THE COMPARATIVE PROFITABILITY OF MILK AND BEEF PRODUCTION ON SEASONAL SUPPLY DAIRY FARMS

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A Thesis presented in partial fulfilment of the requirements for the Degree of Master of Agricultural Science in Farm Management at Massey University.

August 1970

A C K N O W L E D G E M E N T S

The author wishes to thank Professor A.R. Frampton for his advice, encouragement and helpful criticism throughout this study. The author also benefited from discussions with many staff members at Massey University, particularly Dr. W.R. Schroder, Mr. J.N. Hodgson and Mr. A.W.F. Davey.

The author is indebted to the farmers interviewed in the survey, especially the three case farmers for their time and co-operation and for the interest they showed in this investigation.

Thanks are also due to Mrs. C. Miers, who typed this Thesis and to Mrs. J. Lattimore for her assistance and encouragement during this study.

The author was employed by the Department of Agriculture during the study. Their financial support is gratefully acknowledged, as is the financial assistance provided by the Manawatu Co-operative Dairy Company.

C O N T E N T S

CHAPTER 1

INTRODUCTION

New Zealand dairy farmers who have changed, partly or wholly to beef production from surplus calves may lead the world in intensive pastoral beef production. The main contributing factor to their likely success in this new field is that they are experienced with the calf rearing techniques and intensive rotational grazing systems which are vital to producing a high net profit per acre from beef cattle.

1.1 THE PRESENT POSITION OF THE DAIRY INDUSTRY

At the present time there is growing concern over the future prospects for increased export production from the New Zealand Dairy Industry. This industry is comprised of farmers producing milk on seasonal supply for the production of butter, cheese, milk powder, casein and many other minor products for export. Approximately 70 percent of these farmers supply whole milk and hence the bulk of their income is derived from milk sales with the remainder coming from the sale of cull cows and bobby calves for slaughter. The farmer's profit is therefore, dependent on the payment received for milk and it is this factor which is causing the present concern over the long term future of the industry.

Coupled with this price uncertainty for future dairy exports is the trend in dairy farm costs. Table 1.1 shows that dairy farm costs (especially dairy farm workers' wages) have increased at a faster rate than the milk price over the last twenty years. The divergence between these factors is particularly noticeable since 1965 and present indications are that this trend will continue in the future. This situation has put increasing pressure on dairy farmers, who have had to increase butterfat 1/ production in order to maintain their incomes.

This has been accomplished, at least partly, by the increased productivity of labour and dairy cows and by technological change. The increased productivity of labour has come about by substituting capital for labour, (for example, by hiring contractors and by building herringbone milking sheds which enable a larger number of cows to be milked per man-hour than older type sheds).

Other factors such as the increasing size of milking herds and the amalgamations of dairy units have tended to increase the net profit per dairy farm owner (Anon., 1968 A).

Notwithstanding the technical and managerial adjustments which farmers have adopted to meet this changing situation, some dairy farmers are seeking new enterprises which can be incorporated into the dairy farming system.

One such enterprise which has come into prominence recently is beef production 2/ from calves of the larger framed dairy breeds like the Friesian.

The interest in beef production has increased over the last two years because market forecasts indicate that the demand for beef on world markets should continue to increase over the next 10 - 15 years and the world supply is unlikely to increase at the same rate (Anon., 1967 A).

1/ The milk produced on seasonal supply dairy farms is sold to co-operative dairy companies on the basis of the butterfat content, though up to 30 percent of the total payout may be derived from the solids-not-fat fraction of the milk.

2/ The term beef production is used here in a broad sense to describe farm enterprises which produce cattle for sale to other farmers (calves, weaners, yearlings, etc.), as well as enterprises which produce cattle for slaughter.

TABLE 1.1

INDEX OF PRICES AND COSTS, 1950-1970

(1950 = 100)

YEAR	ALL DAIRY FARM COSTS 3/	DAIRY FARM WORKERS' WAGES 3/	TOTAL PAYOUT PER LB. BUTTERFAT 4/	AV. BOBBY CALF PRICE 5/	OPENING SCHEDULE 6/	
					G.A.Q. Ox	BONER BULL
1950	100	100	100	100	100	100
51	112	109	104	140	123	118
52	119	124	120	117	160	132
53	123	135	126	137	175	144
54	127	139	131	187	182	184
55	132	149	130	203	257	199
56	134	152	127	206	158	221
57	137	152	131	187	123	-
58	141	158	125	247	175	353
59	141	158	117	274	263	485
60	142	159	117	238	237	426
61	145	164	116	238	237	412
62	147	166	117	211	202	355
63	149	167	117	215	237	332
64	150	167	127	216	219	300
65	152	168	137	214	263	397
66	155	172	140	239	263	397
67	160	176	140	306	272	485
68	164	180	143	320	246	478
69	170	183	128	429	316	618
70	N.A.	N.A.	128 1/	461 2/	396	676

1/ The total milk payout in the 1969/70 season is expected to be 32cents per pound butterfat.

2/ Based on an expected average payout of $9.50 per calf.

3/ Taken from Anon. (1967 C)

4/ For a Manawatu Co-operative Dairy Company.

5/ From Anon. (1950)

6/ From Anon. (1951)

The present demand for beef on world markets is reflected in the beef schedule price paid to farmers which has risen dramatically over the last four years as is shown in Table 1.1. At the production level, two major advantages often advanced for beef production over dairying are the lower level of farm costs and the lower labour input required for beef production. These benefits are especially relevant in view of the divergence between product prices and input costs for milk production shown in Table 1.1.

Many dairyfarmers are able to move into beef production 1/ very quickly because a significant proportion of dairy herds are comprised of Jersey Friesian cross cows or other breeds 2/ whose calves are suitable for beef production. The increasing number of crossbred herds is indicated by the increased use of Friesian semen from the Artificial Breeding service, as shown in Table 1.2.

A further incentive to beef enterprises on dairy farms was given in 1969, when the New Zealand Government instituted the Dairy Industry Beef Scheme. The aim of the scheme is to divert increased grassland capacity on dairy farms away from dairy production into beef production, by granting an incentive payment and low interest working capital facilities for beef production on dairy farms 3/.

A small number of dairy farmers have adopted beef production as a major enterprise on their farms 4/ but a larger number are experimenting with beef production at the present time. A survey conducted by the

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1/ Beef from cattle of dairy origin is sometimes called 'dairy-beef' to distinguish it from 'beef' produced by cattle of the traditional breeds (Angus and Hereford). However, owing to definitional problems, this term (dairy-beef) is not used but will be discussed in Section 2.2.

2/ These include the other large-framed dairy breeds, Ayrshire and Milking Shorthorn as well as the Friesians.

3/ For a fuller explanation see Section 2.9.

4/ Eighteen such farms are outlined in Chapter 4.

TABLE 1.2

PROPORTION OF INSEMINATIONS FROM EACH BREED

IN ALL N.Z. HERD IMPROVEMENT ASSOCIATIONS

Year	BREED				
	Friesian	Jersey	Ayrshire	Shorthorn	Hereford
1960	14.3%	79.7%	3.8%	0.7%	1.5%
61	16.3	77.4	3.5	0.8	2.0
62	18.4	76.4	3.1	0.6	1.5
63	18.1	76.8	2.9	0.5	1.7
64	18.1	77.5	2.4	0.3	1.7
65	20.6	74.8	2.0	0.2	2.4
66	26.4	68.9	1.8	0.2	2.7
67	30.0	66.4	1.4	0.2	2.0

Note: 1. All figures are expressed as a percentage of the total inseminations.

2. The table is given for all spring matings but excludes all deep frozen semen except that from Milking Shorthorns which is all deep frozen.

Source: N.Z. Dairy Board : Farm Production Reports 1960/61 to 1967/68.

New Zealand Dairy Board, in the 1967/68 season, showed that 48 percent of the dairy farmers in the survey were rearing, on average, nine beef calves (Anon., 1960).

1.2 OBJECTIVE AND OUTLINE OF THE STUDY

The preceeding discussion has outlined the reasons why some dairy farmers have adopted (or are considering adopting) beef production, either partly or wholly, on dairy farms.

It is therefore important to examine in detail the profitability and feasibility of beef production from dairy bred calves on dairy farms in its various forms, before a large number of dairy farmers adopt beef production as a major enterprise on their farms.

The objective of the study is to examine in detail the economics of beef production from retained (or purchased) calves on the dairy farm where these calves are available at present. That is, dairy farms with milking cows which produce surplus calves 1/ suitable for rearing as beef animals. In other words, farms with milking cows of the dual-purpose breeds. In New Zealand these milking herds are usually comprised of Friesian or Friesian cross cows but some other breeds and crosses are also suitable and are used by farmers for producing beef calves.

The study is not concerned with the economics of changing the breed of milking cows on a dairy farm from one which is adapted mainly to milk production to a dual-purpose breed. However, some of the factors which may influence this decision are given in the following two chapters.

The detailed evaluation in the study was a case farm approach in which the feasibility and profitability of beef production was examined on one mixed beef-dairy farm and two dairy farms all with Friesian cross

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1/ That is, surplus to replacement requirements.

milking herds. Before the evaluation was done on these farms, a survey of selected mixed beef-dairy farms was carried out to obtain the ideas and experiences from a larger number of farmers on the various facets of beef production from calves of dairy origin on dairy farms. The main limitation of this case farm approach is that care is required when the results from the case farms discussed are applied to some other dairy farm.1/ However, the results can be used so long as they are adjusted to the resource structure of the farm being considered.

1.3 ORGANISATION OF THE STUDY

In Chapter 2 there is a review of technical considerations relevant to the study and an outline of the Dairy Industry Beef Scheme introduced in 1969.

Chapter 3 presents a simple theoretical framework for viewing the farm management problem being studied and discusses the methodology employed.

The results and views obtained in the farm survey are given in Chapter 4, while Chapter 5 presents the detailed evaluation of the three case farms. Finally, Chapter 6 summarises the usefulness of the methodology used as well as summarising the results and conclusions from the case farms.

1/ This is discussed in more detail in section 3.2.1.

CHAPTER 2

TECHNICAL CONSIDERATIONS RELATING TO BEEF PRODUCTION ON DAIRY FARMS

2.1 INTRODUCTION

This chapter outlines some of the important technical aspects of increased beef production on dairy farms.

2.2 THE TERMINOLOGY USED IN THE STUDY

It is necessary at this point to carefully define the terms "beef cattle" and "beef" as used in this study.

Beef cattle of dairy origin are often called "dairy-beef" cattle to distinguish them from cattle of the traditional beef breeds. The distinction is made according to the different rearing systems used to each case. "Dairy-beef" calves are usually either reared artificially or multiple-suckled on nurse cows, though some calves are single suckled on dairy cows. However "beef" calves are usually single suckled on beef cows for 6 - 8 months, though double suckling is becoming more popular by suckling a "dairy-beef" calf on the cow as well as her own calf. For the above classification, the term "dairy-beef" is useful. However, after beef calves from either source have been weaned the situation becomes more confused. The growth rate, age at slaughter and carcase grades obtained by either type of beef animal is dependent on the management system used and the environment in which it is grazed. Thus on commercial farms, prime beef (G.A.Q.) carcases or boner beef (Y.A.Q.) carcases can be obtained from "beef" or "dairy-beef" cattle depending on the type of farm on which they are grazed and the management system used.

However, because many dairy beef cattle are grazed at high stocking rates and hence a high proportion are graded Y.A.Q. (when slaughtered at 18 months of age) some people assume that "dairy-beef" production is synonymous with boner beef production. Since boner beef is sold as manufacturing beef the term "dairy-beef" is sometimes used to imply an inferior product. Thus, the source of the calves may be thought to determine the outcome when, in fact, it is probable that the management system employed was aimed at boner beef production.

Candy (1967) expressed concern as follows:-

> "I regret to say that the term "dairy-beef" in many people's minds connotes an article of inferior value, which is not at all true for beef properly raised from the heavier breeds of dairy stock."

and as Edwards (1965) said,

> "Beef from dairy herds is beef. From some breeds and crosses, its characteristics are completely in accord with modern consumer demand."

To summarise, it is convenient to have a simple term (dairy-beef) to distinguish calves which are reared by different methods but there is much less need to make a distinction after the calves have been weaned.

In this study, because all the beef cattle referred to are of dairy origin, unless otherwise specified, no confusion can arise. Therefore, it has been decided to use the term "beef cattle" to describe animals of dairy origin which are reared artificially or multiple suckled on nurse cows and which produce "beef" regardless of how this meat is graded.

2.3 THE BREEDS OF POTENTIAL BEEF CALVES BORN ON DAIRY FARMS

Everitt (1967) estimated that Jersey cattle comprised "over 80 percent" of the National Dairy herd. The remaining 20 percent is made up mainly of Friesians and Friesian cross with some Milking Shorthorn and Ayrshire cattle.

However, with the marked increase in the use of Friesian semen from the Herd Improvement Associations, the above figures do not give a true picture of the breeds of calves born.

Barton (1966) estimated the breed of dairy calves surplus to replacement requirements as follows:-

TABLE 2.1

BREEDS OF SURPLUS DAIRY CALVES

Breed or Cross	Percentage of Surplus Calves
Jersey	72.6
Jersey Cross Friesian	7.4
Friesian - spring born	8.1
autumn born	4.0
Others (Milking Shorthorn, Ayrshire, Angus cross and Hereford cross).	7.9
	100.0 percent

In view of the increased use of Friesian semen since 1966 - see Table 1.2 - when these estimates were made, the proportion of Friesian and Friesian cross calves will now be higher than is shown in Table 2.1.

2.3.1 Suitability of the Jersey Cattle for Beef Production

From Table 2.1 it can be seen that it would be convenient if surplus Jersey calves could be reared for beef production because 72.6 percent of the surplus calves are of this breed.

There is an objection to the use of Jersey cattle for beef production owing to their supposed tendency to produce yellow fat. However, Morgan and Everitt (1968) have found that the importance of yellow fat in Jersey steers may not be as great as was formerly thought.

In any case, yellow fat is not a problem so long as the beef is sold in trimmed boneless form. Therefore, Jersey beef is suitable for sale as manufacturing beef.

The other main criticism of Jersey beef cattle is their relatively slow growth rate. However, growth rate per animal is not the sole factor influencing net profit per acre. The other main factors are the number of beasts carried per acre and their associated costs (calf cost, animal health, supplementary feed, freight, etc.). Research work overseas has inferred that the efficiency of conversion of feed into beef by Jersey cattle may be lower than for other breeds like the Friesian (Bond et al, 1965). Nevertheless, it is very difficult to estimate what this lower efficiency of conversion of the Jersey breed means in terms of a lower beef output per acre on New Zealand farms, compared with other breeds. Such a difference, if it exists, would have to be weighed against the lower Jersey calf cost as compared with other breeds and possibly the increased number of beasts carried per acre. That is, the future of Jersey beef production will not be finally known until trials have been conducted to find the comparative profitability of the Jersey with other breeds.

2.3.2 The Case for the Jersey Cross Friesian Cow

Since 80 percent of dairy cows are Jerseys and the suitability of the Jersey for beef production has not been fully demonstrated, the dairy farmer must decide which breed of bull to use if he wishes to diversify into beef production.

Stitchbury (1966) has pointed out that the Friesian sire is the most suitable because:

(a) The Friesian cross Jersey calf is a good beef producing animal.

(b) The Friesian cross Jersey heifer is quite suitable for rearing as a replacement. Indeed considerable interest is being shown in the Jersey cross Friesian hybrid as a desirable cow for commercial milk production (Edwards, 1965).

(c) The Jersey cross Friesian herd allows emphasis to be changed from beef to milk or vice versa, depending on the state of the respective markets.

The future of the crossbred milking cow will therefore be influenced by the beef to milk price ratio and the relative carrying capacities of Friesian and Jersey cows per unit land area. (Everitt, 1967).

However, there are a number of management considerations which may influence this discussion. The merit rating of bulls in the Artificial Breeding service, stock thrift, winter soil conditions and personal preference may all affect the choice of breed.

2.3.3 Genetic Considerations

If a dairy herd is adapted for producing beef calves as well as for milk production, the question arises as to the effect on milk output of breeding towards 'beef-type' animals. Langlet (1965) has defined a beef-type animal or a cattle beast with a high beef output per unit of time as 'an animal with a tendency to reach a large mature stature with enough width and good muscle development.'

There are two alternative breeding programmes which can be used either singly or together. These programmes are crossing Jersey cows with a Friesian bull or selection within a breed, like the Friesian, for 'beef-type' animals.

(a) Crossbreeding (Jersey Cross Friesian)

It is generally accepted that whilst the Friesian cow is more efficient as a producer of pounds of milk solids-not-fat per acre than the Jersey; the Jersey is more efficient as a producer of pounds of butterfat per acre, (Campbell, 1966).

Although the present milk payout system of Co-operative Dairy Companies is based on the butterfat content of milk, it is not at all clear which breed of cow is the most profitable to the individual supplier. Basically, there are two issues involved.

1. Which dairy breed contributes most to the profit of the Co-operative Dairy Company. This will depend on the particular products produced (for example butter, butter and skim milk powder, butter and casein, cheese, etc) by the company and their respective prices.

and 2. Given the present milk payout system, which breed will return the greatest profit to an individual dairy company supplier.

Obviously, this is a very complex question to which there is no simple answer. The problem is further confused by the differential amount of meat produced by each breed.

Campbell points out that Friesian cull cows and calves have a higher monetary value than their Jersey counterparts, owing to the superior beef producing ability of Friesian calves and the heavier cows. Nevertheless, it has not yet been determined what price margins, for Friesian cull cows and calves, are necessary to offset the more efficient butterfat production per acre of the Jersey, given the present milk payout system.

(b) Selection for 'Beef-type' Within The Friesian Breed

It is hypothesised that the beef producing potential of the Friesian breed has not yet been realised because little, if any, selection has been done within the Friesian breed for beef performance characteristics as described by Langlet (1965). These include selection for weight gain, muscle development and the efficiency of conversion of feed into meat. The performance of Friesian cattle inbeef production is likely to improve if selection for these factors is introduced and intensified.

In the future, we would not expect the increase in the efficiency of butterfat production to be as great as that to be obtained by selection for increased beef performance, since selection for butterfat production has been carried out for a large number of years, for example, herd production testing has been in operation by the N.Z. Dairy Board and Herd Improvement Associations since 1920.

This study is therefore conducted at a time when the efficiency of butterfat production per acre is at a high level and beef production is only in a developmental phase with regard to genetic improvement.

In view of the preceding discussion one would therefore expect that the efficiency of beef production per acre may increase relative to butterfat production per acre over the next ten years.

Furthermore, it has been shown, although not conclusively, that selection for beef producing qualities within a dual-purpose breed, like the Friesian, does not lead to decreased milk production. That is, a small positive genetic correlation has been found between milk and beef production (Langlet, 1965). However, a negative genetic correlation exists between milk production and butterfat percentage (Robertson, Waite and White, 1956). Both these studies are overseas work but if they are found to be significant under New Zealand conditions, selection within say, the Friesian breed, for beef producing qualities will lead to increased efficiency 1/ in milk production but perhaps decreased efficiency in butterfat production. To summarise then, the present milk payout system may cause divergent aims in combining milk and beef production from the same breed, since breeding towards the Friesian by crossbreeding or selection within a

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1/ That is, technical efficiency in terms of gallons of milk.

breed (for better beef producing characteristics) will almost certainly result in larger dairy cows. Although these cows may be more efficient milk producers, they may be less efficient butterfat producers per acre or per farm.

The factors which will most influence a farmer in his breeding programme are likely to be:

i. The basis of payment for milk, and

ii. the ratio of milk and beef prices including the value of the calves which are sold for beef rearing and slaughter, as well as the value of cull cows.

2.3.4 Suitability of Friesian and Friesian Cross Cattle for Beef Production.

The suitability of Friesian cattle for beef production has been well demonstrated in New Zealand. Many workers have shown that very high levels of beef output per acre can be achieved using Friesian steers. Joyce (1969) has shown that 700 pounds of carcase beef per acre can be obtained from intensively grazed Friesian steers. Barton (1968), Everitt, Evans, Franks (1969) and Hollard (1968) have all shown that the Friesian is at least equal to the traditional breeds as an efficient producer of beef.

Furthermore, the Friesian-Jersey cross steer has also performed satisfactorily in research and commercial trials (Everitt, Evans, Franks 1969; Barton, Jones, Donaldson, Barnes, Evans and Clifford 1968; Joblin, 1966).

2.4 GRADING STANDARDS

New Zealand has a meat grading system which grades beef carcases subjectively on the basis of conformation and fat cover within various weight ranges.

Carcases with the 'correct' conformation (Barton, 1965b) and with a good covering of fat are placed in the higher priced G.A.Q. 1/ and F.A.Q. 2/ grades, whereas, lean, dairy-type carcases are placed in the lower priced Y.A.Q. 3/ grade. Barton (1965b), points out that the shape of a carcase has very little effect on the weight of saleable meat present and clearly, external fat, which is trimmed off during the boning out process, does not increase the value of the beast.

Friesian steers, slaughtered at 18 months of age and at light weights are often penalised by the present grading system because they have not sufficient fat cover and have not the required conformation to be put into the higher priced grades (Everitt, 1970). This is an anomalous situation since it has been shown that the yield of saleable meat, including the high priced cuts, from 18 months old Friesian steers is at least equal to that obtained from beef 4/ steers of comparable age and carcase weight (Everitt, Evans and Franks, 1969).

