumptions and cost data) and to compare the results of such recalculations with the data shown in Figures 8.26 and 8.27.

If the reader should disagree with the assumptions made or with details of the cost data used, for the calculation of the cost revenue ratios of the representative farms corresponding to the low points of the long run average cost curves, the effect of variations in the per unit costs of the representative farms, upon the shape of the long run average cost curves can be determined by recalculating the cost revenue ratios using a similar procedure to that discussed on pages 199 - 200.

8.10 SUMMARY

In this chapter, a detailed account has been given of the nature of the cost-size and profit-size relationships. The results indicate that whereas within each subclass relatively large reductions in the cost revenue ratio are obtained as the degree of plant utilisation increases, comparatively small reductions in the cost revenue ratio are obtained by changing plant size. Further, between plant sizes when the output per labour unit data of the representative farms approximates the maximum figure of a comparable survey farm, extremely small differences in the cost revenue ratios are observed.

The net income data indicates that in all cases within each subclass, the net income increases continuously as the degree of plant utilisation increases, and within each plant size, the net income increases as one moves from the cut-off point of subclass (a) to the cut-off point of subclass (c). Further for comparable cut-off points, the net income (in all cases) increases as one moves from plant size one to plant size five and consequently the highest net income figure is recorded at the cut-off point of plant size five subclass (c).

When the level of milkfat production per cow remains constant irrespective of changes in plant and herd size, the minimum ratio of cows per labour unit and output per labour unit required for the entrepreneurial income of comparable subclasses to be positive declines as one moves from plant size one to plant size five. A similar trend is discernible in the output per labour unit data when the milkfat production per cow varies with plant and herd size. The continuous decline for comparable subclasses as one moves from plant size one to plant size five is not apparent in the data relating to the minimum ratio of cows per labour unit required when per cow production varies with plant and herd size. This results because of the higher per cow production of the representative farms of the smaller plant sizes. In this case, the minimum ratio of cows per labour unit is recorded by plant size two.

The breakeven analysis indicates that both when the level of milkfat production per cow varies and remains constant with changes in plant and herd size, relatively small increases in the milkfat produced per cow, and relatively small decreases in the per unit costs, are required for the cost revenue ratios of the representative farms corresponding to the latter degrees of plant utilisation of each subclass, to be equal to those of the low points of the long run average cost curves.

CHAPTER NINE

IMPLICATIONS OF THE STUDY AND CONCLUSIONS

9.1 INTRODUCTION

In this chapter, some of the more salient implications of the study are discussed and the author's conclusions presented.

9.2 PROFIT MAXIMISATION AND COST MINIMISATION CONSIDERATIONS

The results of the analysis illustrate an important point which should be borne in mind when considering economies of size studies. In the case of plant size one subclass (c), the low point of the short run average cost curve (when the level of milkfat production per cow varies with plant and herd size) corresponds to a herd size of 130 cows. [1] Further increases in the degree of plant utilisation lead to the realisation of diseconomies of size. However, although diseconomies of size are realised as the degree of plant utilisation increases beyond a herd size of 130 cows, net income (in all five cases) increases.

Similarly, it is possible to move from a given point on a particular short run average cost curve to a higher point on another short run average cost curve (and hence diseconomies of size are realised) and for the change to be associated with an increase in net income. For example, the five series of cost revenue ratios corresponding to a plant size one subclass (c) representative farm, with 130 cows are shown in Column (1) of Table 9.1. The corresponding figures for a plant size two subclass (a) representative farm, with a herd size of 180 cows are shown in Column (2) of Table 9.1.

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1. The low point corresponds to a herd size of 130 cows, when the short run average cost curves are derived from the third, fourth and fifth series of cost revenue ratios. When the cost curves are derived from the first and second series of cost revenue ratios, the low point corresponds to a herd size of 120 cows.

Table 9.1 Cost Revenue Ratios corresponding to Herd Sizes of 130 cows (Plant size one) and 180 cows (Plant size two) (Variable Milkfat Production per cow).