Beef grading in Otago and Southland is operated on a yield grading system which grades beef carcases on the yield of saleable meat and if this system is adopted nationally then beef from dairy bred animals may be more able to enter the higher priced beef grades than they are under the present grading system (Everitt, 1970). The schedule price difference between G.A.Q./F.A.Q. and Y.A.Q. beef grades varied from $1 to $2 per 100 pounds in 1970 and hence the disincentive to the production of beef from light dairy bred steers due to grading was small, compared with the advantages of mating dairy cows with a large framed dairy bull (like the Friesian) for beef production 5/.

1/ Good average quality

2/ Fair average quality

3/ Young average qulity

4/ Angus or Hereford

5/ See Section 2.3.2

2.5 CALF REARING FOR BEEF PRODUCTION

The present interest in beef production in New Zealand has focussed attention on methods of calf rearing because a large number of potential beef cattle are available from dairy herds as four day old calves. However, the rearing of the calves requires an efficient system if it is to be done economically. Therefore, attention has been paid to calf rearing systems which:

a) require less labour (since calf rearing occurs in the Spring which is the busiest time on a dairy farm),

b) result in heavier calves weaned,

c) are cheaper than conventional rearing methods, and

d) produce healthier calves.

2.5.1 Nurse Cow Rearing

Recent work in New Zealand has shown that suckling three or four calves on a milking cow for 8 to 10 weeks to be an efficient calf rearing system, because:

a) After the initial "mothering-on" stage, the labour required for calf rearing is less than is required for artificial rearing.

b) Calves reared on a cow grow faster until weaning and have less animal health problems than artificially reared calves.

c) The calves stimulate the cow's milk production so that the cow produces at a higher level post-weaning than if it had been machine-milked from calving. That is, the loss in milk to the calves is partly made up by a suckled cow in the post-weaning milking phase of her lactation. One qualification which was made to this trial was that the milking stimulation response, of the cows after weaning, was greater in poor producing cows and in heifers than in cows which produce well under normal circumstances (Everitt, Phillips and Whiteman, 1968).

Farmer views have supported the findings of Everitt et al (Candy, 1967; Anon., 1967D). However, more recently Everitt (1969) has found that the stimulation effect mentioned in (c) may not be as good as was shown initially and thus, the net loss of butterfat from a cow which is suckled by three or four calves for 8-10 weeks may be greater than was shown in the trial.

Hence, the major benefits for nurse-cow rearing over artificial rearing are the savings in labour and the healthier calves produced.

2.5.2 Artificial Rearing

Conventional calf rearing methods using calfeterias, troughs or buckets have been improved in recent years to enable large groups of calves to be reared on milk or reconstituted milk powder (Barnes, 1966; Easton, 1966). Also, some novel rearing techniques have been developed. One has been described in which the calves are fed partly on reconstituted milk powder and suckled onto nurse cows once a day at the evening milking (Anon., 1968B).

The main aim of these new techniques has been to decrease the labour input in calf rearing. However, Davey (1966) points out that considerable care is required when rearing large groups of calves to ensure that disease does not become a serious problem.

2.6 INTENSIVE BEEF PRODUCTION

As mentioned in Chapter 1, the research work that has been carried out in New Zealand over the past ten years, and is being continued, on intensive beef systems, has encouraged dairy farmers to consider beef production because it is reputed to require less labour than dairying and the outlook for beef exports in the long term appears to be good according to some market forecasts (Anon., 1967A).

Up until 1966, our knowledge of the level of beef output per acre that could be obtained from intensive grazing systems was very limited. Even more work is required in this field especially in the area of energy requirements for growth and maintenance of beef animals under New Zealand conditions.

The research work being carried out in New Zealand on intensive beef production has highlighted the fact that the most profitable export beef 1/ policy on well-developed farms is one in which the beasts are slaughtered before their second winter, at 18 - 20 months of age (Joblin, 1966B).

The number of winters over which a cattle beast is carried on a dairy farm is an important criterion for profit because the cost of wintering an animal in terms of scarce autumn saved pasture and expensive conserved feed is the major cost involved in growing cattle. Also, the efficiency of conversion of pasture into meat declines rapidly after about 20 months of age due to the higher maintenance requirement of a heavier beast and the "laying-on" of fat which requires three times the quantity of feed per pound of gain as that required to put on a pound of muscle (Joblin, 1966B).

Joblin points out that there are two major opposing economic conditions operating, which determine the slaughter time at which maximum profit is obtained.

a) The decline in feed conversion efficiency which tends to reduce the age of slaughter at which maximum profit is obtained,

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1/ Beef sold at the export meat schedule price as distinct from beef sold to the local butchers market which generally pays a premium price for beef cattle slaughtered out of season (Winter and Spring).

and b) The opportunity cost [1] of the calf reared for beef production which tends to increase the age of slaughter for maximum profit.

Besides these two factors there are other considerations such as feed supplies, product prices and input costs.

With respect to (a) and (b) above, trials at Ruakura Agricultural Research Centre have indicated that the optimum slaughter weight [2] is probably between 700 and 900 pounds live-weight for Angus cattle (Joblin, 1966B).

However, the optimum slaughter weight for Friesian cattle is likely to be higher than this figure since they are slower maturing and the efficiency of conversion of grass into meat does not decline rapidly until the Friesian is older than the faster-maturing Angus.

2.7 FEED REQUIREMENTS OF CATTLE

A most important consideration in evaluating the place of beef cattle on dairy farms, is the substitution of milking cows for beef cattle or vice versa. Scientific work has been mainly concerned with estimating the feed required by dairy cows and beef cattle in separate trials and no detailed published work is available on the inter-relationship of milking cows and beef cattle for feed.

The feed requirements of milking cows have been well documented for New Zealand conditions (Coop, 1965; Hutton, 1962; Hutton, 1963; Wallace, 1961) and abundant literature is available overseas concerned with the feed requirements of beef cattle (Morrison, 1959; Anon., 1965; Anon., 1958). However, in New Zealand, the only data

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1/ The opportunity cost is the opportunity foregone of the sale of the bobby calf plus the grass made unavailable by the calf to other stock or to supplementary feed production.

2/ For maximum profit.

available in this field are from trials at very preliminary stages (Joyce, 1969). Hence, it has been necessary to adjust overseas feed requirements for beef cattle to approximate New Zealand grazing conditions (Appendix I).

At present only one trial is being carried out to try to determine the relationship between dairy and beef production on the same area (Campbell and Clayton, 1969). This trial was only begun in 1968 and hence no published information is yet available.

2.8 THE ECONOMICS OF BEEF PRODUCTION ON DAIRY FARMS

The economic aspects of substituting beef cattle for milking cows on New Zealand dairy farms has not been investigated in detail.

However, many articles have been published, in popular journals, concerned with the comparative profitability of dairy cows and beef cattle usually in the form of a gross margin or partial budget analysis (for example, Baker, 1968: Bowman, 1966: Armstrong, 1969).

Australian work on the place of beef cattle on dairy farms (Hardman, 1966: Lindner, 1969) is not easily adjusted to New Zealand farming conditions owing to the marked difference between carrying capacity per acre, farm size and price relationships.

2.9 THE DAIRY INDUSTRY BEEF SCHEME

The New Zealand Government in its 1969 Budget proposed "The Dairy Industry Beef Scheme" which aims to divert increased grassland capacity on dairy farms from milk to beef production. A payment will be made to dairy farmers of $10 per cattle beast run on the farm over the period 31 December, 1969 until 30 September, 1970. The beef cattle must be calves born to dairy cows between 1 June and 31 December, 1969 and no restriction as to sex is imposed. Furthermore, special advances of working capital ($30 per animal) are available at 3 percent interest in view of the deferred income from beef production relative to dairying. The scheme was extended to cover the 1970-71 season in 1969 (Anon., 1969A).

Although the scheme was intended as a dairy disincentive, from the dairy farmer's point of view it is an incentive to graze beef cattle. That is, it is a payment for carrying beef animals on the dairy farm subject to certain restrictions.

The beef incentive payment 1/ is available to dairy farmers, who produced not less than 6,000 pounds of butterfat in the 1968/69 season, for beef cattle grazed on the dairy farm or its associated runoff. The runoff must have been utilized as an integral part of dairying operations in the 1968/69 season.

At the time of writing, the scheme had not been extended beyond the 1970/71 season. That is, the incentive payment will also apply to cattle run on a dairy farm from 31 December, 1970 until at least 30 September, 1971.

The term 'Beef Incentive Payment' will be used in this study to describe the $10 payment from the Dairy Industry Beef Scheme. However, the payment is made on a per head basis and the above term is not meant to imply a payment for beef production but rather for holding beef cattle on a dairy farm subject to the restrictions stated previously. That is, it is available only to dairy farmers and not to beef producers generally.

1/ The term incentive payment could have been replaced with the term subsidy. However, a subsidy usually implies a grant by the State of longer duration and which is more generally available than the above scheme. Hence the term incentive payment was preferred.

2.10 SUMMARY

The research work that has been carried out in New Zealand and Overseas has shown that Friesian and Friesian cross milking cows are dual-purpose animals whose progeny are suitable for beef production. There are a number of calf rearing techniques available which should result in the production of healthy, well-grown beef calves from dairy cows.

It is likely that on intensive dairy farms, the optimum time of slaughter for these cattle will be before their second winter, if the beef produced is sold at the export schedule price.

The farmer's decision of whether to change the breed of his herd so that he can produce calves more suitable for beef production is a very complex question which will be influenced by the products produced by the dairy company supplied, the breed structure of the other suppliers' herds, the relative prices of beef and dairy products as well as many farm management considerations. Nevertheless, many dairy farmers have made a decision in favour of large framed dairy cows which provides them the flexibility of being able to change from milk to beef production or vice versa depending on current prices and the future outlook.

CHAPTER 3

ECONOMIC ASPECTS OF BEEF PRODUCTION ON DAIRY FARMS

3.1 INTRODUCTION

In the first part of this chapter, it is proposed to examine in economic terms, the implications to the individual farmer of beef production on a dairy farm and to establish a priori some of the factors that may influence a dairy farmer deciding whether to increase beef production. The second part of this chapter will establish the data requirements and the data collection techniques for the study and briefly examine the advantages and disadvantages of adopting linear programming as the analytical technique for evaluating the profitability of beef production on three case farms.

3.2 THE PRODUCTION POSSIBILITIES FOR MILK AND BEEF PRODUCTION.

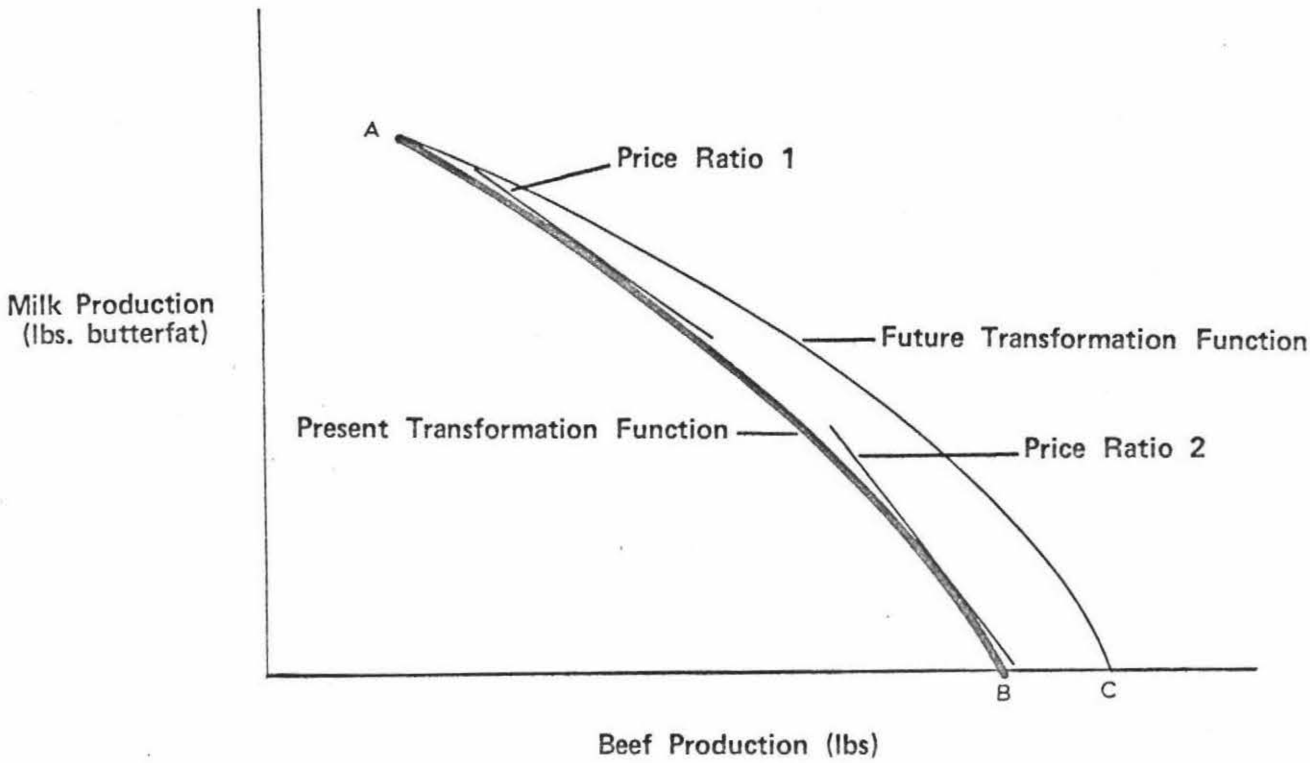
The production possibilities for beef production (from steers, heifers or bulls) and milk production have been diagramatically represented in Figure 3.1.

The transformation function AB represents, schematically, the combinations of milk and beef that could be produced on a dairy farm.

On the present transformation function, AB, the point A represents a dairy farm devoted entirely to milking cows plus their replacement heifers. In this situation a small quantity of beef is produced from the slaughter of cull cows and bobby calves. That is, point A does not lie on the vertical axis.

As the production system moves a small distance away from A towards B, the breed of the milking herd changes to a dual-purpose breed which produces a higher beef output but lower milk output, in

Figure 3.1 PRODUCTION OPPORTUNITIES ON A DAIRY FARM



terms of pounds of butterfat, from the farm. The higher beef output comes from the heavier cull cows and bobby calves sold.

The next change occurs further towards B, when surplus calves are retained on the dairy farm and reared for beef production. Finally, at point B, the farm produces all beef and no milk. This is achieved by buying in store beef cattle (calves, weaners, etc.), for rearing and sale to other farmers, or for slaughter.

The purpose of this study can now be seen graphically. It is to examine situations which can be schematically represented by the present transformation function from the point where a dual-purpose breed is present on the farm (devoted predominantly to milk production) to point B, where the farm is engaged in all beef production. Once this range of possibilities has been specified, then it is possible to discover the production points for maximum profit corresponding to different prices for milk and beef. This will be shown in Section 3.2.2.

3.2.1 Factors Affecting the Shape of the Transformation Function

The marginal rate of transformation [1/] of milk for beef production on a particular dairy farm will depend on the resource structure of that farm. This is because the resource structure of that farm will influence the shape of the transformation function and, as will be shown in the next section, the shape of this function will determine the combination of beef and milk production at which maximum profit is obtained.

The resources available to a farmer may vary as follows:-

(a) The capital involved in stock on a mixed beef-dairy farm is expected, a priori, to be similar to that same farm milking all dairy cows, but working capital requirements are expected to be greater with a beef enterprise because the income from beef cattle is obtained in large lump sums on the sale of the beef cattle over a short period of time. However, income from milk production is obtained monthly throughout the lactation period.

(b) A large number of factors relating to the land resource [2/] may have a significant effect on the rate of transformation of beef for milk production on a dairy farm.

(c) Labour can also be expected to influence the transformation rate since beef production requires less labour than milk production.

1/ As represented by the slope of the curve AB in Figure 3.1.

2/ For example: farm size, contour, access, distance from the milking shed, weather uncertainty, etc..

(d) It is expected that the organizational skills required on a mixed beef-dairy farm will be greater than on a specialized unit predominantly concerned with beef or dairy production. Indeed, organizational skills, which are part of the management resource, may be a limiting factor on mixed beef-dairy farms since the organisation required for grazing management, buying and selling cattle etc. may itself impose a restriction for some farmers on the combinations of beef cattle and milking cows that they would be willing to consider. Another facet of the management resource which is important here, is the period of learning which the farmer usually goes through when changing enterprises from, say, dairy to beef production. This means that the farmer usually has to accept a lower financial performance for the first season or two until he becomes familiar with the new enterprise.

Technological change will also influence the shape of the transformation function over time. The current research being carried out at research stations and by farmers into intensive beef production is expected to bring about new technical and management innovations which may increase the rate of transformation of beef for milk production [1/]. That is, it can be expected *a priori* that the transformation function AB in Figure 3.1 will change to, say, AC over the next few years. This change would increase the milk to beef price ratio at which beef could be profitably substituted for milk, or if the price ratio remains the same, then the new transformation function increases the quantity of beef that could be profitably substituted for milk.

1/ See section 2.3.3

3.2.2. The Beef-Dairy Combination which Maximises Profit

In Figure 3.1, the combination of beef and dairy production which maximises profit for this farmer, with his particular resource structure, occurs at the point of tengency of the inverse price ratio line 1/ to the transformation function.2/ However, the farmer does not know with certainty what the future prices will be and it is necessary to consider price uncertainty in the analysis.

3.2.3. Price Uncertainty for Beef and Dairy Products

The price uncertainty for beef and dairy products is a very important factor in deciding whether to make the change to beef production of a more than short term nature.

The prospect of the United Kingdom joining the European Economic Community (E.E.C.) without special trade concessions for New Zealand and the butter surplus' being stored by the E.E.C., are causing anxiety as to the future of New Zealand's dairy exports at present prices. Onion (1969) points out that while the outlook for increased dairy exports over the next two years is not good, the longer term outlook is better, because he considers that a more rational approach to international dairy produce marketing will be adopted. However, predictions are very difficult to make and at the present time all that can be said is that for the next 10-15 years, the outlook for increased exports of dairy products is uncertain.

Onion (1969) also points out that the future for beef exports (of the type produced by beef cattle of dairy origin 3/) "looks promising" over the next 10 years.

1/ For example, in Figure 3.1, price ratio 1 favours milk production and price ratio 2 favours beef production.

2/ A mathematical proof of this statement can be found in Heady (1965).

3/ Usually 20 months old steers or bulls which are graded Young Average Quality (Y.A.Q.) or Boner Bull and exported as boneless beef and fabricated cuts (Everitt, 1967).

Nevertheless, the current high schedule price 1/ being paid to farmers for steers and bulls grading Y.A.Q. and boner bull is dependent on the quota of beef exports permitted into one high priced market viz. the United States of America (U.S.). In 1968, approximately 80 percent of New Zealand's exports of boneless beef 2/ and veal was sold to the United States and a similar proportion is expected to be exported there in 1969 (Anon., 1969B). In February 1970 the U.S. price for boneless manufacturing beef was 44-45 cents (N.Z.) per pound F.O.B. 3/. If this market had not been available, the next highest priced markets were Canada and United Kingdom where the price of manufacturing beef was 37 and 28 cents per pound respectively (Fraser, 1970).

The U.S. quota of beef imports can be reduced by Government intervention at any time and such a move would cause a substantial decrease in the schedule price 4/ for these classes of beef.

The Food and Agriculture Organisation of the United Nations (Anon., 1967A) has projected a future demand for beef greater than the expected supply in 1975 and 1985. Tier (1969) deduces from this projection that a rise in the world beef price may occur which would reduce this "surplus demand", but he also points out that owing to trading barriers 5/, bilateral agreements and fluctuations of domestic beef production in beef importing countries, there may continue to be a wide difference in the price paid between countries.

1/ At the time of writing: Y.A.Q. ox over 401 pounds carcase weight was $23.50 per 100 pounds and boner bull, 376-550 pounds was $25.50.

2/ Largely manufacturing beef.

3/ Free-on-board.

4/ The price the farmer receives from a meat export company.

5/ Tariffs and quotas.

It is very difficult to predict the future price of beef because it will depend on access to the high priced markets and the degree of protectionism, in the form of tariffs and other factors, adopted by beef importing countries.

The implication that can be derived from these factors is that, while the present high schedule price should continue provided the U.S. market remains open, and provided the quota increases, there is a possibility that the schedule price would fall if access to this market was cut off or reduced.

If the present high beef schedule price is to be maintained, New Zealand must have access to a beef quota in the U.S. which is increasing at a similar rate as New Zealand's export beef production, otherwise a proportion of the increased production must be sold on lower priced markets which will tend to reduce the beef schedule price paid to farmers.

Cameron (1969), has summarised the export beef price situation as follows:

"There are two basic (beef) price levels in the world today:

i. U.S.A. level

ii. Other markets."

and further,

> "One of the effects of the U.S.A. quota should our production exceed greatly the percentage increase in quota allowance, will be that the price of manufacturing meat will fall well below the price of high quality prime meats.
>
> On the other hand, should the quota limit be lifted beyond our ability to supply, then we will see a continuing closing in the price gap between prime meats and other meats including manufacturing beef."

This question of the future prices for milk and beef is a most difficult one for the reasons just outlined. From the farmer's viewpoint, he receives a guaranteed price for the butterfat portion of milk sold. The guaranteed price in 1969 constituted approximately 80 percent of the total milk payout to the farmer. Furthermore, provisions in the Act 1/ ensure that large fluctuations in this guaranteed price do not occur between seasons.

On the other hand, the guaranteed beef price in 1969 was only 35-39 percent of the beef schedule price. This guaranteed beef price is actually a minimum export price. If the export price falls below the minimum price, a deficiency payment is made by the Meat Producer's Board to meat exporters up to the level set by the Meat Export Prices Committee. This enables the meat exporter to pay farmers a schedule price equivalent to the minimum export price (Anon., 1955).

In 1969, the minimum export beef price for Y.A.Q. ox and boner bull was 18 cents per pound F.O.B. for boneless meat. If a carcase is assumed to yield 65 percent saleable meat and the average net cost 2/ of meat processing is 5.825 cents per pound of meat on a boneless basis (Fraser, 1970), then this minimum export price is equivalent to a schedule price of approximately $8 per 100 pounds carcase weight.

Thus the minimum export price for beef (which is, in effect, the guaranteed price) in the Y.A.Q. and boner bull grades is only 35-39 percent of the 1969 schedule price 3/. This means that the stabilising effect of the minimum export beef price is far less than the guaranteed butterfat price at the present time.

1/ Dairy Board Act, 1961.

2/ That is, the total cost of killing, processing, freight and insurance less the value of the hide.

3/ The opening beef schedule price for Y.A.Q. ox was $20.50 per 100 pounds and for boner bull $23.00.

The effectiveness of the guaranteed price system may be as important to farmers when they are deciding between beef and milk production as the future outlook for the products overseas.

Price uncertainty was not incorporated in the detailed analysis given for the three case farms. However, the stability of a particular production alternative for each farm was examined for price variation to illustrate to the case farmers the effect of a change in these price parameters. The case farmer's view of the feasibility of a policy on his farm, which was influenced by the future price uncertainty for milk and beef, was then obtained.

3.2.4. The Effect of the Level of Costs on Beef Production

The attitudes of mixed beef-dairy farmers to beef production was obtained in the farm survey which is described in Chapter 4. Some farmers 1/ considered that while beef production may not be more "profitable" than dairy production, they were prepared to accept a lower income for the benefit of not having to milk cows. However, the high level of overhead costs 2/ and costs common to both enterprises 3/ on some dairy farms, may impose a limit on the extent to which a particular farmer is able to reduce the size of his milking herd and increase the level of beef production.

The costs of a dairy farm may also affect the change to beef production in another way. It is conceivable that beef production may be more profitable, in terms of net revenue, than dairying on some farms at low milk prices (say, 27 cents per pound butterfat). But at that milk price neither enterprise would provide a net revenue high enough

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1/ One farmer interviewed, having milked cows for twenty years, was pleased to have found an enterprise (intensive beef production) with "about the same net profit" but which did not involve milking cows twice a day for most of the year.

2/ These include interest, principle repayments, rates and insurance.

3/ Which includes fertilizer, repair and maintenance, vehicle expenses and personal drawings.

to meet the overhead costs and the costs common to both milk and beef production. For such a farmer,[1] the fact that beef production is more profitable than dairying, at 27 cents per pound butterfat, is irrelevant and some other high income or low cost enterprise would have to be adopted if the farmer was to continue in operation.

3.2.5. The "Real World" Problem

The preceding discussion, which defined the problem of finding the most profitable combination of beef cattle and dairy cows, has been explained in a simple, theoretical framework. The real world problem is more complex owing to the difficulty of defining the transformation function and the uncertainty regarding the price data to employ. No long term price predictions have been given in this study but a wide range of product prices have been used in the evaluation to illustrate the effect of relative price changes.

In the course of the study a number of subjective and non-economic criteria will be mentioned because:

"Production economics, more than any other phase of applied agricultural economics, must draw upon the subject matter of the other social sciences. The process of decision-making under uncertainty involves psychology as much as it involves economics" (Heady, 1965).

3.3 REQUIREMENTS OF THE STUDY

The first requirement of the study was to find out as much as possible about the input/output relationships in intensive beef production on dairy farms. This information was obtained from two sources, from current research work and from dairy farmers engaged in beef production.

1/ For example, case farm 1 in Chapter 5.

3.3.1 Research Data

The work of researchers given in Chapter 2 has been used to supplement the information gathered from dairy farmers expecially on aspects which were too complex to enable farmers to provide objective data. For example, the cattle feed requirements in Appendix 1 were obtained fram the research work of Hutton, Wallace, Morrison, Blaxter and Joyce but compared with the information obtained fram dairy farmers to ensure that the research estimates were applicable on commercial farms.

3.3.2 The Survey of Dairy Farmers

The objective of the survey was to obtain information from dairy farmers relating to the experiences with beef production and to establish the input/output relationships being attained on commercial dairy-beef farms. Candler (1965) termed this type of survey an interview or purposive survey 1/.

The objective of the survey necessitates that it be carried out on a free-form basis because interesting, new management techniques adopted by the farmers constitute a major part of the information collected and for this type of data it is better to let the farmer describe the system in his own way rather than restrict him to a set order of questions.

(a) Area of the Survey

The four dairying areas in the southern North Island (Taranaki, Manawatu, Horowhenua and Wairarapa) were chosen as the survey area owing to their proximity to Palmerston North.

(b) Selection of the Survey Farmers

Farm Advisory personnel and farmers were asked for lists of names

1/ For a discussion of Farm Management surveys see Cartwright (1967) and Wesney (1964).

of dairy farmers who were engaged in beef production in each region. These persons included:

a) Farm Advisory Officers of the Department of Agriculture,

b) Dairy Board Consulting Officers,

c) Farm Improvement Club Advisers,

d) Farmers in each area contacted from a), b) or c) above,

and e) Sheep farmers who had contracted to buy beef weaners reared on dairy farms.

The names of 40 farmers were obtained from these sources being dairy farmers who had been engaged in beef production for at least one season. It is important that the farmer should have had at least one season's experience so that he would be aware of management changes that might occur over the whole year.

One farmer was unwilling to provide the time for an interview while four other farmers reared beef cattle only for home consumption and had too few (less than 10) beef cattle to warrant inclusion in the survey.

(c) The Information Obtained from the Farmers

In order to study the economic and non-economic factors relating to beef production on dairy farms, it was necessary to find out from the farmers interviewed:

a) The reasons for increasing beef production on the dairy farm,

b) The types of beef enterprise currently being incorporated on dairy farms,

c) The management system 1/ being employed to integrate dairy and beef production,

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1/ A management system refers to the integration of all the technical and financial aspects of the farm business.

d) Input/output data relating to the particular management system,

and e) Critical factors affecting beef production on dairy farms.

The results of the interview survey are presented in chapter 4.

3.4 THE EVALUATION OF PROFITABILITY

The second part of the study was the evaluation of the profitability of beef production, from calves of dairy origin, on dairy farms. Three dairy farms were chosen purposively to represent different resource structures with respect to farm size, soil type, climatic conditions, owner's equity, managerial skill and labour complement. The results of the analysis are only valid for these case farms and care would be necessary if the results were directly applied to some other farm (Candler and Sargent, 1960). Nevertheless, case farms are useful in farm management research since they can be examined in detail and provided their resource structure is typical of a larger number of farms, some general conclusions can be made, pertinent to the industry as a whole or at least the analysis will highlight the critical production factors relevant to the study (Stewart, 1967).

An analysis for each case farm was carried out ex ante because the new enterprise 1/ has not been in operation for many years on intensive dairy farms. Ex ante analysis enabled policies obtained from the survey farms to be applied to the case farms. If ex poste analysis had been adopted, there would have been problems of relating past technical and financial performance in each year to the particular price, cost and climatic factors which operated in those years.

1/ Namely, beef production in combination with dairying.

On the other hand, an ex ante evaluation enables the analyst to apply controlled conditions to the problem. For example, the effect of a dry Autumn could have been examined by specifying a particular pattern of grass growth and determining the financial outcome. Because one factor (in this case, Autumn grass growth) can be varied at a time, its relative importance can be isolated without the complication of numerous other varying factors.

3.4.1 Evaluation Technique

Linear programming was used to evaluate the profitability of beef production on the case farms. 1/ The advantages of using this technique, most relevant to this study, are given in the following section.

3.4.2 The Advantages of using Linear Programming in this Study

a) The Combination of Beef and Dairy Cattle for Maximum Profit

The efficiency of harvesting grass in situ by dairy cows and converting it into milk has been developed to a very high level in New Zealand. This efficiency has been obtained principally by fitting the feed requirement pattern of a milking cow as closely as possible to the pattern of grass growth 2/. The imposition of a beef enterprise onto such a dairy farm can be expected a priori to create new problems of balancing feed supply and demand because the feed requirement patterns of beef and dairy cattle are not the same 3/. Linear programming enables the

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1/ For a detailed description of the application of linear programming to New Zealand Farms, see Rae (1969), Kingma (1968), Frampton (1964) and Stewart and Nuttall (1964).

2/ See Hutton (1966).

3/ See Appendix 1.

most profitable combination of beef and dairy enterprises to be found within the limitation of the feed supply. However, if budgeting had been adopted as the evaluation technique, the analyst would have had to specify a point on the production surface to be examined (Candler, 1959). An extension of this property which was used in this study are resource transfers which were used to determine endogenously, the winter feed supply by transferring feed from the Spring and Summer as hay and from the Autumn as saved pasture to be grazed *in situ*.

b) Supplementary Information

A linear programming analysis provides supplementary information such as the marginal values of scarce resources and the price ranges over which an optimum plan is stable. This data is very important when attempting to assess the feasibility of a new farm enterprise because if the new enterprise is only profitable over a narrow range of prices or, for example, puts considerable pressure on the winter feed supply 1/, then the farmers may be unwilling to adopt it.

c) Parametric Solutions

Candler (1957) has described an efficient linear programming technique which enables optimum solutions to be found over a range of prices. These parametric solutions provide a sensitivity analysis of the plans with respect to price and enable normative supply functions 2/ to be derived.

A supply function for a representative case farm may approximate the aggregate supply function for the industry provided the case farm is typical of the resource structure of a large

---

1/ That is, if the marginal value of winter feed is very high.

2/ See Kingma (1968) and Frampton (1964).

proportion of other farms (Kingma, 1968).

3.4.3 Disadvantages of Using Linear Programming in the Study

The deterministic linear programming model used in the study has a number of disadvantages which stem from the mathematical assumptions of the technique. Most of these assumptions have been discussed by Rae (1969) and Frampton (1964). One aspect which is restrictive in this model is its static, deterministric nature.

A farmer's management decisions 1/ are made in an uncertain or risk 2/ environment. Feed supply is a major item in this respect and farmers decide on their stocking policy by intuitively assessing the present feed situation and estimating the most likely level of grass growth for (say) the following month. Thus a farmer plans ahead on a sequential basis taking account of future risk.

Arcus (1963) has used simulation techniques to evaluate such processes but he found that a lack of suitable data made it impossible to construct a simulation model for a commercial farm. Another technique which may have been suitable was stochastic Dynamic programming. This method has been used to solve farm management problems involving a small number of alternative policies (Burt and Allison, 1963). Alternatively, linear programming can be adapted to incorporate decisions under risk (Heady and Candler, 1963).

However, all these techniques require statistical data on the frequency distribution of grass growth and its relationship to climatic factors which is not currently available for commercial farms. Therefore, a deterministic model was used in this analysis.

The linear programming analysis of the case farms is presented in Chapter 5.

1/ For example, when to buy and sell stock or how much winter feed to provide.

2/ For an explanation of the technical difference between risk and uncertainty, see Heady (1965).

CHAPTER 4

THE FARM SURVEY

This chapter describes the results of an "interview survey" of 35 dairy farmers who are engaged in beef production. The reasons for the survey and the method of selecting farmers was given in Chapter 3. The survey was carried out in January and February 1969.

4.1 LOCATION OF THE FARMS

The farms included in the survey were located in the following districts:

District	Number of Farms
Northern Taranaki	10
Southern Taranaki	11
Manawatu	9
Levin - Horowhenua	2
Wairarapa - Southern Hawkes Bay	3

Figure 4.1 shows the distribution of the survey farms over the southern part of the North Island of New Zealand.

4.2 GENERAL DESCRIPTION OF SURVEY FARMS

The major characteristics of the survey farms are given in Tables 4.1 and 4.2. The farms have been placed in two groups on the basis of their predominant beef cattle policy.

Table 4.1 Farmers selling predominantly weaner calves.

Table 4.2 Farmers selling beef cattle mainly at 18 months of age.

TABLE 4.1

FARMERS SELLING PREDOMINANTLY WEANER CALVES 1968/69

Farm No.	Farm Area	Runoff Area	Topography	Soil Texture	Cows Milked	Calves Reared for Sale	Butterfat Production (pounds)	Labour Units	Replacement Heifers Grazed on Farm
1	125	100	Flat	Silt L.*	140	70 bulls	45,000	2	Yes
2	142	-	Flat	Sand	90	15 steers	30,000	1	Yes
3	280	80	Flat	Silt L.	230	200 bulls	72,000	3	Yes
4	147	101	Flat to rolling	Silt L.	144	62 bulls	41,500	2	Yes
5	240	-	Flat	Stony Silt L.	180	34 steers	48,000	2	Yes
6	100	50	Flat to rolling	Silt L.	116	60 bulls	36,000	2	Yes
7	171	-	Rolling	Silt L.	166	25 bulls	38,500	1	Yes
8	150	20	Rolling	Silt L.	150	65 bulls	44,000	2	Yes
9	155	-	Flat	Sandy L.	119	76 bulls	28,000	1.5 1/	Yes
10	218	-	Rolling	Silt L.	136	30 bulls	46,500	2	Yes
11	100	-	Rolling	Silt L.	95	30 steers	22,500	1	No
12	143	-	Flat	Silt L.	130	44 bulls	38,000	2	No
13	127	-	Rolling	Silt L.	132	50 bulls	35,000	2	No
14	230	-	Rolling	Silt L.	120	46 steers	31,500	2	Yes
15	79	-	Rolling	Silt L.	60	18 steers	18,000	1	Yes
16	130	-	Flat	Silt L.	150	25 bulls	44,500	1	No
17	245	-	Flat	Sand	152	20 steers	48,000	2	No

* Silt L. means Silt Loam

1/ This indicates that a man is employed for six months on a casual basis.

TABLE 4.2

FARMERS SELLING BEEF CATTLE MAINLY 18 MONTHS OF AGE 1968/69

Farm No.	Farm Area	Runoff Area	Topography	Soil Texture	Cows Milked	Beef Cattle Wintered 1/	Butterfat Production (pounds)	Labour Units	Replacement Heifers Grazed on Farm
18	120	105	Flat and Rolling	Sand	125	100 bulls	39,000	2	No
19	200	-	Flat	Silt L. 2/	120	30 steers	39,000	1	Yes
20	130	29	Flat	Silt L.	154	35 steers	45,000	2	Yes
21	200	-	Flat	Silt L.	156	50 steers	47,000	1.5 3/	Yes
22	120	480	Flat	Silt L.	150	180 steers	46,500	2	Yes
23	240	-	Flat	Sand	100	62 steers	34,000	2	Yes
24	320	345	Flat	Sand	260	220 steers	59,500	4	Yes
25	102	-	Flat to rolling	Silt L.	92	45 steers	27,000	1	Yes
26	88	36	Flat	Silt L.	70	30 steers	30,000	1	Yes
27	125	160	Flat	Sand	98	76 bulls	28,000	2	Yes
28	230	-	Flat	Silt L.	200	24 steers	56,500	2	Yes
29	128	120	Flat	Silt L.	157	120 steers	44,500	3	Yes
30	224	156	Flat	Sand	169	60 steers	55,500	2	Yes
31	210	150	Flat	Silt L.	200	90 steers	50,000	2	Yes
32	207	28	Flat	Silt L.	210	22 steers	56,000	2	Yes
33	225	-	Steep	Silt L.	104	60 steers	24,000	1	Yes
34	163	-	Flat	Silt L.	86	34 steers	29,500	1	Yes
35	264	-	Flat	Sand	180	20 steers	59,000	2	No

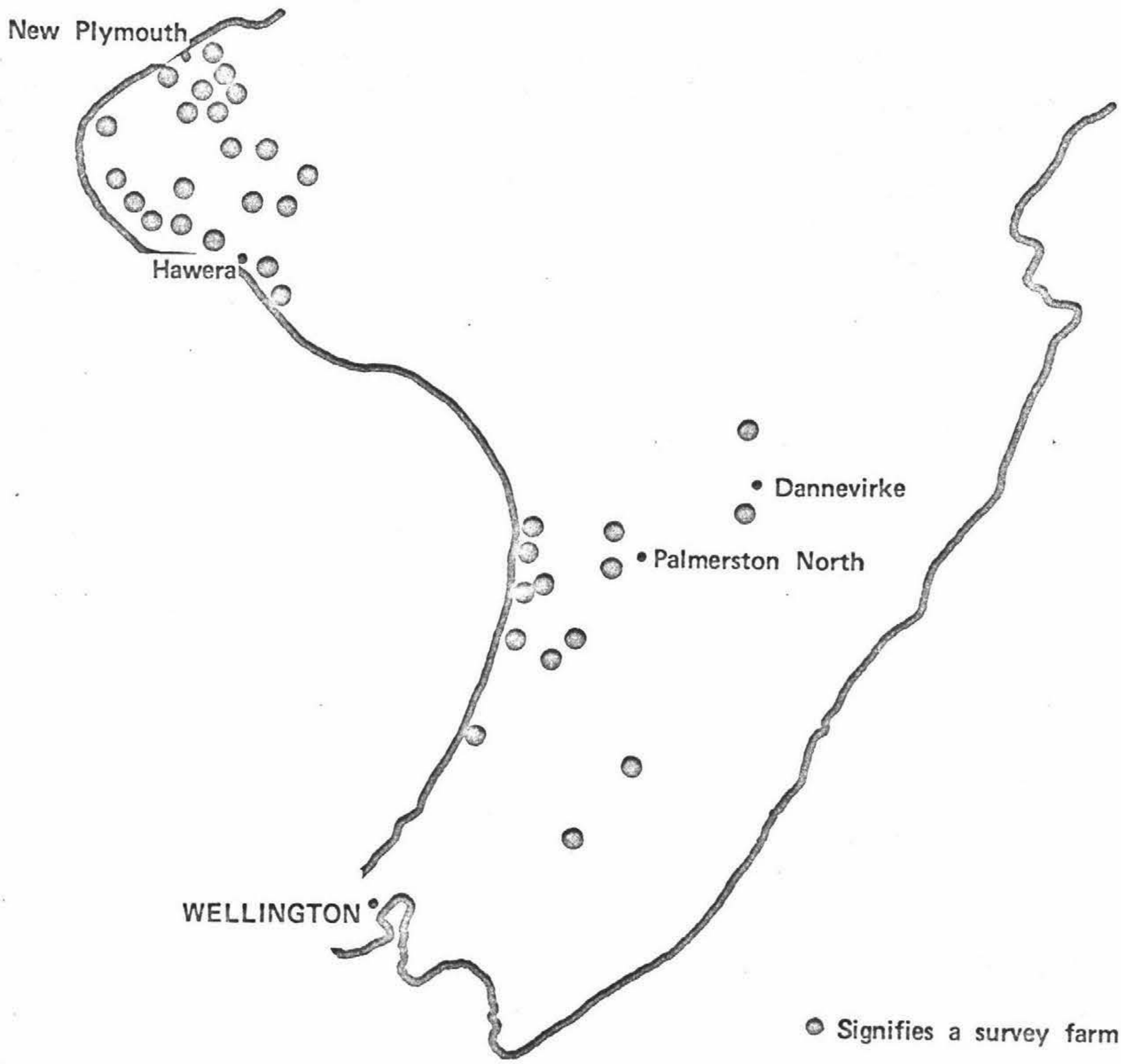
1/ Yearling steers or bulls except on Farms 24, and 33 on which 2 year cattle comprised 40 percent of beef cattle.

2/ Means Silt Loam.

3/ A man is employed for six months.

LOCATION OF SURVEY FARMS

Figure 4.1



Southern North Island, New Zealand

4.3 THE REASONS FOR INCREASED BEEF PRODUCTION ON DAIRY FARMS

The farmers interviewed 1/ were combining dairying with at least one beef enterprise and their reasons for adopting this policy were as follows:

a) Seventeen farmers were rearing calves for sale as weaners either at three months or six months of age. These farmers

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1/ Hereafter called "the farmers" unless otherwise specified.

considered that the calves made profitable use of the surplus grass available in the Spring. Those farmers who sold weaners at six months of age generally had contract arrangements for their sale with sheep farmers at relatively high prices (see section 4.10).

b) Two farmers reared calves to the weaner stage on the dairy farm to varying ages (three to eight months) and then the weaners grazed on a sheep farm until slaughtered. The dairy and sheep farmers shared the gross return equally when the cattle were slaughtered. No adjustments were made for the expenses incurred by each farmer and the dairy farmers rearing the calves were satisfied with this arrangement.

In this case, the beef calves, whilst on the dairy farm were eating surplus grass rather than competing directly with the milking cows. However, the farmers considered that the calves were eating a significant amount of grass which could have been used for supplementary feed.

c) Some farmers had budgeted that it would be unprofitable to increase the herd size beyond its present level because such additional numbers would involve extensions to or replacement of the milking shed and the net profit resulting from the extra cows would be lower than the net profit from the beef animals replaced.

c) Coupled with the added capital cost of milking shed extensions involved with increases in milking cows, was the increase in labour required in some cases. Notwithstanding the fact that it may have been profitable to increase the labour complement with an increase in cows milked, some farmers were unwilling to employ single labour because accommodation for the employee had to be found in the house and either the farmer or his wife found this situation unacceptable.