Cost Revenue Ratio	Plant size one Subclass (c) 130 cows (1)	Plant size two Subclass (a) 180 cows (2)
Ratio 1	0.2850	0.3894
Ratio 2	0.3117	0.4118
Ratio 3	0.6520	0.7341
Ratio 4	0.8337	0.8613
Ratio 5	0.8937	0.9213

The net income data of the two farms corresponding to the cost revenue ratio data of Table 9.1 are shown in Table 9.2.

Table 9.2 Net Income Data corresponding to Herd Sizes of 130 cows (Plant size one) and 180 cows (Plant size two) (Variable Milkfat Production per cow).

Net Income	Plant size one Subclass (c) 130 cows (dollars) (1)	Plant size two Subclass (a) 180 cows (dollars) (2)
Cash Income	11,809	14,401
Net Farm Income	11,368	13,872
Operator Labour and Management Income	5,746	6,270
Operator Management Income	2,746	3,270
Entrepreneurial Income	1,755	1,855

From Tables 9.1 and 9.2, it can be seen that although the cost revenue ratios of the plant size two farm are in all (five) cases greater than those of the plant size one farm, the corresponding net income figures of the plant size two farm are in all (five) cases greater than those of the plant size one farm. This arises because, although the net return per dollar of gross farm income is lower in all five cases for the plant size two farm, the number of units of gross farm income (i.e dollars) of the plant size two farm is sufficiently great to overcome the lowered per unit return and cause the absolute (income) sum to be greater. 2/

Although it seems likely that the main factor of interest to a farmer considering a change of farm size is whether such a change will lead to an increase in net income, it is desirable that any change in farm size be such that economies of size are realised. (Consequently, the total cost of producing a dollar of gross farm income is reduced and hence the net return per dollar of gross farm income increased.)

In order for such changes in farm size to be accompanied by the realisation of economies of size, it is essential that all resources (and particularly those which in this study constitute the fixed plant be utilised as fully as possible. For example, if a change is made from a farm corresponding to the low point of the short run average cost curve, of plant size one subclass (c) to a farm corresponding to a plant size two representative farm with 210 cows, the resulting cost revenue ratios and net income data are shown in Table 9.3.

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2. For example, the gross farm income of the two farms is:

Plant size one	16,517 dollars
Plant size two	23,586 dollars

The first cost revenue ratios for the farms are:

Plant size one	0.2850
Plant size two	0.3894

The net return per dollar of gross farm income is therefore:

Plant size one	(1 - 0.2850)	=	0.7150 dollars
Plant size two	(1 - 0.3894)	=	0.6106 dollars

The net cash income is therefore:

Plant size one	16,517 x 0.7150	=	11,809 dollars
Plant size two	23,586 x 0.6106	=	14,401 dollars

Table 9.3 Cost Revenue Ratios and Net Income Data corresponding to a Herd Size of 130 cows (Plant size one) and 210 cows (Plant size two) (Variable Milkfat Production per cow).

Cost Revenue Ratio	Plant size one 130 cows	Plant size two 210 cows	Net Income	Plant Size one 130 cows	Plant Size two 210 cows
Ratio 1	0.2850	0.3729	Net Cash Income	11,809	16,562
Ratio 2	0.3117	0.3950	Net Farm Income	11,368	16,026
Ratio 3	0.6520	0.7168	Operator Labour and Management Income	5,746	7,499
Ratio 4	0.8337	0.8301	Operator Management Income	2,746	4,499
Ratio 5	0.8937	0.8901	Entre-preneurial Income	1,755	2,910

From Table 9.3, it is apparent that in the case of the fourth and fifth series of cost revenue ratios, the cost revenue ratios of the plant size two farm are lower than those of the plant size one farm and hence economies of size are realised. Thus moving from the 130 cow farm to the 210 cow farm, gives rise not only to a greater gross farm income but also to a lower total cost per dollar of gross farm income and consequently a higher net return per dollar of gross farm income.

Further in this context, it seems likely that in certain circumstances, the magnitude of the cost reductions which accompany increases in farm size (as indicated in this study) will be reduced and consequently, it may be extremely difficult for a change in farm size to be accompanied by the realisation of economies of size.

For example, there are three main ways in which the area of the farm a farmer operates can be increased.

a) The existing property can be sold and another purchased;

b) Contiguous areas of land can be purchased and farmed in conjunction with the present property.

c) Non contiguous areas of land can be purchased and farmed in conjunction with the present property.