In cases where a second house or cottage was not available on the farm, then the employment of married labour would involve additional capital expenditure in erecting a house.

e) Two large dairy farms had areas of partially developed land which was unsuitable for the milking herd. The farmers intended to carry out the development of this land in due course but in the meantime they considered that beef cattle were the most profitable alternative on the undeveloped block.

f) A number of farmers owned or leased runoffs which were larger than that required for making hay, rearing replacements and wintering cows from the home farm. In these cases, the farmers found 18 months old beef cattle production a profitable supplement to the dairy herd.

g) Finally, many farmers expressed a number of intangible reasons for tending to increase beef cattle numbers at the expense of dairy cows. These farmers were prepared to accept a lower net income if they could either milk less cows or allow more time off milking for the owner and the labour employed.

As an example, one owner placed a higher monetary value on being able to take Summer holidays. He considered that by reducing the cow numbers to a level easily managed by the married couple, and increasing beef cattle numbers, he was able to achieve his objective.

4.4 SOURCE OF CALVES

Most of the farmers reared calves from their own herd for beef production.

Calf Source

	Own Herd	Bought some Calves	Bought all Calves
Number of Farms	25	6	4

Those farmers who purchased large numbers of bobby calves had made contractural arrangements with the vendors prior to calving.

4.5 SELECTION OF CALVES FOR BEEF PRODUCTION

Farmers preferred Friesian or Friesian cross calves for beef production and the majority of herds were at least half Friesian.

Breed of Herd

	Friesian or Friesian cross	Jersey	Ayrshire
No. Herds	20	13	2

Most of the Friesian cross herds had formerly been predominantly Jerseys but by the introduction of Jersey cross Friesian replacement heifers, the breed of the herd had gradually been changed.

Breed of Calves for Beef Production

	Friesian or Friesian cross	Jersey x Angus or Hereford	Ayrshire x Hereford
No. Farms	28	5	2

Traditional beef breed (Angus or Hereford) cross calves were not as popular as Friesians because heifer calves of the former cross could not be used as herd replacements.

The Friesian-Jersey cross has the flexibility in being able to dispense with the selective mating of poor producing cows to a beef bull, and allows the farmer to use a Friesian bull over all his mature cows and select crossbred heifer calves from the higher producing cows for herd replacements.

Some calving troubles had been experienced with Jersey two year old heifers mated to Friesian bulls and this practice was not popular with the surveyed farmers. The most common practice was to mate the mature Jersey cows to a Friesian bull for three or four seasons and use the crossbred heifer calves as herd replacements. After this time, the choice of bull was flexible depending on the long term aims in the farmer's beef and dairy programmes. Replacement heifers were mated to either Jersey, Hereford or Angus bulls and the calves either sold as bobbies or reared as beef calves in the case of the Hereford and Angus cross.

Calf weight at birth was another important criterion in the selection of beef calves. Heavy (70 pounds and over) Friesian or Friesian cross calves were much preferred except where Hereford or Angus cross calves had been bred especially for rearing as beef animals.

4.6 METHOD OF CALF REARING

There was a tendency for farmers who were keeping beef animals until slaughter to rear their calves on nurse cows because they considered the calves so reared were healthier and grew at a faster rate. On the other hand there was a tendency for farmers selling weaner calves to rear the calves with either whole milk or reconstituted milk using a calfeteria or buckets.

	Method of Rearing	
	Nurse Cows	Artificial
Farmers who retained weaner calves	11	7
Farmers who sold weaner calves	5	12

4.7 ARTIFICIAL REARING

4.7.1 Feedstuffs

The major consideration in the selection of calf feed was the price of butterfat relative to the cost of milk powder (usually buttermilk powder).

Wholemilk was the most popular feedstuff in the 1968 season because the expected butterfat payout made this feedstuff cheaper than purchasing milk powder. Generally, beef calves received more feed than heifer calves for replacements, especially on farms which retained beef weaners. The amount of feed was equivalent to 16 - 20 pounds of butterfat as wholemilk. All the farmers who fed reconstituted milk did so in liquid form even when the milk was taken to the calves for feeding in the paddock. None of the farmers had any experience with feeding calves milk powder and meal in dry form which has had some success in research trials (Davey, 1966), although a few farmers did supplement the milk ration with barley meal.

4.7.2 Calf Rearing Management

It is important that calves reared for beef production are left with their dams for 3 - 4 days after calving. This ensures that the calf gets the colostrum which helps to reduce disease problems in early life and gives the calf a good start.

The calves are taken away from the cows and put into a calf shed or a temporary shelter, say, a hay shed. The calves remain in the shelter for up to a week while they are being taught to drink. During this housing period it is essential that the calves be kept dry and warm and that the area is kept clean because the young calves are very susceptible to infection. Outbreaks of scouring can quite easily cause up to 15 percent of deaths in the calves and be very expensive to control as well.

Most of the farmers fed the calves in batches of 8 - 12 at a time on a calfeteria. The feeding was usually carried out after milking or during the later stages of milking if two or more milkers were present.

After the calves had been taught to drink, they were grouped into mobs of 20 to 30 and put out to graze. It was common to graze the calves ahead of the cows in rotation, although some farmers found it more convenient to set-stock calves which were fed milk in the paddock.

The farmers used two basic methods of rearing the older calves. Some farmers grazed the calves out on the farm and took the milk out to the paddock. This system was the most suitable for rearing large numbers of calves artificially since it did not require the calves to be grazed in the small house paddocks which were usually in demand at calving time and it usually ensured that the calves were getting some fresh grass. It was also quicker to take the milk to the calves than vice versa, in most circumstances. Where smaller groups of calves were being reared, the farmers kept them in a paddock close to the milking shed and brought the calves into a yard for feeding.

While the calves were in a shelter, they were fed twice a day and thereafter once a day. This had been quite satisfactory. However, some farmers were feeding twice a day for four to five weeks but this practice was not popular with large groups (150 calves or more).

4.7.3 Weaning

Farmers selling calves, weaned them at eight to nine weeks of age, but those farmers who retained calves after weaning tended to wean later.[1/]

	Weaning Age (weeks)			
	6 - 7	8 - 9	10-12	Over 12
Number of Farms	2	13	3	1

4.7.4 Labour Considerations for Artificial Calf Rearing

Those farmers who reared a large number of calves (including heifer calves for replacements) had adopted labour saving practices, some of which have been mentioned in the previous section. The adoption of these practices allowed more calves to be reared per man than would be possible with conventional calf rearing systems.

The most time consuming facet of calf rearing was teaching young calves to drink and owing to the close attention and standard of hygiene required, farmers were unable to make large savings of time in this particular operation. It was estimated that one man hour is required per day to teach nine to ten calves to drink. This is six to eight times more labour than is required to feed older calves which have learned to drink by artificial methods. It is therefore desirable to spread out the supply of new calves coming in, over as long a period as possible provided that very late calves do not have to be reared for beef production. One compensation is that this "bottleneck" in the rearing system is only acute where large numbers of calves are being reared (say 200 per man) and in these circumstances the calves are generally purchased and it is usually possible to organise the calf supply so that the farmer receives a batch of young calves each week. This spreads the labour demand over a longer period and allows a more systematic approach to be adopted.

Savings in the labour required to feed large numbers of calves,

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1/ See section 4.8.6.

after the first week, were made by set-stocking batches of calves in separate paddocks, each with its own calfeteria, and taking the milk out to paddocks for once a day feeding.

4.7.5 Division of Labour

The farmers preferred to have one person responsible for the calf rearing wherever possible. On one and two-man dairy units, calf rearing was often the responsibility of the farmer's wife but extra help was given by the farmer and children during the school holidays, when the calves were being taught to drink. Alternatively, farmers' wives often taught the calves to drink once the calves were out in the paddock, the farmer or the permanent man took over the calf rearing.

4.7.6 Labour Involved in Artificial Rearing

If additional labour was available to help feed the young calves or if the calf supply was spread evenly over six to eight weeks or so, then it was possible for 1 man to rear 100 calves in addition to his normal farm work (including milkings). Moreover, if one labour unit was spared from milkings then he was able to rear 300 calves, (but considerably more labour would be necessary if the man had to teach more than 40 calves to drink at any one time).

4.7.7 Calf Health

The majority of farmers treated calves for scouring but on average, animal health problems were not serious except on three farms where outbreaks of coccidiosis, leptospirosis and salmonellosis occurred which caused 9, 13 and 10 percent death rates in calves.

The three problem cases cited serve as a reminder of what can happen if care is not taken when rearing large groups of calves. The desire to rear large numbers of calves per man can lead to the neglect of some of the essential details of artificial calf rearing. Such things as cleaning calf housing (a concrete floor is very desirable in this context), hygiene in mixing calf feed and regular washing of calfeterias are very important practices.

Another potential source of infection was that from bought-in calves and it is desirable to isolate brought-in calves initially to check whether or not they are scouring. This isolation factor was overlooked by one purchasing farmer and 35 calves died as a result.

The average death rate of calves until weaning was 4 - 4.5 percent but was noticeably higher (5.5 - 6 percent) on farms rearing 100 calves or more.

All the farmers drenched their calves at weaning and most calf groups were sprayed for ectoparasites. Dehorning was not as common as one might have expected as it is far easier to dehorn calves while young than it is later on. This task was generally performed in the Autumn when more time was available.

4.8 NURSE COW REARING

4.8.1 Selection of Nurse Cows

Farmers had established a priority list for selecting nurse cows:

a) Poor milkers. That is, cows which were low producers, mastitis prone, possessed a poor shed temperament or had dried off early.

b) Cows known to possess a good mothering ability.

c) Cows with small teats were favoured because the farmers considered there were less teat cracking problems with these cows.

d) Cows which had recently calved were often candidates for nurse cows for no other reason than they were available at the time a batch of calves was ready to be "mothered-on".

4.8.2 Nurse Cow Management

Fostering a batch of calves onto a nurse cow is similar in importance to teaching a calf to drink by artificial means:

a) It is the most important facet of calf rearing,

b) It requires considerable time and patience, and

c) It occurs at calving time on the dairy farm which places considerable stress on labour.

The calves were introduced to the recently calved nurse cow, which was confined to a small area, and the farmer made sure that each calf got a drink. It was often necessary to give the cow a vaginal douche (with, say, iodine solution) to make her accept the calves more readily. When the farmer was dealing with a small number of cows, a convenient pen for the cows and calves was made using the backing gate of a round yard although some obstinate cows had to be put into a bail to allow the calves to get their first drink. The cow's teats were then greased with dairy ointment and she was put back with the herd until the next milking. The cow was drafted off again and the process repeated, until it became obvious that the cow had accepted the calves. This was usually achieved in two to five days.

This system required some modification where a larger number of nurse cows were used. When calves were being mothered-on to, say, eight nurse cows at a time, pen facilities were available to carry out the operation. For ease of management, the pens were sited near the milking shed (so that nurse cows could be drafted into them), and close to the calf house or calf paddock. With a suitable layout, one man was able to supervise 8 nurse cows at once. Provided, also, that the "mothering-up" of the nurse cows and calves, was spread over one to two months, then a man was able to supervise the "mothering-up" of 40 nurse cows per season, in addition to his normal work.

As with artificial rearing, it was often convenient for one milker to leave the shed half an hour before milking was completed (where two or more milkers were present) to supervise the "mothering-up" operation.

When the farmer was reasonably confident that the cow had accepted the calves, they were put into a paddock alone, for 10 days if possible. However, the need for small paddocks at calving time usually did not allow the farmer to set aside a paddock for 10 days with only one cow and her calves in it, and a compromise had to be made. The cow and calves needed at least 5 days isolated from other stock in order to reduce mis-mothering when they were put with other cows and calves.

After this period, the nurse cow and her calves were put into a mob of similar sized calves with their foster mothers.

There were many variations to this system: it was also common, for example, to isolate the cow and calves in a paddock right from the outset and to supervise calf feeding in a corner of the paddock night and morning until the cow accepted the calves. This system, even though it may have been more successful than the previous one, required more paddocks, more time and it was more inconvenient if it was found that the cow had to be bailed up in the initial stages. Mothering-up in a yard close to the milking shed was more convenient on most farms and it was easier to treat the cow for sore teats, etc. when a bail was handy.

Notwithstanding the trouble a farmer went to with the nurse cows, some cows always rejected the calves. The rate of rejection was usually about 10 percent of potential nurse cows but it was as high as 20 or 30 percent of cows with farmers who were trying the technique for the first time.

It was very important to be able to identify the cows and their calves at all stages and tags which were visible from a distance, were of great benefit when checking for mismothering.

4.8.3 Number of Calves per Nurse Cow

Generally, the farmers put three calves on mature cows and two calves on heifers or poor milkers but high producing cows and heifers sometimes reared five and four calves respectively. It was essential to be able to judge how many calves a particular cow required because too few calves resulted in either overfeeding which led to calves scouring or the cow not being milked out which meant that she did not get sufficient stimulation to milk at a high level when returned to the herd. Too many calves, on the other hand, resulted in either the cow rejecting the calves or her condition deteriorating, so that the calves had to be removed.

In the former case it was sometimes possible, depending on the temperament of the nurse cows, to mother an extra calf on and chaining a new calf to the cow's favourite calf (sometimes the biggest calf) with the aid of dog collars was usually successful.

4.8.4 Labour Requirements

The labour required to mother calves on to nurse cows was not much greater than that needed to teach calves to drink artificially but with the nurse cows the time required to "mother-on" increased considerably if a cow and calves were put into the mob too soon or if "mothering-up" facilities were not adequate. After this initial stage, nurse cow rearing usually required less labour than artificial rearing but here again, if sore teats, mastitis or scours became problems it was more time consuming to treat these ailments with a nurse cow rearing system than with artificial rearing.

4.8.5 Grazing Management

The farmers considered that 10 - 15 nurse cows per mob was large enough not to have too many mobs to find paddocks for and yet small enough to allow calves to be checked for mis-mothering. However, two farmers set-stocked groups of 40 nurse cows and calves without any difficulties but this system may have failed if the large mobs had been rotationally grazed with intensive management.

The mobs were usually rotationally grazed, behind an electric fence to allow the calves to "creep" graze fresh pasture ahead of the cows. The intensity of grazing was on the same basis as the milking herd so that nurse cows were given a fresh break of grass every 24 hours. This required more stock shifting on the farm with say three mobs of nurse cows, the milking herd and the yearling heifers but having to shift the electric fence was a good opportunity to check the calves to see that they were being fed. When the nurse cows were set-stocked at the back of the farm, they did not receive the same attention.

4.8.6 Weaning

Farmers tend to wean calves later than with artificial rearing to take advantage of the good growth rate obtained from calves on nurse cows. (Compare this table with section 4.7.3).

	Weaning Age (weeks)			
	8 - 9	10 - 12	13 - 16	Over 16
Number of Farms	4	5	3	4

4.8.7 Animal Health Consideration

a) Nurse Cows

Most farmers had nurse cows which developed sore teats but if dairy ointment was applied at the early stages, the problem was not as great. Furthermore, prevention takes little time (since the cows are close to the milking shed for "mothering-up") whereas curing cracked teats in the later stages means that the cow and calves have to be brought in from the paddock. Cows with small or black teats were not so badly affected as other cows, which was an incentive in some cases to use heifers as nurse cows rather than mature cattle.

b) Calves

Scouring was common in nurse reared calves and may have been due to overfeeding or perhaps to fluctuations in the cow's milk supply. The average death rate of nurse reared calves was slightly lower (3 - 3.5 percent) than for artificially reared calves. Without exception the calves were drenched for worms and sprayed for lice at weaning.

4.8.8 Subsequent Nurse Cow Milk Production

Fifteen of the eighteen farmers put their nurse cows back into the milking herd after the calves had been weaned. These farmers were satisfied with the production from the returned cows. In the case of heifers and poor producing cows, the farmers were surprised that these cows milked so well. However, it was not possible to obtain objective estimates of milk production changes due to suckling on these farms even though most of the farmers were herd production testing.

4.8.9 Breeding Management

The nurse cows did not show visible signs of oestrus which made it difficult to use the Artificial Breeding Service for inseminating cows while they were rearing calves. This caused difficulties when the farmer wished to retain nurse cows in the milking herd. There are a number of alternatives open to a farmer, he could;

a) run a bull with the nurse cows,

b) use cows which were to be culled, as nurse cows, hence obviating the need to get them in-calf,

c) wean the calves early (8 weeks) and use artificial insemination in the usual way, or

d) buy cows especially for nurse rearing which are sold at weaning.

On intensive dairy farms alternatives a) and c) are the most popular since they are making the best use of scarce feed. In principle, nurse cow rearing can be a cheap, efficient, labour saving technique provided that the overhead feed cost of maintaining the nurse cow, while the calves are suckling, can be borne by the subsequent milk production of the cow.

Therefore, policies which do not recover the cow overhead maintenance feed cost from the subsequent milk production, place this cost on the calves reared and they may be very expensive calf rearing systems under intensive dairy farming. Alternative d) and sometimes alternative b) often fall into this latter category.

4.9 THE INTEGRATION OF DAIRYING AND CALF REARING

4.9.1 The Grass Eaten by Calves

The farmers considered that while calves were being reared they do eat an appreciable amount of grass. On most farms, the grass eaten by the calves was surplus to milking herd requirements but the calves were directly competing with feed conservation programmes (hay or silage). On some farms, the grass eaten by calves did not restrict the amount of feed available for the milking herd probably because the stocking rate was such that the calves were eating grass, which in their absence, would not have been fed off or conserved for other stock anyway, but would have been wasted. Thus on lightly stocked farms, beef calf rearing may result in the more efficient use of Spring grown grass.

4.9.2 Grazing Management

The impact of additional calves on the grazing system was very important. In the case of nurse cow rearing, the farmer had three or four groups of nurse cows to fit into a rotation where he only had one group of heifer calves before. This was best overcome by establishing separate areas to rotate the milking herd and the nurse cows. The nurse cow groups were rotationally grazed on a separate area using electric fences.

However, where the calves are artificially reared, Easton (1966) found it more convenient to set-stock the calves and rotate the cows in the normal way, even grazing the calf paddocks in turn with the milking herd.

The major "bottleneck" was in organising calving cows, calf rearing and the dry stock, at calving time; when there, invariably, were not enough small paddocks (or not enough electric fences to make small paddocks) for all the stock which the farmer wished to isolate. For this reason, it is important that a farmer plans in advance for whatever system he is contemplating adopting.

4.9.3 Co-ordinating Calf Supply

It was important to select nurse cows with regard to the likely calving dates, especially when contracts were made to buy calves, to ensure that suitable calves (with regard to breed) were available when potential nurse cows were expected to calve.

4.9.4 Labour Organisation

The added work load through rearing extra calves was not great provided a realistic number of extra calves were reared for the labour available and provided adequate rearing facilities were made available in advance ("mothering-up" pens, calfeterias, etc.).

4.10 WEANER CALF PRICES

Seventeen farmers sold calves as weaners at various ages and contract sale arrangements were very common.

The prices realised for weaner calves in the 1968/69 season are given in Table 4.3.

TABLE 4.3

BEEF WEANER PRICES

1968/69 SEASON

Number of Farms	Age (weeks)	Weight (lbs)	Breed	Price Range
				$
5	8	170	½ Friesian	20 - 22
1	10	n.a.	½ Friesian	22 - 24
3	10	200	¾ Friesian	27 - 30
2	12	200	½ Friesian	26 - 30
2	12	n.a.	Friesian & F.Hereford	26 - 30
1	16	n.a.	Friesian	32 - 35
1	20	350	Friesian	to 39
2	24 - 28	380 - 410	¾ Friesian	45 - 53

n.a. - not available

4.10.1 Negotiation of Calf Contracts

Farmers who had made contract sale arrangements for weaners before calving had been aided by various agencies who had helped them to find buyers. These agencies included the Department of Agriculture, Federated Farmers' Committees and stock agents from the stock and station firms.

However, the basis for these contracts was a "gentleman's agreement" and hence was not legally binding. This was quite satisfactory in most cases but two farmers had had contracts broken at the time of sale, due to the buyer being short of finance and this caused some inconvenience in finding new buyers.

The need to make contract sale arrangements is being reduced, owing to the increasing demand for beef calves from suitable dairy breeds at the various "dairy beef" weaner sales throughout the North Island. These sales may provide a sounder basis for selling weaner calves on a national scale than is afforded by private contracts.

4.11 WINTERING BEEF YEARLINGS

Eighteen farmers retained beef calves over their first Winter. The majority of these beef cattle were either slaughtered or sold at auction at 18 - 20 months of age.

Farmers preferred to slaughter Friesian cattle rather than sell them in the sale yards because they considered the market was prejudiced against this breed. However, this situation may be changing as Friesian cattle become more popular for beef production. Those farmers who specialised in the production of store 18 months old cattle were using Hereford cross animals.

4.11.1 Wintering Rising 2 year Cattle

Only two farmers retained beef cattle over a second Winter and these farms had large runoffs which were extensively grazed.

The remaining farmers considered that beef cattle which were run under intensive conditions could not be profitably run over two winters if the cattle were to be sold at export beef schedule prices.

4.11.2 Grazing Management of Beef Cattle

After weaning, the beef and heifer calves were run together through the Summer and early Autumn except when bull calves were involved and in that case the calves were separated soon after weaning or whenever sexual activity became evident.

In any case, the heifers and steers were separated eventually so that they could be differentially fed.

Generally, there was a greater need for the intensive dairy farmer to control the grass intake of the beef cattle than there was under less intensive conditions because the weaned beef calves competed with the dairy herd for Summer-Autumn grass which caused difficulties in dry periods.

Winter grazing was usually provided in a rotation separate from the milking cows and the female dry stock. This meant that at least two and sometimes four mobs of cattle were grazing separately.

a) Mature milking cows,

b) heifer replacements (if not included in a)),

c) Yearling heifers (if they are not grazed off the farm),

and d) Yearling beef cattle.

Some farmers avoided the problem of having three or four mobs of cattle by confining the beef cattle to a dry area during the Winter and feeding hay or silage whenever grazing became scarce due to wet weather.

An interesting trial being conducted at Ruakura Agricultural Research Centre is testing the feasibility of wintering all the female stock (a, b and c from above) together (Campbell and Clayton, 1969). If this practice is shown to be feasible on commercial farms, it could simplify the grazing management of mixed farms considerably.

4.11.3 Growth Rate of Beef Cattle

The farmers did not aim to produce cattle with heavy carcase weights at slaughter (18 - 20 months of age) and generally carcase weights of 375 - 450 pounds were attained.

4.11.4 Bull Beef Production

Two farmers had changed from rearing Friesian steers to rearing bulls for slaughter. This change was made because bull carcases are not subject to eye-appraisal methods of carcase evaluation for grading purposes, as are steer carcases, and the farmers were of the opinion that steer beef from dairy breeds was discriminated against.

Bull carcase grading is determined by weight, thus giving the farmer more confidence that he is receiving a fair return for his cattle. The other reason for the change to bull beef production was that the higher price being paid for bull beef provided the carcase was 376 pounds and over.

Some farmers did have difficulties in intensively rearing bulls on a dairy farm mainly due to fighting and mounting. Bulls did cause damage to gates and fences, although three-wire electric fences were the best deterrent and quite effective. Few bulls suffered injury from fighting.

This adverse behaviour was very noticeable at 12 to 15 months of age and during the Spring it was often necessary to break up large mobs of bulls into even sized groups. This often caused difficulties where the farmer was attempting to breakfeed the beef cattle and made it awkward to organise the grazing management system.

Another reason for the current interest in bull beef production, besides the high price and lack of grading problems, is the higher growth rate reported for bulls compared with steers and heifers. Turton (1962) considers that 10 - 12 percent increase in growth rate of bulls compared with steers can be expected. However, the increase in growth rate, is probably related to the level of feeding, and may vary from 0 - 17 percent under New Zealand conditions (Everitt, 1968). Everitt's view is supported by recent work which found the efficiency of feed conversion into beef is very similar for bulls, heifers and steers (Joblin, 1970).

4.12 INTEGRATION OF DAIRYING AND BEEF PRODUCTION

4.12.1 Grazing Management

The allocation of feed between the milking cows and beef animals was a major problem on mixed farms where both classes of stock use the same area (see Table 4.2, farms 21, 25 and 34). The major problem that arose was: "which class of stock should receive preferential treatment in the event of poor grass growth at any time of the year". This question is related to the profit being obtained from each enterprise (beef production and dairying) and hence the price of beef and milk. The farmers were unable to set out any formal rules for this decision because there are a number of factors to take into account. In the event of poor Autumn growth, the farmers were prepared to sell the beef cattle rather than risk "drying-off" the cows earlier than normal.

However, this decision can not be used as a general rule because the question of when to sell the beef cattle in the face of a dry period will depend on the store cattle prices ruling at the time, the stage of lactation of the cows, the weight of the beef cattle and the probability that the farmer places on the dry period continuing for a further x weeks. Obviously, the nearer the cows are to the end of lactation, when the dry spell occurs, the more likely is the farmer to favour the beef cattle with feed, especially if they are likely to change from one schedule to another with a small increase in weight (for example a carcase weight increase of 20 pounds from 370 to 390 pounds in a bull results in the revenue from the carcase increasing by approximately $17).

Nevertheless, beef cattle have the flexibility in so much as they can usually be sold for slaughter 1/ or at auction at any time of the year and this enables the mixed farmer to adjust his stocking rate to suit the season without penalizing the milking herd.

4.12.2 Labour

After the calf rearing stage, the labour required to manage beef cattle is very small. Shifting stock, spraying and drenching are the only major tasks and normally the heifers require this treatment anyway, so that the extra time taken is not great.

4.13 SUMMARY

The farmers were generally quite satisfied with the technical feasibility of beef production (in its various forms) on dairy farms. Their future plans with regard to both beef and dairy production would be influenced mainly by the price relationships of bobby calves, beef and milk and most of the farmers preferred to remain in a situation that would allow for the expansion of either policy (beef or dairying) depending on the state of the respective markets.

1/ That is, provided killing space is available at the freezing works.

CHAPTER 5

THE CASE FARM EVALUATION

5.1 INTRODUCTION

Three case farms were chosen for a detailed study of the feasibility and profitability of beef production on dairy farms. The farms were selected purposively to represent different resource structures mainly with respect to farm size, soil type and management.

A general deterministic linear programming matrix was developed and this model was applied to each farm after making appropriate between farm adjustments. 1/ The matrix will be described in relation to the first case farm and the adjustments for the other farms will be noted in turn.

5.2 THE LINEAR PROGRAMMING MODEL FOR CASE FARM I

Stewart (1961) listed the data required for constructing a linear programming model as follows:-

a) Decide upon the alternatives available,

b) the restraints to impose,

c) the units,

d) the input - output coefficients,

and e) the prices or net revenues to use.

The linear programming matrix is given in Appendix 2 and will be described under the above headings.

5.2.1 Restraints

The restraints imposed on the model have been grouped in the

1/ For example, feed supply and labour supply.

following way:

a) reconciliation and accounting restraints,

b) labour restraint,

and c) feed restraints.

a) Reconciliations

1) Heifer replacement reconciliation X_1

This restraint ensures that sufficient heifer replacements are provided for the milking herd.

2) Beef calf reconciliation X_2

Calves of suitable weight produced by the milking herd may be reared for beef production or sold at four days of age as heavy bobby calves.1/

3) Heifer calf reconciliation X_3

Heifer calves from cows of sufficient productive merit may be reared as heifer replacements or sold as light bobby calves.

4) Milk reconciliation X_4

The milk produced by the herd may be sold to a dairy factory on a per pound butterfat basis 2/ or used to feed calves.

5) Cow beef transfer X_5

Cull cows are slaughtered at an average carcase weight of 383 pounds. The beef is transferred through this row to the cow beef selling activity P_3.

1/ The Manawatu bobby calf pools have three weight classes of bobby calves: heavy, over 65 lbs; light, 50 - 65lbs; skinners, under 50 lbs.

2/ The milk price is made up of the guaranteed price of butterfat plus the price realised for the products from the solids-not-fat portion of the milk or the cheese price. However, payment to the farmer is made per pound of butterfat supplied.

6) Bobby calf transfer X_6

Mixed sex bobby calves which are unsuitable for rearing as replacement heifers or beef production are transferred to the activity selling these calves, P_5.

7) Beef transfer X_7

Beef produced by activities P_6, P_{14}, P_{18} and P_{19} is transferred to the beef selling activity P_{15} through this row to enable beef prices to be readily adjusted when computing the parametric solutions.

8) Calf feed reconciliation X_8

Over the period of calf rearing (August to November), a dairy cow produces sufficient milk to rear five beef calves on a calfeteria. This row ensures that there are sufficient cows available when calves are being fed whole milk. Milk powder may be used to supplement or replace whole milk if required. Activity (P_{10}) supplies milk powder equivalent to one pound of butterfat as wholemilk and hence supplies 0.05 units of the feed required by one beef calf.

This reconciliation is only necessary when the ratio of cows milked to calves reared is small (0.02 or less) as at higher ratios calf feed is accounted for by the annual milk production reconciliation X_4.

9) Heifer grazing reconciliation X_9

This row restrains the amount of heifer grazing that is purchased off the farm (P_{27}) to the number of replacement heifers in the plan (P_2).

b) Labour Restraint X_{10}

Dairy farmers are very flexible in their attitude to work load if the extra work is only for short periods. This is the situation at calving time on the dairy farm which is the period of peak labour demand.

This farmer considered that provided a feasible combination of milking cows and calves (for rearing) were carried over the early Spring, then the number of beef cattle on the farm would not greatly increase the work load. The farmer specified that with his family and a single man, he would milk 125 cows and rear 115 calves on a calfeteria (heifer replacements and beef calves) but without the single man he would only be prepared to milk 90 cows and rear 40 calves. Excluding family labour, the above two combinations of cows milked and calves reared are feasible with respect to Spring labour for a two-man and a one-man farm respectively. These base combinations represent the Spring labour supply by assuming that the Spring labour requirements of two calves reared artificially are the same as that required for one milking cow. That is, the farmer supplied 220 calf rearing units (c.r.u.) of Spring labour 1/ and the farmer, with a single man, would provide 365 calf rearing units. A calf rearing unit is the labour required to rear one calf over the August to November period. The combinations of calves reared and cows milked assumes a linear relationship for the labour requirements of these two enterprises. On theoretical grounds, it could be expected that the functional form of this relationship would be more complex than the one used. However, because the case farmers were prepared to work harder than usual for short periods, it was very difficult to specify the labour situation precisely. The simplified linear labour function, while overlooking economies of size in milking and calf rearing, is easy to incorporate into the model and it was considered that, because some error will usually be involved in defining labour restraints 2/, no matter what form the labour function takes, the extra time involved in collecting detailed information on labour requirements would probably not be warranted by the extra precision obtained in the linear programming model.

The labour feasibility of rearing calves on nurse cows for 8 - 10 weeks

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1/ Ninety cows at two units plus 40 calves at one unit.

2/ For a detailed discussion of the problems of defining labour requirements see Frampton (1964) and Kingma (1968).

and subsequently milking the cows was considered ex poste because it was difficult to represent the two phases of this alternative (viz. calf rearing and subsequent milking) as a single coefficient though this could have been done by including a nurse cow transfer row. The optimum plans were also checked for labour with respect to beef cattle (post-weaning) because reliable data on the labour requirements of beef cattle could not be obtained from the case farmers.

c) Feed Restraints X_{11} to X_{27}

Twelve monthly feed restraints (X_{11} to X_{22}) ensure that the feed demanded does not exceed the feed supply in any month.

The year is divided into two periods:

1) September to March X_{12} to X_{18}

In these months, the grass feed supply is measured in terms of the carrying capacity of the farm under the normal rotational grazing system of the farmer. Hay may be made at any time from October to January.

2) April to August X_{11}, X_{19} to X_{22}

The feed supply over this period is specified as closely as possible to the pattern of grass growth and the programme can reallocate the grass grown endogenously according to the activities in the basis by transferring feed ahead in situ. This is a similar technique to that described by Coutu et al (1959).

This system attempts to simulate the grazing management of the farmer who saves Autumn and Winter grown grass for feeding stock in the Winter and early Spring. The technique is commonly known as the "long rotation" wintering system adopted by many farmers in dairying areas which can usually rely oh some Winter grass growth (Campbell and Clayton, 1966).

In this format, the extent of the feed transfer from April to August is only limited by the amount of grass grown in these months. In reality, grass can only be carried forward for two months at this time of the year, without a loss in nutritive value, whereas the programme could transfer feed four months ahead. In the model, the livestock activities in the basis require feed in most Winter months and hence, the situation has not arisen of grass being transferred more than two months ahead.

If further activities were added to this matrix which required say, only August feed, from the Winter period and these activities entered the plan, then the model may require further restraints to keep the feed transferred within practicable limits.

The third group of feed restraints are hay reconciliations (X_{23} to X_{27}). These restraints ensure that the hay required by livestock activities is equal to the hay purchased (P_{20}) plus the hay made on the farm (P_{21} to P_{24}). For convenience, all hay purchased or harvested is transferred into X_{23} and from there transferred to other hay rows (X_{24} to X_{27}) by a series of hay transfer activities (P_{25} to P_{28}).

5.2.2 Feed Supply

The feed available in each month (B column, X_{11} - X_{22}) was calculated by multiplying the stock carried on the farm and the supplementary feed produced in each month, by the feeding standards given in Appendix 2. The linear programme is able to redistribute the available monthly feed supply to other enterprises. This specification of feed supply, together with the feed transfer activities (P_{31} - P_{34}) ensures that the present stocking rate is not exceeded at any time of the year except during the Winter by conserving extra Autumn saved pasture. This approach is valid in the study because it was not intended to examine the developmental problem of increasing the stocking rate but rather to investigate the economics of substituting beef cattle for milking cows at a similar stocking intensity as that previously operating.

5.2.3 Capital

The capital required for stock and seasonal finance was not anticipated to limit alternative plans and was not included in the restraints. The difference in capital involved between plans was taken into account ex poste.

5.2.4 Activities

The input/output coefficients of activity P_1 will be explained in detail because many of the principles explained for this activity are common to other activities. The following discussion will then rely on points discussed for activity P_1.

1) Milking cows P_1

This activity comprises large framed milking cows which produce 315 pounds of butterfat per cow (-315 in X_4) and require 30 percent [1/] replacement heifers (0.3 in X_1) from P_2. The cull cows are slaughtered at 383 pounds carcase weight and hence each unit of the activity supplies 88 pounds of cow beef (-88 in X_5). The cows have a 95 percent calving of which 40 percent (-0.4 in X_2) are heavy bull calves or heifer calves suitable for beef production, 40 percent (-0.4 in X_3) are heifer calves from cows of sufficient productive merit to be reared as heifer replacements and the remaining 15 percent (-0.15 in X_6) are mixed-sex bobby calves which are sold for slaughter.

The mid-point of calving is the first week in August and over the following 10 - 12 weeks a cow produces milk equivalent to 100 pounds of butterfat which is sufficient to feed five beef calves on a calfeteria (-5 in X_8).

1/ Twentythree percent culls and seven percent deaths.

It has been estimated in a preceeding discussion that a milking cow required twice the amount of Spring labour (2 in X_{10}) as a calf reared artificially. This labour requirement refers to the work involved with calving and milking over the August to November period.

The cows may be used to nurse rear heifer calves for eight weeks or beef calves for 10-12 weeks as it is assumed that the feed cost with this system is the same as for artificial rearing [1/].

The labour required to milk a cow over the early Spring is assumed to be the same as that required to foster calves onto a nurse cow. However, if calves are nurse reared for 10-12 weeks, they have a smaller labour requirement than artificially reared calves [2/]. The decreased labour requirement of calves reared on nurse cows for 10-12 weeks and then milking the cow post-weaning was not included in the matrix but the possibility was examined ex poste.

The derivation of the monthly feed requirements for P_1 is shown in Appendix 1. The hay requirements (X_{23} to X_{27}) are dietary constraints to ensure that the proportion of hay feed is in accordance with good husbandry practice and the production level assumed. This procedure has been used for each livestock activity.

From the matrix given in Appendix 2, one unit of activity P_1 requires 16.4 pounds of D.O.M.[3/] as grass in August, 19.1 pounds of D.O.M. as grass in September, 20.3 pounds of D.O.M. as grass in October, ... 7.7 pounds of D.O.M. as grass in June and 12.6 pounds of D.O.M. as grass in July. Similarly, one unit of activity P_1, requires 2.0 pounds of D.O.M. as hay in May, 3.3 pounds of D.O.M. as hay in June ....

1/ See section 2.5.1.

2/ Section 4.8.4.

3/ Feed is measured by the standard Digestible Organic Matter (D.O.M.). For an explanation of this concept see Coop (1961).

and 2.0 pounds of D.O.M. as hay in September.

2) <u>Heifer replacements</u> P_2

One unit of this activity requires 1.09 heifer calves from P_1 which are fed wholemilk or milk powder at the rate of 15 pounds butterfat equivalent (16.4 in X_4) to produce one rising two year old heifer replacement.

Thus, nine percent extra calves are reared to provide the necessary number of rising two year old heifers. The losses are made up of five percent deaths from birth to weaning and four percent deaths from weaning until the heifers enter the herd.

This method of incorporating losses has been used in all the calf rearing activities P_2, P_{11}, P_{12}, P_{13} and P_{14}.

In X_8 the coefficient is the proportion of 20 pounds of butterfat (the row units, X_8) that P_2 requires for calf rearing 1/.

As with other calf rearing activities each unit of output requires one unit of Spring labour as defined previously.

The feed requirements (X_{11} to X_{27}) have been estimated on the same basis as for beef cattle but assuming a slower growth rate 2/. The replacement heifers enter the herd (P_1) in May and hence the grass feed requirements fall sharply at this point (X_{19} to X_{20}) because only the yearlings are included in P_2.

3) <u>Product Selling Activities</u> P_3, P_4, P_5, P_8, P_{15} and P_{16}

Beef from cull cows and beef cattle (bulls in this instance) is sold through activities P_3 and P_{15}, having been transferred from the producing activities by the transfer rows X_5 and X_8 respectively. Similarly, light heifer calves and mixed sex bobby calves surplus to replacement requirements or unsuitable for beef production are sold through the selling activities P_4 and P_5. Both activities were

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1/ That is, 16.4/20 is 0.82.

2/ See Appendix 1.

included to allow different net revenues to be used if required.

Heavy bobby calves surplus to beef production requirements are sold at a higher price than P_4 and P_5 through activity P_{16}.

Milk is sold on the basis of the total final payout per pound of butterfat by activity P_8. The Co-operative Dairy Company supplied by this farmer produces butter and casein and hence, the payout to the farmer consists of the guaranteed butterfat price paid by the New Zealand Dairy Board plus the profit from the sale of casein. The total payout used here is actually paid in two ways, firstly, as a monthly interim payment for milk supplied throughout the lactation period and secondly a final (or bonus) payment at the end of the season. In this analysis both payments are combined 1/.

4) "Baby beef Production 2/ P_6 and P_7

Milking cows may each nurse rear two calves for nine months. On case farm 1, the nurse cows are taken from the milking herd to be sold as culls at the end of the season. Hence, there is no feed required by these activities for the nurse cows in June. The beef yearlings may then be sold either at 300 pounds or 450 pounds carcase weight in June (P_7 - 10 months) and November (P_6 - 16 months) respectively.

The nurse cow activities supply the same proportions of calves and cow beef as in P_1 but they require additional beef calves for rearing through X_2 after allowing an eight and seven percent death rate in P_6 and P_7 respectively.

Activity P_6 produces two 15 months old beef cattle each of 450 pounds carcase weight (900 in X_7) and this beef is transferred to the selling

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1/ Thus, "the milk price" implies the total final payout for milk supplied which is paid to the farmer on a per pound butterfat basis. This convention will be followed throughout the discussion.

2/ "Baby beef" in this instance refers to beef cattle slaughtered between 10 - 15 months of age. The carcase weight ranges from 300 - 450 lbs depending on age at slaughter.

selling activity. The revenue from the sale of beef cattle in P_7 is included in the net revenue because the cattle may be sold to other farmers for growing to slaughter. The Spring labour requirements of both activities (calving and "mothering-up") is the same as for a milking cow (2 in X_{10}), but no additional labour is required for the calves.

The feed requirements of the cows and the beef cattle are aggregated in X11 to X27 from the tables in Appendix 1.

5) Calves reared for Beef Production P_{11} to P_{14}

On this case farm, bull calves may be reared for beef production and sold either as weaners (three or six months of age), yearlings (13 months of age to qualify for the Government incentive payment) or slaughtered at 425 pounds carcase weight (18 - 22 months of age.). These activities are P_{11} to P_{14} respectively.

As for P_2, the calves and milk required by these activities incorporate the expected losses and milk is fed at the rate of 20 pounds of butterfat equivalent per calf over 10 weeks. Hence, the coefficients in X_2, which includes losses, correspond to the coefficients in X_8 because the latter row is measured in units of 20 pounds of butterfat.

Each activity requires one unit of Spring labour if the calves are reared artificially on buckets or a calfeteria. The weaners are sold in mid-December (P_{11}) and mid-March (P_{12}) whilst in P_{13} yearling store cattle are sold at auction in early October after the incentive payment becomes payable on 30 September. The beef cattle in P_{14} (as in P_{18} and P_{19}) are slaughtered in six drafts from January to May.

The feed requirements are taken from Appendix 1 adjusted for the selling times of each activity.

6) Bobby calf purchases P_9

Heavy bobby calves of suitable breeding for beef production may be purchased at four days of age to supplement beef calves produced by P_1.

7) Purchased calf feed P_{10}

Milk powder may be purchased to rear calves depending on the availability of wholemilk. This case farmer considered that feeding wholemilk to calves was more convenient than mixing milk powder and would not be prepared to use milk powder if wholemilk was available. The milk powder is purchased in terms of the whole milk (equivalent to one pound of butterfat) it can replace for calf feed. The P_{10} coefficient in X_8 is thus 0.05.

8) Beef trading activities P_{17}, P_{18} and P_{19}

Three months old weaners may be purchased and sold at 13 months of age (P_{17}) or slaughtered at 18 - 22 months of age (P_{18}). Both these activities qualify for the incentive payment.

Weaners may also be purchased at six months of age and slaughtered at 18 - 22 months (P_{19}).

The feed requirements (from Appendix 1) are adjusted for the time of purchase and sale. As with all other livestock activities, separate hay and grass requirements are used in rows X_{11} to X_{27}.

9) Hay Activities P_{20} to P_{24}

Hay may be purchased by activity P_{20}. Hay made on the farm requires grass to be saved in each of two consecutive months from September to January. One bale of hay requires saved grass equivalent to 0.53 pounds of Digestible Organic Matter (D.O.M.) per day for two months and it supplies 0.66 pounds of D.O.M. per day for one month, assuming a total nutrient loss of 38 percent.

10) Hay Transfer Activities P_{25} to P_{28}

As was discussed previously all hay is supplied into the May hay row (X_{23}) and transferred ahead up to September (X_{27}) according to stock requirements. This procedure is used merely to save the repetition of having four hay producing and one hay buying activity for each of five hay using months.