In all three cases, peculiarities in the shape of the "new large farm" may be such that most of the cost advantages accruing to the larger farms, in terms of reduced per unit investment costs of fencing, water reticulation systems and farm races are destroyed. Further, resources may have to be purchased which are not required, (e.g. dwellings, farm dairies, etc.). The acquisition of such resources which cannot be effectively utilised will tend to increase the per unit costs. In addition in the case of b) and c), pecuniary economies in the acquisition of land may not be realised because land is purchased in small parcels.

However, in the author's opinion, it is extremely important that any farmer contemplating a change in farm size should carefully consider the various factors which give rise to economies of size and wherever possible, take advantage of these factors.

9.3 FARMS WHICH CAN BE CONSIDERED "TOO SMALL"

The results of the analysis also indicate that on those farms of each subclass where the output per labour unit is low, the entrepreneurial income is negative. This does not necessarily mean that such farms will be forced out of production. Such farms will be forced out of production only if:

a) The net farm incomes are negative;

b) The income generated by such farms is insufficient to overcome the reservation price [3] the operators attach to their invested capital, and their personal services of labour and management.

It is interesting to note that both when the level of milkfat production per cow varies and remains constant with plant and herd size,

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3. Maddern (9, p.13) describes opportunity cost as the highest return a resource can earn in any alternative employment currently available. In some cases, the returns to certain resources are lower than the opportunity costs but the resources are still retained in production. In these cases, the reservation price becomes relevant as the lower limit of resource returns below which the resources will be retired from use.

the net farm income of all farms is positive. The lowest figure recorded is that of the 60 cow plant size one subclass (c) farm, when the level of milkfat production per cow remains constant irrespective of plant and herd size. The figure in question being 3,879 dollars.

In this context, Candler (35, p.5) in his submissions to the Scale of Farming Working Party of the Agricultural Development Conference, suggested that:

> "A farm should be considered too small if farm family income is less than the basic wage order."

The lowest net farm income observed (i.e. 3,879 dollars) would appear to give a weekly remuneration which is greater than the average weekly wage earned in New Zealand. [4] However, in addition to meeting the living expenses and taxation liability of the farm operator, the sum in question, in most instances will also be required to service any debt commitments [5] and provide funds for new farm investments.

The operators of those farms where entrepreneurial incomes are negative, may consider that the farms have sufficient earning capacity to overcome the reservation prices they attach to their invested capital and personal services of labour and management while still providing satisfactory levels of "farm family income" and so elect to continue farming.

However, any serious decline in the farmers' terms of trade could result in these farms being unable to provide a satisfactory "farm family income". For example, if the price of milkfat was to drop to 20 cents a pound, the net farm incomes of the representative farms, corresponding to the start points of the five subclass (a) plant sizes are shown in Table 9.4.

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4. The average weekly wage payout per person in New Zealand as at October 1969, was estimated to be 49.945 dollars. (36, p.45)

5. e.g. Interest and principal payments.

Table 9.4 Net Farm Income at the start point of Plant sizes one to five at 20 cents per pound of Milkfat

Plant Size (1)	Constant Milkfat per cow (dollars) (2)	Variable Milkfat per cow (dollars) (3)
1	1,668	2,748
2	1,444	3,124
3	884	2,820
4	692	2,596
5	476	2,144

In the author's opinion, these sums (and particularly those shown in Column (2)) are unlikely to provide a satisfactory level of farm family income and hence such farms under these conditions could be viewed as being "too small".

Further, on farms where the output per labour unit is low (and hence entrepreneurial incomes negative), such losses can be offset if the labour force (plus certain other resources) can be employed in other remunerative activities. For example, a farm operator of a farm where the output per labour unit is low, may be able to "sell" some of the excess labour and machinery capacity of his farm, by performing outside contract work. Maddern (9, p.21) notes that if such farms are viewed as goods and service firms, rather than as firms concerned solely with the production of farm produce, the resulting net income of such farms may be satisfactory. In addition, he postulates that if the increase in costs associated with off-farm activities, are less than the proportionate increase in gross farm income, the farm's cost revenue ratio will decrease.