11) Heifer Grazing P_{29}

Grazing off the farm may be purchased for heifer replacements for twelve months from May until the following April. The activity is linked to P_2 by the heifer grazing reconciliation (X_9).

Negative feed requirements are inserted for the activity, representing the amount of grass and hay eaten by the heifers while they are off the farm which reduces the feed used by P_2 and makes more feed available on the farm.

12) Buy Labour Activity P_{30}

Labour (single man) may be employed on a permanent basis and this activity supplies 145 units of Spring labour to X_{11}.

The permanent labour supply of 220 units (B column, X_{10}) comprises the farmer and family labour over the August school holidays. The Spring labour supplied by the farmer and the employee are expressed in calf rearing units (c.r.u.).

13) Feed Transfer Activities P_{31} to P_{34}

These activities enable grass to be transferred ahead for use in the following month in situ. The period over which grass can be transferred is from April (X_{19}) to August (X_{11}) inclusive.

Units and Input/Output Coefficients

The units used are shown on the matrix in Appendix 2. Feed units are expressed as pounds of Digestible Organic Matter supplied or demanded per day. A per day basis is preferred to a total measure since Animal Nutrition studies use feed intakes per day as the basis of scientific work.

5.2.6 Activity Net Revenues

The prices or net revenues for each activity have been calculated by subtracting the costs which are not common to all enterprises from the gross revenue. The fixed changes 1/ (including taxation) are not included in the model and are subtracted from the total net revenue obtained by the linear programme after computation to calculate the tax-paid profit.

Owing to the supplementary and complementary nature of groups of activities, some variable items (products and costs) have not been directly incorporated into the activity net revenues but are accounted for by buying, selling or transfer activities.

Examples of Net Revenue Calculations

The detailed net revenues for milking cows and 18 months old beef cattle production from calves reared on the farm are given below.

a) Net Revenue for a Jersey-Friesian Cross Milking Cow (P_1)

i) All revenue items are accounted for by selling activities and hence, there is no assigned revenue.

ii) Variable costs

1.	animal health	=	$2.00
2.	breeding expenses	=	$1.70
3.	dairy shed expenses	=	$1.60
4.	electricity	=	$2.00
5.	freight	=	$2.00
Total	assigned variable costs	=	$9.30

Net Revenue = $9.30

1/ The term "fixed charges" is used here to mean the sum of the overhead costs (interest, principle repayments, rates and insurance) and the costs common to both milk and beef production (fertilizer, repairs and maintenance, vehicle expenses etc.).

b) Net Revenue for 18 months old Beef Cattle Production (P_{14}) (1 beast)

i) Revenue

Government incentive payment	=	$10.00
Total assigned revenue	=	$10.00

ii) Variable Costs

1. animal health	=	$1.50
2. freight	=	$2.00
3. sundry	=	$1.00
Total assigned variable costs	=	$4.50

Net Revenue	=	$5.50

All the net revenues for case farm 1 activities are shown in Appendix 3 (table A.3.2.)

5.2.7 Parametric Solutions

A series of solutions to the linear programming model are presented in Appendix 4 for case farm 1. Each set of solutions is a parametric analysis of the model to determine the optimum combination of beef and dairy cattle at a range of milk and beef prices.

The prices for milk and beef are considered to be a major source of uncertainty in forecasting profitability and optimum plans are given at all prices within the range considered most likely to occur in the future. The milk price is varied continuously from 20.0 to 38.0 cents per pound butterfat at each of seven beef price levels within the range of $13.50 to $25.50 per 100 pounds of steer or bull beef (in $2 intervals).

5.2.8 Beef Cattle Price Correlations

The parametric analysis discussed in the previous section is difficult to analyse as a variable price model for two products 1/

1/ For example, see Heady and Candler (1963).

(milk and beef) because the beef schedule price can be expected, _a priori_, to influence the price of store cattle sold or purchased. That is, an alteration in the schedule price of beef (activity P_{15}) is assumed to change the prices of activities which either purchase store cattle (activities P_{17}, P_{18} and P_{19}) or sell store cattle (activities P_{11}, P_{12}, P_{13}, and P_{17}). The beef schedule price is also assumed to influence the price farmers are prepared to pay for suitably bred bobby calves, to rear for beef production.

Kingma (1968) derived a simple linear regression between the beef schedule price and store cattle prices at auction for traditional beef breeds (Angus and Hereford). There is not sufficient data available on the auction price of dairy bred beef cattle to derive a statistical correlation coefficient for this study.[1/] Furthermore, had such an analysis been attempted, the results would be subject to error from a number of sources.

a) The Dairy Industry Beef Scheme was introduced in the 1969/70 season and it may markedly affect the values of store cattle in the future.

b) Many other factors may influence the price of store cattle besides the beef schedule price. The supply of store beef cattle is a very complex function of past prices and past trends in breeding cow numbers. This implies that a lagged statistical model [2/] would be necessary to explain present store cattle prices. Furthermore, the variation in grass growing conditions through the district, the amount of killing space available at the freezing works and many other

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1/ However, three months old weaner prices in the 1969/70 season have been discussed by Clark and Green (1970).

2/ See for example Foote (1958) and Nerlove (1958).

factors also influence the price farmers are prepared to pay for store cattle.

c) The supply of store beef cattle from dairy farms may be influenced by the export price of bobby calves since an increase in the export bobby calf price will decrease the relative profitability of beef production from dairy calves. Hence, the price paid by dairy farmers for store cattle may be influenced by two export schedule prices, the beef price and the bobby calf price.

d) The final difficulty in calculating a correlation between beef schedule prices and store stock prices, is that a group of dairy-bred steers will usually be placed into two beef grades at slaughter.1/ The price difference between the grades has varied from $1 to $4.50 per 100 pounds beef over the last ten years. However, not only does the price differential alter, but, due to the variability of the subjective grading methods used, the proportions of animals from a group of beef cattle of similar weight, age, conformation and fat cover, placed in each grade may vary between freezing works or between seasons.

For these reasons, the beef prices for store cattle were derived after discussion with the farmers in the survey rather than by the statistical analysis of historical records.

Seven schedule beef prices (1 - 7) were chosen for steers, bulls or heifers and at each level, a market price was calculated for beef cattle purchased (bobby calves, three months and six months weaners) and beef cattle sold (three months and six months weaners and yearlings 13 months

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1/ F.A.Q. and Boner Ox (or its equivalent for young steers Y.A.Q.).

of age). The calculations were based on the expected carcase weight of the cattle at the time of sale. The correlated beef prices are given in Appendix 3 (Table A.3.1).

However, with any such set of prices, variations will occur in the short term because price correlations are an average, long term phenomenon and fluctuations about the assumed prices will occur in the short term. Such fluctuations may change the combination of alternative policies in the optimum plan. An example of this short term price variation, was the considerable difference in the prices paid for four day old Friesian calves in the survey area in 1969. The price varied from $12 to $17 per calf. This was due to two factors. Firstly, the opening beef schedule price is announced in January whereas calves are sold for beef raising four months earlier. Hence, the price decided on by the buyer and seller depends on their expectation of a change in the beef schedule from the previous year. Secondly, calves are usually bought privately which is an imperfect pricing mechanism because it takes some time for changes in the market price to be disseminated throughout a district.

5.3 CASE FARM I

5.3.1 General Outline

The dairy farm consists of 225 acres of sandy soil and is situated at Glen Oroua, 20 miles from Palmerston North.

The farm is made up of two blocks. The "home" farm is 120 acres consisting of 110 acres of flat land with two sand dunes of five acres each. The area is all in grass and is subdivided into 23 paddocks. The "runoff" is half a mile from the "home" farm with a main highway forming access between the two blocks. The runoff consists of 105 acres of flat land bisected by a sand dune. This area is all grassed and is subdivided into 11 paddocks.

The "home" farm has a modern house, an 11 aside herringbone milking shed, a calf rearing shed, an implement shed and two hay barns, while the runoff has a hayshed and a new set of cattle yards. Both areas have good high pressure water supply systems provided from bores on each block.

a) Climate and Soils

The farm has an annual rainfall of 33 inches which is evenly distributed between the Winter and Summer. However, rainfall for any particular Spring, Summer or Autumn month is quite variable between years (see Table 5.1).

TABLE 5.1

CASE FARM I

Month	Rainfall (inches	
	Average Year	Range 1/
October	3.8	0.2 - 6.1
November	3.3	0.9 - 6.0
December	3.3	0.5 - 9.1
January	3.0	0.8 - 6.4
February	3.0	0.6 - 4.0
March	2.4	0.6 - 8.2
April	3.3	0.4 - 4.8

1/ Range over the last 13 years.

Source: Meteorological Observations (1957 - 69): Anon. (1957).

The warm summer temperatures and windy climate reduce the effectiveness of summer rainfall on this sandy soil, so that even average rainfall over the December to March period is associated with a rapid decline in grass growth.

The "home" farm consists of a medium fertility Foxton Black Sand with a high water table. This area provides good Summer grass growth, relative to many other sand country soils, but it tends to get very wet in the Winter owing to the height of the water table. The soil type on the runoff is a low fertility Himatangi Sand with a low water table. This area complements the "home" farm by providing a good stock wintering area but it dries out very quickly during the Summer.

b) Stock Numbers and Production

The stock wintered in 1968 were as follows:

140 Jersey Friesian cross cows,

50 crossbred yearling heifers,

and 105 Friesian yearling bulls.

In the 1968/69 season, 39,000 pounds of butterfat were produced from 125 cows. Sixty yearling bulls were slaughtered between December and May at 370 to 420 pounds carcase weight and 40 yearling bulls were sold at auction from August to November. Fifty bull calves were reared with the heifer calves on calfeterias whilst the remaining 55 bulls were purchased as weaners in May. Hay was the only supplementary feed used; 1500 bales were produced on the farm and 2500 bales were purchased.

c) Financial Position

The farmer has a 40 percent equity in the land and buildings. He has an overdraft with a stock firm which also provides short-term finance for purchasing beef cattle. The level of indebtedness means that the total net revenue from the farm must be maintained at least as high as the present level and the farmer is unable to decrease his work load with, say, more beef production unless this results in a higher continuing net revenue.

d) Personal and Labour Considerations

The farmer, who was in his thirties, is married with three sons aged 10, 11 and 13. Some farm work is done by the farmer's wife and family which is mainly calf rearing and stock shifting during the August school holidays. In addition, one permanent single man is employed and casual labour is employed for a month through the Federated Farmers Group Labour Scheme.

e) Management

The two blocks are run together, and stock are transferred between the areas according to the grass available. The milking herd is given priority on the home farm and only in an exceptionally dry season would it be grazed on the runoff during lactation. The bulls are usually grazed on the runoff after they have reached six months of age although small groups of bulls are sometimes brought back to the home farm for a few weeks prior to slaughter. All other stock (heifer and bull calves, yearling heifers and dry cows) are allocated to each area depending on the feed position. The yearling heifers were grazed off the farm from January 1969 until May 1969 owing to the very dry conditions that Autumn, but future heifer grazing is only available on a 12 monthly basis from May until the following April.

In the past, half the hay required, or more, has been purchased depending on Spring-Summer growth. The price of hay has increased by 50 percent, from 40 to 60 cents per bale in the last three years and the farmer is endeavouring to harvest more hay on the farm.

This farm is subject to wide fluctuations in grass growth during the Spring, Summer and Autumn months due to the variation in the rainfall over these months. This factor is simplified in the linear programming model by using fixed average coefficients for the feed supply of the farm.

However, it was not possible in the time available, nor was there sufficient data, to use a more sophisticated technique to simulate the uncertainty facing the commercial farmer with respect to climatic conditions and grass growth. Hence, it is very important to combine beef and hay making policies with the milking herd in a way that allows flexibility in the system over the critical Summer months.

f) Summary of the Important Coefficients for Case Farm 1

a) This farm is concerned with beef production from Friesian and Friesian cross bulls.

b) Thirty percent heifer replacements are required.

c) The average butterfat production is 315 pounds per cow.

d) Purchased hay costs 60 cents per bale.

e) Hay produced on the farm costs 30 cents per bale.

f) Heifer grazing may be purchased for $24 per year per beast.

g) The cost of labour for a single man is $1,560 per year or $30 per week.

h) The beef incentive payment of $10 per head is included for activities P_{13}, P_{14}, P_{17}, and P_{18}.

5.3.2 Solutions for Case Farm 1

The parametric solutions to case farm 1 are given in Appendix 4. At each of seven discrete beef price levels 1/, the milk price has been varied continuously over the range 20 - 38 cents per pound butterfat.

5.3.3 Parametric Solutions

At each beef price level, a series of optimum plans have been derived. For each plan the main physical and financial factor levels have been given. These are the net revenue, milk production, permanent labour hired, the number of beef calves and weaners purchased, the number of beef cattle sold at 13, 15 and 18 - 22 months of age and the total

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1/ The seven beef price levels corresponds to a beef schedule price of $13.50, $15.50, $17.50.......$25.50 per 100 pounds. See Appendix 3.

number of dairy cows. The combination of these activities in each plan has been tabulated against the milk price to produce a set of one-price variable solutions 1/.

For example, at beef price level 1 2/, there are six plans which are optimum within the milk price range 20 to 38 cents. The first plan (plan A_1) is optimum from 38.00 cents down to 25.61 cents per pound butterfat. At 25.60 cents, plan C_1 becomes optimum involving a decrease in milking cow numbers and an increase in the level of beef activities. Similarly, when the milk price is lowered to 25.10 cents, 24.70 cents and 24.20 cents plan M_1, F_1 and G_1, respectively, become optimum. Finally, at 24.10 cents per pound butterfat, plan H_1 becomes optimum. Plan H_1 remains the optimum plan until the milk price falls below 20 cents.

There are seven sets of solutions similar to the one described above for this farm, one for each beef price level. 3/

Each set of solutions provides a normative butterfat supply function. That is, a functional relationship between butterfat output and the milk price 4/ (expressed per pound butterfat). Alternatively, a single plan can be taken from the parametric solutions. The plan is the optimum at the milk to beef price ratio at which it occurs in Appendix 4.

5.3.4 The Presentation of Parametric Solutions

The divisibility assumption of linear programming allows the factors (resources and products) to be produced or used in fractional units. In most cases, no significant error results from rounding the activity levels to the nearest whole number and this procedure was adopted here. One exception is the labour hire activity (P_{30}), in which case

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1/ See, for example, Heady and Candler (1963).

2/ See Appendix 4.

3/ Similarly for case farms 2 and 3.

4/ This is explained and presented in Section 5.5.2

fractional units of labour can be incorporated by employing casual labour or contractors for tasks like cattle spraying, fencing, hay cartage and drain cleaning. Hence, the units of labour hired have not been rounded and fractional units should be interpreted as casual labour or contractors employed for part of a year.

In the parametric procedure used in this study a series of plans are derived at each beef price level. In many cases the same physical plan is obtained at more than one beef price. That is, the plans have identical enterprise combinations. However, the net revenue and the shadow prices of excluded activities and the restraints are different.

The identical physical plans are given the same code (say plan A) in the presentation of the parametric solutions. Hence, a particular plan is referred to by its code and the beef price level (1 - 7) at which it occurs. For example, plan A occurs at five beef price levels (A_1, A_2, A_3, A_4 and A_5).

In order to simplify the presentation of the parametric solutions, the beef activities P_{13}, P_{14} P_{17} and P_{18} have been aggregated in pairs on basis of the class of stock purchased or sold. This procedure may be carried out because the growth rate of the beef cattle in each of these activities is the same at a given point of time. The feed requirements only vary with the time of purchase (calves or three months old weaners) and the time of sale (13 or 18 - 22 months of age). For example, the total number of store yearling cattle sold is the level of activity P_{13} plus the level of activity P_{17}. This procedure has also been adopted for purchased three months old weaners (P_{17} plus P_{18}, adjusted for the respective losses), and beef cattle slaughtered at 18 - 22 months of age (P_{14} plus P_{18}).

5.3.5 The Farmer's Future Policy

A wide range of milk and beef prices have been used owing to the future price uncertainty for these products on world markets 1/. However, in the 1969/70 season the milk price is expected to be 33 cents per pound butterfat 2/ and the beef price is assumed to remain at the 1969 schedule of $21.50 per 100 pounds bull beef 3/.

The farmer's present policy was compared with the optimum plans, with and without the Government beef incentive payment 4/, at the above milk and beef prices. The optimum plan with the incentive payment is plan F_5 and without the incentive payment the optimum is plan A_5. The physical plans with their net revenues are given in Table 5.2.

Firstly, considering the plans including the incentive payment in Table 5.2. At 1969/70 prices, the optimum plan (F_5) indicates that the farmer should increase beef production and decrease milk production to earn an extra $1,356 net revenue.

1/ See Section 3.2.3.

2/ The farmer expected the total payout to be 33 cents for whole-milk to be compared with his average return for the last three seasons of 35.5 cents per pound butterfat.

3/ For the weight range 376 - 550 pounds carcase weight.

4/ This second comparison was included to show the effect of removing the incentive payment on this farmer's optimum plan. For the details of the incentive payment see Section 2.9

TABLE 5.2

PLAN COMPARISONS - 1969/70 PRICES [1]

CASE FARM I

Milk price - 33 cents per pound butterfat

Activity	Activity Code	With incentive payment		Without incentive payment	
		Farmer's Plan	Optimum Plan F_5	Farmer's Plan	Optimum Plan A
Milking cows	P_1	125	68	125	186
Milk production (lbs butterfat)	P_8	37,700	20,704	37,700	57,726
Nurse cows	P_6	-	23	-	-
Total cows	-	125	91	125	186
Beef calves purchased (4 day old)	P_9	-	25	-	-
Beef weaners purchased	$P_{17}+P_{18}$ [2]	55	153	55	-
Total calves reared (incl. heifers)	-	90	90	90	61
Store cattle sold [3]	$P_{13}+P_{17}$	40	79	40	-
Beef cattle sold [4] (15 months)	P_6	-	46	-	-
Beef cattle sold (18 - 22 months)	P_{18}	69	79	60	-
Hay purchased (bales)	P_{20}	2500	-	2500	15
Heifer grazing	P_{29}	on-farm	off-farm	on-farm	off-farm
Permanent labour hired (single man)	P_{30}	1.0	-	1.0	1.4
Net Revenue ($)	-	16824	18180	15774	17258

Note:
1. All plans are computed at beef price level 5 ($21.50) and milk at 33 cents per pound butterfat.
2. The total number of weaners purchased takes account of deaths.
3. The farmer sells store cattle from 13 - 16 months of age, whereas in the optimum plan they are sold at 13 months.
4. These cattle have been reared on nurse cows (P_6) at 2 calves per cow.

a) Feasibility of the Optimum Plan

If the farmer adopted plan F_5, a number of enterprise and management changes would have to be made to his present policy.

The number of cows would be decreased by 34 and beef cattle increased by 104. This apparent substitution (between the farmer's plan and plan F_5) of approximately three extra beef cattle per dairy cow replaced is achieved by grazing the 27 replacement heifers off the farm in the optimum plan whereas the farmer carries 38 heifers on the farm at present. When the feed requirements of the stock wintered on the farm are expressed in ewe equivalents 1/ (Table 5.3), it can be seen that the Winter stocking rate in the optimum plan is similar to that with the present policy.

TABLE 5.3

WINTER STOCKING RATE COMPARISON

Class of Stock	Feeding Standard E.E. a/	Farmer's Plan		Optimum Plan F_5	
		No. Stock	E.E.	No. Stock	E.E.
Dairy cows	7.5	125	938	91	678
Replacement heifers	3.5	38	133	-	-
Yearling beef cattle	4.0	100	400	204	816
Total E.E.'s			1,471		1,494

Note: a. Ewe Equivalents.

The other major policy difference between the plans is that in plan F_5, all the hay required (4,122 bales) is produced on the farm, whereas the farmer buys 2,500 bales of hay. The stocking policy in the optimum plan has enabled the extra hay to be harvested on the farm because,

(a) in the optimum plan, 62 percent of the beef cattle are sold

1/ For an explanation of this feeding standard see Coop (1965).

in the Spring[1/], whereas the farmer at present only sells 40 percent in the Spring,

and (b) in the optimum plan the beef weaners are not purchased until December.

These two changes allow more paddocks to be closed and cut for hay in October and November between the sale of the yearling beef cattle and the purchase of the beef weaners.

The plan requires 153 three months old weaners to be purchased [2/]. The proportion of beef cattle purchased as calves or weaners depends on the relative calf and weaner prices, the cost of labour to rear calves and the value of the spring grass required to feed calves (if they are reared rather than purchased as weaners). The plan is very sensitive to variations in the price of these alternatives and in the practical situation the number of weaners purchased and/or calves reared in this plan would depend on the particular price situation. For example, one of the activities requiring the purchase of three months old weaners is P_{17}. For this activity, the weaner purchase price would only have to increase from $36.00 per weaner [3/] to $39.25 and a new optimum plan would be derived, provided all other prices remained constant. The stability of the optimum plans will be discussed further in Section 5.5.

The cash surplus of the optimum plan (F_5) is given in Table 5.4 at 1969/70 prices. The increase in net revenue that could be obtained by adopting plan F_5 over the present plan is $1,356 but the optimum plan is estimated to require an additional $2,400 for stock purchases and working

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1/ Made up of 30 percent in October (P_{13} plus P_{17}) and a further 23 percent in late November (P_6).

2/ The total weaners required by P_{17} and P_{18}.

3/ This is the weaner cost in plan F_5, see Appendix 3.

capital. This finance would be available through the Dairy Industry Beef Scheme [1] at a three percent interest. The interest on the additional borrowing has been added to the overhead costs in order to calculate the post-tax profit for the two plans which is given in Table 5.4.

TABLE 5.4

CASH SURPLUS COMPARISON - PLANS WITH BEEF INCENTIVE PAYMENT

CASE FARM I

1969/70 prices

	Farmer's Plan	Optimum Plan F_5
Net Revenue $	16,284	18,180
Post-tax Cash profit [2] $	4,021	4,679
Personal Drawings $	3,500	3,500
Cash Surplus $	521	1,179

The cash surplus is the amount available for capital expenditure, debt reduction (other than principal repayments on table mortgages which are included in the overhead costs), off-farm investment or extra personal spending.

b) The Influence of Price Variation on Plan F_5

If the farmer adopted plan F_5 and the milk to beef price ratio increased, then this plan may not remain optimum.[3] The optimum plan for the changed price situation would include more milking cows than

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1/ See Section 2.9.

2/ The post-tax cash profit is the net revenue less the overhead costs (interest, principle repayments, rates and insurance), less costs which are common to both milk and beef production (fertilizer, repairs and maintenance, vehicle expenses, etc.), less income tax calculated for tax code M3 using 1970 tax tables.

3/ See Appendix 4.

plan F_5. However, it would take some time to increase the size of the milking herd by breeding. Hence, it is important that, in the event of an increase in the milk to beef price ratio, plan F_5 be financially feasible to give the farmer time to reach the new optimum by increasing the size of the milking herd.

In Table 5.5, the cash surplus is given for plan F_5 at three milk and four beef prices. Plan F_5 is only optimum at the intersection of the 33 cent milk price and the $21.50 beef price. That is, at the other price ratios, some other plan is optimum. However, assuming that the farmer is committed to plan F_5, he could except a cash surplus provided the beef price was greater than $17.50 per 100 pounds or provided the milk price was greater than 33 cents per pound butterfat. This farmer will, therefore, remain in part milk and part beef production (with a plan similar to F_5) unless the beef price falls to $17.50, in which case the farmer would be forced to consider moving out of beef production into all milk production or some other enterprise.

TABLE 5.5

CASH SURPLUS WITH VARIABLE PRICES - PLAN F_5

CASE FARM I
(including beef incentive payment)

Milk Price (cents per lb butterfat)

Beef Price ($ per 100 lbs)		36	33	30	Beef Price Level
	17.50	$82	-$296	-$697	3
	19.50	$813	$479	$126	4
	21.50	1447	$1179	$843	5
	23.50	1924	$1710	$1471	6

c) The Farmer's Attitude to Plan F_5

The farmer considers that plan F_5 is a workable plan and, to this end, he intends to increase beef production in the 1970/71 season. The single man is leaving at the end of the present season and may not be replaced.

If plan F_5 was adopted, the beef cattle would be split into two groups. One group of 94 bulls would be grazed on the runoff all year and the other group of 110 bulls would be grazed on the home farm in a separate area from the milking herd. The nurse cows (P_6) would be selected from the poorer producing cows and run as one group on the runoff as soon as the farmer was confident that the "mothering-up" operation had been successful.

Of the 90 calves reared in the optimum plan, 46 are suckled on nurse cows for nine months (P_6). The remaining 44 calves (including 30 heifer calves) could either be reared on nurse cows (three per cow) for 8 - 10 weeks or on a calfeteria, since the feed and peak labour requirements of the calves are assumed to be the same for both systems.

However, the farmer would retain some flexibility if he adopted a plan similar to F_5. For example, the time of purchasing weaners, selling store cattle in the Spring and the amount of hay harvested on the farm would depend on the pattern of grass growth. In the event of a dry Summer, weaner purchases would be spread over the Summer, Autumn and early Winter according to the feed available. Similarly, the store cattle would be sold after the incentive payment becomes due but the exact time of sale would depend on store cattle prices and the Spring feed available for stock and hay making. The farmer would also employ casual labour to rear extra calves if he was unable to obtain contracts with other dairy farmers to rear the calves for him, owing to the difficulty of buying the number of weaners required by plan F_5 in December. Casual labour may also be employed from the Federated Farmers group labour scheme to assist with drenching and cattle spraying in the Autumn.

d) The Effect of the Beef Incentive Payment

The farmer is confident that product prices will continue to favour increased beef production and hence, he proposes to increase beef cattle numbers. At the same time, he is aware that, if the beef price falls or the beef incentive payment is removed, then the most profitable policy would be one involving increased milk production. This is shown in Table 5.2 in the comparison between the farmers policy and the optimum plan at present prices without the beef incentive payment. In this situation, Plan A_5 would increase the farmer's net revenue by $1,484 above the present policy, but after tax, fixed charges and personal drawings have been deducted this difference would be reduced to $870, as shown in Table 5.6.

TABLE 5.6

PLANS WITHOUT INCENTIVE PAYMENT

CASE FARM I

	Farmer's Plan	Optimum Plan A_5
Net Revenue $	15,774	17,258
Post-tax Cash profit $	3,414	4,284
Personal Drawings $	3,500	3,500
Cash Surplus $	-86	784

Table 5.6 indicates that without the beef incentive payment the farmer may have to increase the milking herd (to say, plan A_5) in order to meet his fixed charges, since his present policy would result in a cash

deficit of $86 without the beef incentive payment.

The farmer considers that the all-cow policy (plan A_5) would be feasible on his farm because the runoff is reasonably close to the milking shed (half a mile away). However, if this policy was adopted, all the hay could be harvested from the runoff in order to reduce the number of times the cows had to be grazed off the home farm. The 1.4 labour units required for plan A5 could be incorporated by employing a married man (instead of the 1.4 single men) for whom a house is available on an adjoining farm. A salary of up to $2,184 1/ per year could be paid to the married man.

To summarize, the beef incentive payment has two main effects on case farm 1. Firstly, the farmer receives an increase in net revenue of $1,050 without changing his present policy but if he increased beef production (plan F_5), the net revenue on this farm could be increased a further $1,356. Secondly, if the beef incentive payment was removed at present prices, the farmer could increase his net revenue $1,484 by adopting an all milk production policy (plan A_5). Hence, unless the farmer is assured that the beef price will increase on 1969/70 prices, he is unlikely to decrease milk production beyond that in plan F_5, in response to the incentive payment. Furthermore, if the incentive payment is removed or decreased, the farmer may tend to increase milk production.

5.3.6 Variation in the Beef Price

In order to illustrate the wide range of physical plans given in Appendix 4, five plans have been selected for detailed analysis.

1/ That is, 1.4 times the salary paid to a single man ($1,560).

These five plans are the optimum combinations of milk and beef production at a milk price of 32 cents per pound butterfat for each beef price level (1 - 7). However, plan A is the optimum enterprise combination at beef price levels one, two and three (A_1, A_2 and A_3) and therefore only the last beef price is given in the comparison, that is, plan A_3.

In other words, the optimum plan, at 32 cents per pound butterfat, was selected from each beef price level (A_1, A_2, A_3, E_4, G_5, H_6, J_7), but since plan A occurs at three beef prices the first two plans (A_1 and A_2) were omitted from the discussion. The last five plans (A_3 - J_7) are given in Table 5.7 for the fixed milk price and the net revenue of each plan has been recalculated at this price. The recalculation was necessary since the net revenue of each plan in the parametric solutions is calculated at the "border" milk price. For example, plan G_5 is stable over the range 30.8 to 32.3 cents per pound butterfat and the net revenue given in Appendix 4, is calculated at 32.3 cents which is the upper "border" price.

It can be seen from Table 5.7 that beef production does not substitute for milk production until the beef price exceeds $17.50, when the milk price is 32 cents. Above $17.50, beef cattle replace milking cows until at $25.50 the optimum plan has no milking cows.

The predominantly beef plans are characterised by the large numbers of beef weaners purchased rather than reared from calves on the farm, because it is not profitable to hire permanent labour solely for calf rearing. However, it will be shown in a following section, that the farmer could profitably employ casual labour over the Spring to either rear calves or to perform other duties which enabled the farmer to rear more calves. If this labour was available more calves could be reared and the number of purchased weaners could be reduced.

TABLE 5.7

THE EFFECT OF VARIATION IN THE BEEF PRICE

CASE FARM I

Milk Price - 32 cents per pound butterfat

Activity	Name	Plan-Beef Price				
		A_3 $17.50	E_4 $19.50	G_5 $21.50	H_6 $23.50	J_7 $25.50
Milking cows	P_1	186	73	38	28	-
Milk Productions (lbs butterfat)	P_8	57,726	22,498	9.575	6,020	-
Nurse cows	P_6	-	23	17	16	12
Total cows	-	186	96	55	44	12
Calves purchased	P_9	44	11	117	146	229
Weaners purchased (3 months)	P_{17},P_{18}*	-	155	155	156	136
Store cattle sold (13 months)	P_{13},P_{17}	-	74	136	144	169
Beef cattle sold (15 months)	P_6	-	46	34	32	24
Beef cattle sold (18-22 months)	P_{14},P_{18}	-	76	108	121	143
Heifer grazing	P_{27}	Off-farm	Off-farm	Off-farm	Off-farm	Off-farm
Labour hired (Single man)	P_{30}	1.4	-	-	-	-
Net Revenue	$	15741	16603	17757	19646	21708

Note:

1. All figures rounded.

*2. The levels of P_{17} and P_{18} have been adjusted for death rates.

3. The net revenue has been recalculated on the basis of 32 cents per pound butterfat.

The production of store yearling cattle (which receive the incentive payment) from calves or purchased three months old weaners is a very profitable beef policy and one of these activities (P_{13} or P_{17}) is present in all beef plans. These activities were specified because beef cattle which are run on the dairy farm for a minimum period of nine months (January to September inclusive) qualify for the incentive payment of $10 per head.

Table 5.7 and the preceeding discussion has aggregated the beef activities P_{13} and P_{17} in terms of the class of stock sold. However the valid [1] price ranges of these activities are given separately in the following table owing to the difficulty of aggregating the valid ranges of these two activities.

The valid price ranges, of the activities in the basis are given in Table 5.8. If the net revenue (or price) of an activity in the plan moves outside this range (or stability limit), then the optimum plan will change.

1/ The valid price range is that range of prices (for the factor being varied) over which the optimum plan is stable.

TABLE 5.8

NET REVENUE STABILITY LIMITS

CASE FARM I

(Milk price - 32 cents per pound Butterfat)

Activity	Name	Plan	Upper Limit	Current Net Revenue	Lower Limit
Milk (cents per lb butterfat)	P_8	A_3		32	31.9
		E_4	32.2	32	31.3
		G_5	32.4	32	30.9
		H_6	32.6	32	28.9
		J_7	32.8	32	0.0
Bull Beef ($ per 100 lb)	P_{15}	E_4	20.2	19.5	19.3
		G_5	22.8	21.5	21.4
		H_6	24.7	23.5	22.9
		J_7	27.4	25.5	25.4
Store cattle ($ per beast)	P_{13}	G_5	72.4	70.5	70.4
		H_6	79.0	76.5	75.6
		J_7	84.4	82.5	82.2
	P_{17}	E_4	33.6	29.25	27.9
		G_5	33.6	33.25	30.4
		H_6	38.6	37.25	33.4
Nurse cows ($ per cow)	P_6	E_4	19.3	12.6	10.1
		G_5	14.0	12.6	3.4
		H_6	20.7	12.6	4.4
		J_7	14.5	12.6	6.8
Heifer grazing ($ per heifer per year)	P_{29}	A_3	-43.8	-24.0	+37.6
		E_4	-33.9	-24.0	-20.5
		G_5	-38.4	-24.0	-23.3
		H_6	-43.5	-24.0	-17.2
		J_7	-43.2	-24.0	-23.2

The stability limits indicate that the optimum plans are sensitive to price changes when beef production is combined with milk production (plans E, G, H and J.). The instability is caused by the adjustments which are made to the combinations of correlated beef activities over small price intervals (mainly P_{13}, P_{14}, P_{17} and P_{18}). That is, the labour (X_{10}), feed (X_{11-27}) and calf supply (X_2) restraints cause adjustments to be made to the numbers of calves reared and weaners purchased over a narrow range of prices. This implies that seasonal feed and price fluctuations will cause variations in the optimum combinations of beef activities even at high beef prices (say, $25.50) and that the purchasing and marketing skill of the farmer will be an important criterion of profit.

The activities which produce yearling and 18 months old beef cattle (P_{13}, P_{14}, P_{17} and P_{18}) are the most profitable beef policies at the assumed prices.

Replacement heifers are grazed off the farm in all plans and the valid price ranges indicate that the farmer can pay up to $33.9 in plan E_4 and up to $43.8 in plan A_3 per heifer per year for off-farm grazing before the plans will change.

The imputed values of the restraints are given in Table 5.9. The imputed values indicate the increase in net revenue that would be earned if the restraint was relaxed by one unit. The imputed value will remain constant as the restraint is relaxed until another factor becomes limiting. If the restraint is relaxed beyond this range (valid range) the imputed value will decrease.

The imputed values of the feed restraints indicate that September and March feed becomes more limiting as the optimum tends to the all beef policy (J_7) 1/, whereas Autumn-Winter feed becomes less limiting.

1/ That is, the imputed value of scarce September and March feed increases.

TABLE 5.9

IMPUTED VALUES - CASE FARM I

Restraint	Row Name	Units	Imputed Values				
			A_3	E_4	G_5	H_6	J_7
September feed	X_{12}	1-lb D.O.M. per day	-	-	0.4	1.6	2.1
March feed	X_{18}	" "	-	1.7	1.9	2.9	3.2
Autumn-Winter feed	X_{11}, 19-22	" "	1.0	0.5	0.5	-	-
Spring labour	X_{10}	1 c.r.u.	10.7	10.3	7.8	5.8	4.1

Note: 1. Digestible Organic Matter (D.O.M.), see Appendix 1.
2. Calf rearing unit (c.r.u.), See section 5.2.1.
3. All figures rounded.

The imputed value of the Spring labour restraint (X_{10}) is of particular interest on this farm because no provision has been made for hiring casual labour over the Spring when labour demand is expected to be at its peak. If casual labour was available at this time, it could be profitably employed in plans E, G and H, because one man could rear 200 calves in 18 weeks (August to November) for $50 per week [1]. Thus, the labour cost per calf reared would be $4.50. When the imputed value of X_{10} is greater than $4.50 per calf rearing unit (as in plansA, E, G and H) it would be profitable to hire specialist calf rearing labour [2]. The availability of such labour would determine the proportions of calves reared and three months old weaners purchased in plans E, G and H. Casual labour can not be employed in plan A

1/ This is the gross wage.

2/ The question of how much casual labour could be profitably hired for these plans is not known because the computer programme used in the analysis did not calculate the range over which the imputed value remained constant. However, because casual labour was not considered to be an alternative, this loss of information was not great.

(as a substitute for permanent labour) because milking cows require a continuing high labour input throughout lactation and not only during the Spring.

TABLE 5.10

BASIS VALUES FOR EXCLUDED ACTIVITIES

CASE FARM I ($)

Policy	Excluded Activity	Price or Value	Plans				
			A_3	E_4	G_5	H_6	J_7
Selling 3 months weaners	P_{11}	Current Basis	28.0 37.1	30.0 38.1	32.0 38.2	34.0 40.2	37.0 40.1
Selling 6 months weaners	P_{12}	Current Basis	33.0 38.6	35.0 43.5	37.0 45.0	39.0 49.3	42.0 49.7
Buying 6 months weaners	P_{19}	Current Basis	-38.0 -13.6	-40.0 -26.0	-42.0 -28.5	-44.0 -29.3	-46.0 -31.0
Buying Hay (1 bale)	P_{20}	Current Basis	- -	-0.60 -0.45	-0.60 -0.48	-0.60 -0.45	-0.60 -0.41
Permanent labour (1 single man)	P_{30}	Current Basis	- -	-1560 -1494	-1560 -1124	-1560 - 844	-1560 -598

Note:
1. The basis price is the net revenue required by the policy before the activity will enter the basis.
2. The current prices are given in Appendix 3.

The shadow prices (imputed values), have not been listed for excluded activities. Instead, the basis value has been given for the excluded activities in Table 5.10. The basis value is the price which must be paid (or received) before the activity will enter the optimum plan 1/. Each basis value is compared with the current value (or the price used in the analysis at the particular price level). For example, in Table 5.10, if the selling price of three months old weaners was $38.2 (basis value) instead of $32.00 (current value), then this activity (P_{11}) would enter the basis at the $21.50 beef price ($G_5$). As for the imputed value of the restraints, the basis value is constant only over a particular (valid) range. That is, until another restraint becomes limiting. In plan G_5, three and six months old weaner production (P_{11} and P_{12}) would enter the optimum plan if the farmer could obtain $38.2 and $45.00 per weaner respectively, at present prices. 2/ However, 18 months old beef cattle production from purchased six months old weaners would not compete with other beef policies until the purchase price was reduced to $28.5 per weaner in plan G_5, all other prices remaining constant.

5.3.7 Normative Beef Supply Response

The normative beef supply response is given in Figure 5.1 for case farm 1 at three milk prices, 27, 31 and 35 cents per pound butterfat. The change in beef supply (or output) corresponding to a discrete change in the beef price (Figure 5.1) is normative in that

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1/ That is, the basis value is the sum of the shadow price and the net revenue (current price).

2/ All other beef prices remaining constant (Level 5).

it points out the policies the farmer _should_ adopt in a certain price environment. However, it takes no account of price uncertainty or objectives other than profit maximisation. Much more information would be required [1/] to measure how the farmer _will_ respond to changes in the beef price [2/].

The beef supply response was derived by calculating the net beef output of the optimum plan for the three milk prices at each beef price level. This procedure was adopted because the matrix contained 12 beef price correlated activities, only four of which were linked with the beef selling activity P_{15}. Thus, it would have been difficult to parametize the correlated beef prices in the usual way (Candler, 1957). Furthermore, the parametric solutions were computed for $2 intervals in the beef price which enables the general form of the supply response to be seen.

The beef supply response is given as a series of points representing the net beef output of the optimum plan corresponding to the particular milk to beef price ratio. The method of analysis made it difficult to estimate the valid beef price ranges (that is, the vertical segments) over which the optimum plans are stable.[3/]

The author considered that, whilst further "steps" could have been

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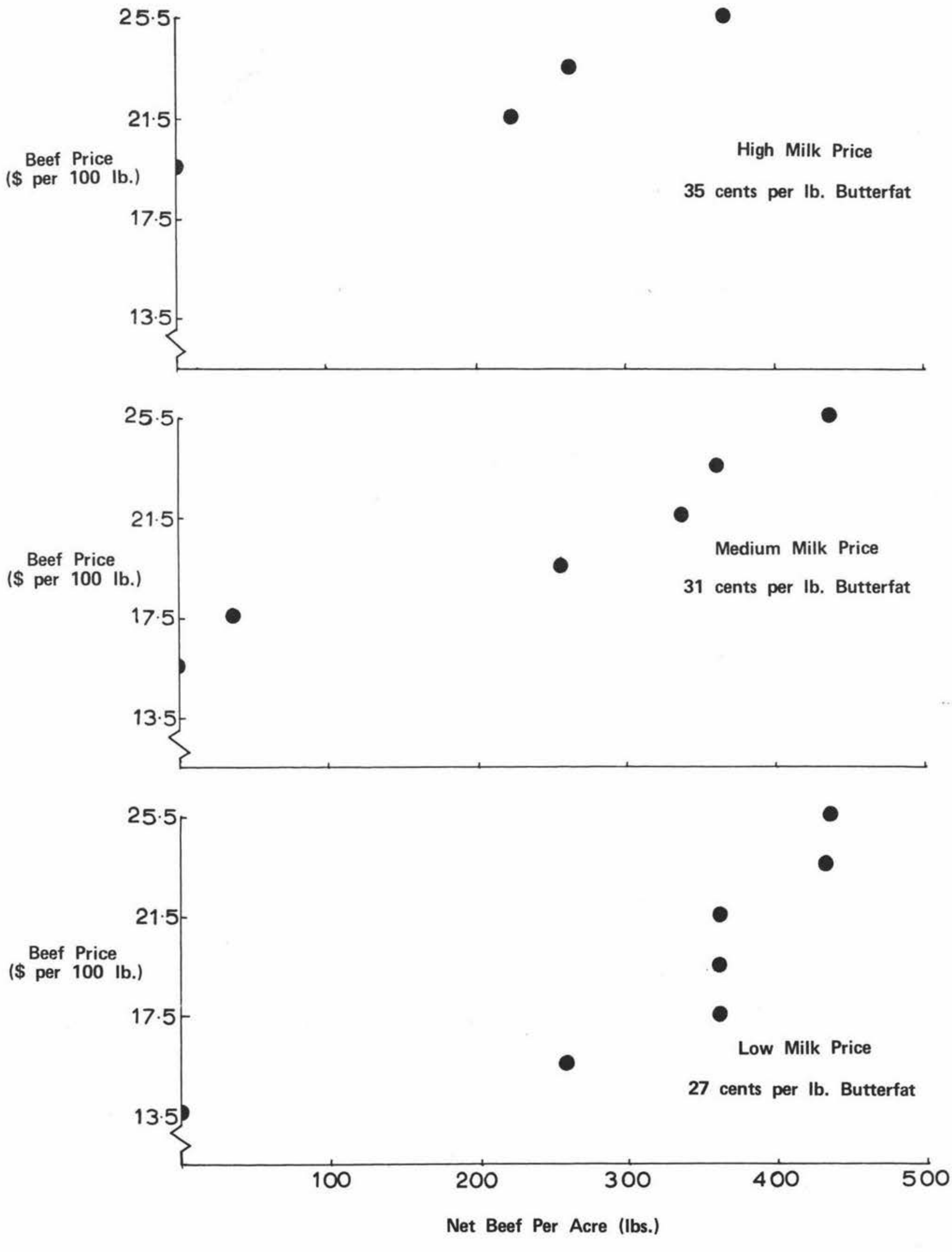
1/ Which may include the farmer's _risk preference_ and _attitude_ to future product prices.