Finally, the data shown in Tables 8.5 and 8.6 showing for each subclass, the minimum herd size and output per labour unit required for the entrepreneurial income to be positive are based upon an imputed interest charge, which is assessed on a percentage basis of the data shown in Figure 7.13 (i.e. the total farm investment data). Investigations, however, indicated that the total investment requirements of the representative farms, were in excess of those expected to be required by farms of comparable plant and herd sizes in the Awahuri district. Hence, when the interest charge is assessed on the data shown in Figure 7.14 (i.e. the estimated "market value" of farms), the minimum herd size and output per labour unit figures required by each subclass for the entrepreneurial income to be positive will be lower than those shown in Tables 8.5 and 8.6.

9.4 THE EFFECT OF VARIATIONS IN MILKFAT PRICE

Increases or decreases in the price of milkfat do not alter the shape of the long run average cost curves. (i.e. The L.R.A.C. curve in all cases is segmented, comprises segments of all 15 S.R.A.C. curves and the low point is recorded at the cut-off point of plant size five subclass (c).) The effect of an increase in the price of milkfat is to decrease the minimum herd size (and hence output per labour unit) required by each subclass in order that entrepreneurial income be positive. Conversely, the effect of a decrease in the price of milkfat is to increase the minimum herd size (and hence output per labour unit) required by each subclass in order that the entrepreneurial income be positive.

At a milkfat price of 25 cents per pound, losses are recorded on all 129 representative farms. At a milkfat price of 27.5 cents per pound of milkfat, losses are recorded on all farms except those corresponding to the latter degrees of plant utilisation of plant sizes four and five. However, it must be remembered that there were no examples of Group III and IV survey farms where the output per labour unit data is equal to or greater than those of comparable representative farms. Consequently, if a new series of cost revenue ratios are calculated for varying levels of milkfat price so that the output per labour unit data of the representative farms, approximates the maximum figure recorded by a comparable survey farm, it is found that at a price of 27.5 cents per pound of milkfat, on none of the farms of the five plant sizes is entrepreneurial income positive. Consequently in the event of a severe drop in the price of milkfat, advantages will accrue to plant size four and five farms but only if the output per labour unit figures of such farms can be increased above the levels currently being achieved.

9.5 CONCLUSIONS

One of the most salient features of the farm survey was the extremely high ratio of cows per labour unit and output per labour unit on some of the Group I farms. The high productivity of these farms does not necessarily indicate that phenomena exist which give advantages to one man farms relative to multi labour unit farms in terms of labour productivity. The extremely high ratios of cows per labour unit and output per labour unit on the Group I farms were achieved by the labour units working extremely long hours (particularly in the spring), taking little time off during the milking season, making extensive use of contractors and specialising in stock work. The author believes that the differences between the four groups of farms in terms of the output per labour unit would decrease, if the ratio of cows per labour unit and hence the hours of work of the labour units on some of the Group III and IV farms were increased.

Although specialisation and division of labour was evident on all multi-labour unit farms, the author considers such division and specialisation to be of little importance. The author is of the opinion that the main reason for such division and specialisation was because of the large numbers of animals carried on some of the farms, technical difficulties were encountered with certain tasks (e.g. calf rearing, detecting in-season cows for artificial breeding etc.) In order for such tasks to be performed to a satisfactory level of proficiency, the labour units performing these tasks must be skilful and experienced. There were some tasks where advantages could be gained by allowing the labour units to specialise in tasks for which they had a natural aptitude. (e.g. machinery work, and repairs and maintenance work.) However, the author considers that cost economies resulting from this source are likely to be of little significance because such tasks are performed infrequently and do not contribute greatly to the productivity of the farm.

The data of the farm survey indicates that over the range of herd sizes studied, there appeared to be few technical diseconomies. There was a trend towards a lower milkfat production per cow on those farms of the larger herd sizes. Such data are extremely difficult to interpret because of the difficulties in disentangling the effects of such factors as stocking rate, age composition and genetic merit of the herd. In this context, it was of interest to observe that certain of the large herds were producing or had produced at satisfactory levels (i.e. 300 pounds of milkfat per cow or more) in the past.

In the absence of a detailed study, little can be said about the effect of herd size on animal health problems. The author considers that the manager of a large herd would have to pay more attention to calf rearing and herd condition.

The author does not consider that increases in herd size are accompanied by any significant deterioration in stock performance statistics. (i.e. percentages of stock losses, herd wastage, empty cows and heifers and calving percentages.) The author believes that the detection of in-season cows becomes increasingly difficult as herd size increases and can be regarded as a possible technical diseconomy.

The farm survey data does indicate that it is likely that advantages will accrue to the larger farms because of pecuniary economies. The author takes the view, however, that the obtaining of pecuniary economies is probably more a function of managerial ability than herd size per se.

There is little to suggest that cost economies could accrue to farms of larger herd sizes because of the employment of superior resources and techniques. There were no major differences between the systems of farming employed by the four groups of survey farms.

The author is of the opinion that the managerial problems of the multi-labour unit farms are greater than those of one man farms. Two reasons are advanced for this. First the employment of labour necessitates some effort by management to evolve and apply strategies which give rise to high labour productivity and second, technical difficulties are encountered when large numbers of animals are run in a single herd, (e.g. calf rearing, detecting in-season cows, herd condition, etc.)

The results of the analysis indicate that economies of size exist in New Zealand dairy farming. However, although within each subclass, relatively large reductions in the cost revenue ratio are obtained, as the degree of plant utilisation increases, relatively small reductions in the cost revenue ratio are obtained by changing plant size. For example, Figures 8.6 and 8.11 show that for each of the three subclasses associated with each of the five plant sizes, reductions in the cost revenue ratio in excess of 0.170 dollars are obtained by increasing the degree of plant utilisation. The difference between the cost revenue ratios of the most efficient plant size one farm and the most efficient farm is however:

> 0.1281 dollars, per dollar of gross income when the level of milk-fat per cow remains constant irrespective of plant and herd size.
>
> 0.0478 dollars, per dollar of gross income when the level of milkfat production per cow varies with plant and herd size.

(The differences in both cases are in the same direction. That is the cost revenue ratios of the plant size five farm are lower than those of the plant size one farm.)

Further, when a new series of cost revenue ratios are computed so that the output per labour unit data of the plant size two to five representative farms approximates that of the maximum figure recorded by a comparable survey farm, the difference between the most efficient plant size one farm and the most efficient farm is only 0.0192 dollars.

It seems likely therefore that one man farms can achieve a cost revenue ratio which is comparable to that of multi-labour unit farms, but in order for this to be achieved, it is probable that the hours of work of the labour units of the one man farms must be greater than those of the labour units of the multi-labour unit farms.

Both within and between plant sizes, proportionality relationships are largely responsible for the reductions in the cost revenue ratios. The compilation of the cost data and the results of the analysis confirm the observation made from the farm survey that pecuniary economies exist.

In certain circumstances, changes in farm size may be accompanied by the realisation of diseconomies of size despite the fact that the change is accompanied by an increase in net income. In the author's view, it is important that any farmer considering a change in farm size should pay attention to the various factors which give rise to economies of size and wherever possible, take advantage of these factors.

The author does not advocate a major restructuring of the New Zealand dairy industry towards solely large units. The results of the analysis indicate that losses are recorded on those farms of each subclass where the output per labour unit is low, and hence it would seem more desirable to encourage the formation of farms where the output per labour unit is high irrespective of plant size. Substantial increases in the labour productivity of those farms corresponding to the latter degrees of plant utilisation of plant sizes four and five could give such farms definite advantages particularly in the event of a substantial fall in the price of milkfat.

The recent evolution of rotary farm dairies and automatic cup removal devices are important developments. If the employment of rotary farm dairies and automatic cup removal devices can lead to a greater number of cows being handled per labour unit (and hence a greater output per labour unit), then it seems likely that for farms of each plant size, opportunities may exist for lower cost revenue ratios to be obtained and higher net incomes to be earned, and in addition, these innovations may be of considerable importance in combatting the effects of a continuation in the cost price squeeze. Further, if by the utilisation of rotary farm dairies and automatic cup removal devices, advantages accrue to a particular plant size, the shape of the long run average cost curves may be markedly altered.

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