2/ That is, a positive supply function.

3/ While it would have been possible to carry out this analysis, the author considered that the extra information obtained would not warrant the additional computation.

CASE FARM 1

Figure 5.1 NET BEEF SUPPLY RESPONSE



added to the function, had the extra analysis been done, the points given at $2 price intervals are sufficient to provide an indication of the beef supply response.

The net beef production is the gross beef output per acre (pounds) from store and slaughtered beef cattle less the weight of beef purchased as calves and/or weaners. This includes the cow beef produced by activity P_6 (and P_7 if it had entered the plans) because nurse cows, rearing calves for nine months, are part of the beef rather than the milk enterprise.

5.3.8 Normative Butterfat Supply Function

In Figure 5.2 the normative butterfat supply function is given for three beef prices, $15.50, $19.50 and $23.50 per 100 pounds of beef. The function is expressed in terms of the quantity of butterfat produced because milk is sold on this basis. The normative butterfat supply function was obtained directly from Appendix 4 at beef price levels 2, 4 and 6 and is presented with the usual arrangement of co-ordinates(Heady and Candler, 1963).

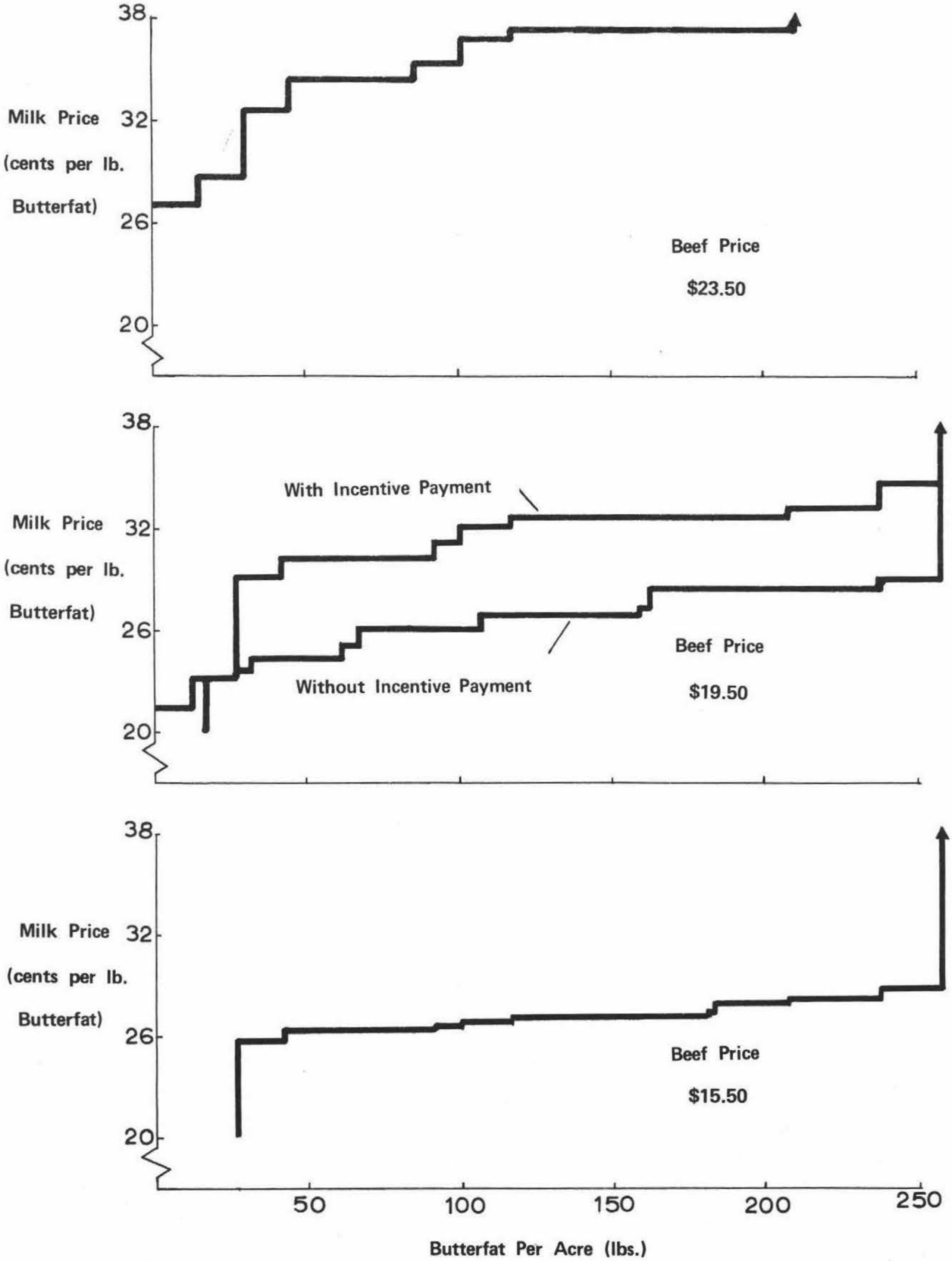
At the second beef price ($19.50), two normative butterfat supply functions are given. The first, derived as above, includes the incentive payment of $10 per beast in the net revenue of activities P_{13}, P_{14}, P_{17} and P_{18}. The second supply function was derived at the same beef price level except that the incentive payment was removed from the net revenues of the activities given above.

The difference between the two functions shows the increased profitability of beef production which is attributed to the incentive payment. That is, at any given milk price, less butterfat is produced with the beef incentive payment and correspondingly, beef production is increased.

Figure 5.2

CASE FARM 1

NORMATIVE BUTTERFAT SUPPLY FUNCTION



The difference between the "incentive" and the "non-incentive" butterfat supply functions indicates the value of the incentive payment at the $19.50 beef price. Over the central milk production range (100-200 pounds butterfat per acre), the incentive payment decreases the milk price, by 4.6 to 6.4 cents per pound butterfat, at which a given level of milk is produced. This value is high because 40 - 50 percent of the beef output from case farm 1 is produced from store beef cattle. These store cattle (activities P_{13} and P_{17}) have been on the farm for the minimum period to qualify for the incentive payment. Therefore, the incentive contributes more per pound of meat added than is the case with activities in which the cattle are carried for a longer period. This means that if the beef incentive payment was removed, the net revenue of the beef enterprises (especially store beef enterprises) would be markedly reduced, thus making dairying relatively more profitable.

5.4 CASE FARM 2

5.4.1 General Outline

This farm is 126 acres of flat land situated 10 miles west of Palmerston North. The farm is all in pasture, except for two acres of bush, and is subdivided into 34 paddocks. The farm has a house, a 15 aside herringbone milking shed, a wintering platform and two haybarns.

a) Soils and Climate

The soil is a fertile Manawatu silt loam which only requires low rates of fertilizer (1.5 - 2 cwt superphosphate) to maintain good grass growth. The farm has been tile and mole drained since the paddocks tend to get very wet during the Winter but even with this extensive drainage, stock have to be put onto the wintering pad or into the bush area for at least 14 days in the Winter.

The farm has a well distributed 35 inch rainfall but the area can suffer from dry conditions in February and March. Cold windy conditions in the early Spring may reduce grass growth in this period also.

b) Production

The stock on the farm at July 1968 was as follows:

162 Jersey and Jersey-Friesian cross cows and heifer replacements,

35 yearling heifers,

and 2 bulls.

In the 1968/69 season, 48,000 pounds butterfat was produced from 153 cows, 2,000 bales of hay were made on the farm that season and 1,000 bales were bought.

c) Management

The farmer usually grazed heifer replacements off the farm from May until they are due to calve the following year 1/ owing to the wet soil conditions in most Winters. Hence, in May and June, stock numbers are reduced by selling the cull cows in the Autumn and not bringing the heifer replacements onto the farm until July.

The cows begin calving in the first week of July to take advantage of early Spring growth and to ensure that the cows had produced as much milk as possible before the Autumn should a dry spell occur.

d) Reason for Selection

The farm is managed by a sharemilker 2/ who has had some experience with beef production on a property he leases a few miles away on a similar

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1/ That is, from May to July, a period of 14 months.

2/ The sharemilker has a 50 percent/50 percent agreement with the farm owner. For a description of this share farming system, see Anon.(1968A).

soil type. The farm was chosen because it represents a well-developed intensive dairy unit on a Winter - wet alluvial soil. The sharemilking agreement poses special difficulties with beef production on dairy farms, with regard to the distribution of profits and will not be examined in this study. Instead, this analysis assumes that the farm will be managed by the sharemilker within the financial limits of the owner of the property.

e) Labour and Financial

The sharemilker, who is in his early thirties, is married with a young family. A single man is employed for 10 months from July till April and casual labour is available at any time of the year. Contractors are employed for hay baling and drain cleaning, but the sharemilker does his own hay cartage.

The farm owner is in a strong financial position and capital, for stock and seasonal finance, was not expected to limit the alternatives on the farm. As for case farm 1, capital involved in stock and overdraft facilities will be accounted for in the post-computational analysis (ex poste).

f) Alterations to the General Model

Beef Production

The farmer 1/ prefers to consider beef production from Friesian steers since the farm is surrounded by other dairy farms and he is unwilling to accept the risks associated with grazing large groups of bulls.

Feed

The nurse cows for activities P_6 and P_7 are not necessarily cows to be culled at the end of the season. Hence, one unit of activity P_6

1/ Hereafter, the sharemilker will be called the farmer.

requires 16.1 pounds of D.O.M. as grass in June, 3.4 pounds of D.O.M. as hay in May and 7.3 pounds of D.O.M. as hay in June. One unit of P_7 requires 7.7 pounds of D.O.M. as grass in June, 2.0 pounds of D.O.M. as hay in May and 3.3 pounds of D.O.M. as hay in June. These values have been inserted into the matrix (given in Appendix 2) for this case farm and also for case farm 3.

The milking cows on this farm produce 330 pounds butterfat per cow as compared with 315 pounds on case farm 1. However, the difference in production level per cow was not considered to be significantly different in terms of extra feed consumed.[1/] Hence, the feed requirements for milking cows on this farm were assumed to be the same as those used for case farm 1.

Heifer replacements may be grazed off the farm for 14 months from May until the following July at a cost of $27.00 per head.

Bought hay costs 50 cents per bale and hay produced on the farm costs 20 cents per bale.

The feed supply on this farm was calculated from the monthly stock carried on the farm in a normal year by multiplying the stock numbers by the feeding standards derived in Appendix 1. The monthly feed supply is given in the following table.

1/ Significant in the sense that the production per cow difference between the farms was probably due to factors other than any difference in the level of feeding. These "factors" include milking technique and genetic merit.

Month	Feed Supply (lbs D.O.M. per day)
August	2,100
September	3,367
October	4,150
November	3,790
December	3,325
January	3,242
February	2,859
March	2,718
April	2,903
May	2,106
June	1,336
July	1,336

Labour

The proximity of this farm to Palmerston North enables casual labour to be obtained at any time of the year. A single man also may be employed for 10 months (costing $1,100) to assist with milking and general farm work.

This farmer was prepared to milk 110 cows and rear 27 calves on his own which amounts to 247 calf rearing units of Spring labour [1/] (B column value, X_{10}). If a single man was employed for 10 months then the farmer considered that 160 cows could be milked and 40 calves reared (360 calf rearing units). Hence, the single man (P_{30}) supplies 113 units [2/] of Spring labour (X_{10}).

The general matrix has been modified to allow for the possibility of hiring casual labour (P_{35}) specifically to assist with calf rearing over the period August to November. A competent man receiving $50 per week could rear 200 calves over this period (see section 5.4), which amounts to $4.50 per calf reared (net revenue, P_{35}). The inclusion

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1/ Using a linear substitution rate, as in case farm 1, see section 5.2.1

2/ That is, 360 units less 247 units.

of this casual labour hire activity requires an additional restraint to ensure that casual labour is not used to provide labour for milking cows because this latter activity requires permanent labour 1/. In Table 5.11, a sub-matrix is given, outlining the new hire casual labour activity P_{35} and the new permanent milking labour restraint X_{28}.

Input-Output Coefficients

The following coefficients are peculiar to case farm 2:

(a) Milking cows produce 350 pounds of butterfat.

(b) Twenty-five percent herd replacements are required.

(c) The feed requirements of the stock are the same as those used in case farm 1 (see Appendix 2).

5.4.2 Solutions for Case Farm 2

As for case farm 1, parametric solutions were computed for this farm at the seven discrete beef prices 2/ over the continuous range of milk prices from 20 - 38 cents per pound butterfat. These parametric solutions are given in Appendix 5. (The presentation of these solutions was discussed in section 5.3.3).

5.4.3 The Farmer's Future Policy

The farmer's present policy 3/ is compared with the optimum plan at 1969/70 prices both with and without the beef incentive payment in Table 5.12.

The expected total payout for wholemilk supplied in the 1969/70 season by this farmer is 32 cents per pound butterfat and the beef price is taken at the opening schedule in 1970 of $21.50 per 100 pounds

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1/ See section 5.2.1.

2/ See Appendix 3.

3/ Plan P - all milking cows.

TABLE 5.11

CASE FARM 2 - LABOUR SUB-MATRIX

Restraints	Resource Availability	Relation-ship	Milking Cows (1 cow) P_1	Heifer Replacements (1 heifer) P_2	Beef Rearing Activities - P_{11}	- P_{12}	- P_{13}	- P_{14}	Hire Labour 10 months (1 boy) P_{30}	Hire Labour Casual (1 c.r.u.) P_{35}
Net Revenue ($)									-1100.0	-4.50
Spring Labour X_{10}	247 c.r.u. 1/		2	1	1	1	1	1	-113	-1
Milking Labour X_{28}	247 c.r.u.		2	1					-113	

1/ Calf rearing unit, see section 5.2.1

beef in the Y.A.Q. grade [1]

The optimum plan with the beef incentive payment indicates that the farmer should reduce cow numbers and increase beef production at 1969/70 prices.

a) The Feasibility of the Optimum Plan K_5 - With the Beef Incentive Payment

The farmer considers that plan K_5 is feasible on this farm. The optimum plan would involve only a small increase in the winter stocking rate which is a critical factor on this soil type. This is shown in Table 5.13 using the feeding standards derived by Coop (1965).

1/ For the 401 lbs/over weight range.

TABLE 5.12

PLAN COMPARISON - 1969/70 PRICES [1]

CASE FARM 2

Milk Price - 32 cents per pound butterfat

Activity	Activity Code	With Incentive payment		Without Incentive payment	
		Farmer's Plan	Optimum Plan K_5	Farmer's Plan	Optimum Plan
Milking cows	P_1	162	110	162	140
Nurse cows	P_6	-	-	-	14
Butterfat production (lbs)	P_8	52,720	34,242	52,720	45,657
Beef calves purchased (4 days old)	P_9	-	33	-	-
Beef weaners purchased (3 months)	P_{18}	-	40	-	-
Store cattle sold (13 months)	P_{13}	-	71	-	-
Beef cattle sold (15 months)	$2.P_6$	-	-	-	28
Beef cattle sold (18 months)	P_{18}	-	38	-	-
Heifer grazing	P_{27}	off-farm	off-farm	off-farm	off-farm
Permanent labour hired (single man)	P_{30}	1.0	-	1.0	0.6
Casual labour hired (c.r.u.)[2]	P_{35}	-	71	-	28
Hay purchased (bales)	P_{20}	1,121	1,275	1,121	2,068
Net Revenue	$	15,755	16,354	15,755	15,867

Note: 1. Beef price level 5 - $21.50

2. Calf rearing units.

TABLE 5.13

WINTER STOCKING RATE COMPARISON

CASE FARM 2

Class of Stock	Feeding Standard E.E.[a]	Farmer's Plan		Plan K_5	
		No. Stock	E.E.	No. Stock	E.E.
Dairy cows	7.5	162	1,215	110	825
Beef yearlings	4.0	-	-	109	436
Total E.E.	-	-	1,215	-	1,261

a/ E.E. - Ewe equivalents.

The beef calves would be grazed with the heifer calves in two or three groups until the heifers are grazed off the farm in May. Throughout the Winter, the beef cattle would be rotationally grazed whenever possible but during wet periods they would be confined to the wintering pad and fed hay to avoid pugging. During the Spring and Summer, the steers could be intensively grazed in the milking rotation about 10 - 14 days behind the cows using a front and back electric fence. This should allow sufficient time for some regrowth to occur.

An alternative grazing procedure would be to use two separate areas, one for the milking herd rotation and the other for the beef cattle. However, this system would remain flexible to the extent that paddocks which were not eaten out sufficiently by the cows would be put into the beef cattle rotation for more intensive grazing between two electric fences. The flexibility in the grazing system would be used to achieve good grass control, especially over the Spring when the grass growth tends to be greater than can be controlled by the present stock numbers. The store beef cattle would be sold according to the feed position on the farm and the store cattle prices.

During the Summer and early Autumn, when grass growth is reduced in a dry season, the farmer considered that the smaller number of milking cows in plan K_5 (as compared with the present policy) would make it quite feasible to achieve the growth rates assumed for the slaughter beef cattle and not impinge on the grass required for the milking herd.

The farmer was confident that the plan was feasible with respect to labour provided that casual labour was employed during the Spring because at this time the calf rearing, store cattle sales and hay making would be done.

The small number of beef calf and weaner purchases required should not cause any difficulties as contracts could be readily obtained for both classes of stock, if required.

The optimum plan would increase the farmer's cash surplus by only $173 at 1969/70 prices as shown in Table 5.14.

TABLE 5.14

CASH SURPLUS COMPARISON - PLANS WITH BEEF INCENTIVE PAYMENT

CASE FARM 1

1969/70 prices

	Farmer's Plan	Optimum Plan
Net revenue $	15,755	16,354
Post-tax Cash profit $	5,950	6,123
Personal Drawings $	4,000	4,000
Cash Surplus $	1,950	2,123

Note: 1. The net revenue is taken from Table 5.12.

The farmer would not change to the optimum plan because he considered that the nine percent increase in cash surplus to be earned was insufficient to warrant the risk involved in adopting the new policy especially since the farmer considered that the future beef price was more uncertain than the future milk price at least over the next two years.

However, if the optimum plan, involving decreased milk and increased beef production could be shown to increase the cash surplus by 20 percent and provided that he was confident of a high future beef price, then he would be prepared to adopt plan K_5. The farmer required this increased profit margin from plan K_5 to offset the increased management input required to organize the mixed beef-dairy unit and to buffer the poorer than average production performance that might be encountered during the first season's operations.

The optimum plan would increase the cash surplus over the present policy by 20 percent only if the beef price increased to $25.50 per 100 pounds or greater. This is shown in Table 5.15 which gives the post-tax cash surplus for both the farmer's policy and the optimum plan at three beef prices.

TABLE 5.15

CASH SURPLUS WITH VARIABLE BEEF PRICES

CASE FARM 2
(Milk Price - 32 cents per pound butterfat)

Beef Price $ per 100 lbs	Farmer's Plan	Plan K	Increase in Cash Surplus from Plan K
21.50	1,950	2,123	9%
23.50	2,070	2,381	15%
25.50	2,168	2,631	21%

However, at the $25.50 beef price in Table 5.15, plan K is not the optimum. The optimum plan at this beef price is plan M_7 (See Appendix 5) which has a cash surplus of $2,737. That is, at beef price level 7, plan M has a cash surplus $106 higher than plan K but the farmer was unwilling to consider plan M owing to the large reduction in milking cow numbers required to achieve this plan. If this farmer decreased milking cow numbers to take advantage of the present high beef price, he wished to be able to build up the herd again should the milk to beef price ratio increase.

One modification to plan K_5 which the farmer would probably make would be to buy 73 three months old weaners 1/ thus reducing the number of calves reared on the farm. This change would not alter the net revenue very greatly provided the casual labour hired was decreased in proportion to the lesser number of calves reared, because the casual labour is employed in plan K_5 to rear 71 beef calves and if beef weaners are purchased instead then this labour must be excluded if the net revenue is not to be reduced by $319.50 2/

(b) The Optimum Plan Without the Beef Incentive Payment

If the beef incentive payment was removed at 1969/70 prices, the optimum plan(from Table 5.12) would include 140 milking cows and 28 beef cattle reared on 14 nurse cows. The beef cattle would be slaughtered at 15 months of age. However, the optimum plan would only result in an increase of $112 in net revenue over the present policy. The farmer was not prepared to adopt the optimum plan without the beef incentive payment because the change involved would not be worth the extra net revenue obtained. Thus, at present prices the farmer is not likely to increase beef production (and decrease milk production) unless the

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1/ Rather than buy 33 calves and 40 weaners. See Table 5.12

2/ That is, 71 c.r.u. of Spring labour at $4.50 per unit.

beef incentive payment is available. However, even if the beef incentive payment is available, the farmer would not adopt a mixed beef-dairy policy (say, plan K_5) unless the beef schedule price was $25.50 per 100 pounds or greater at the present milk price.

5.4.4 <u>The Effect of Variation in the Beef Price</u>

In Table 5.16 the optimum plans corresponding to the 32 cent milk price are presented for each beef price level.

TABLE 5.16

THE EFFECT OF VARIATION IN THE BEEF PRICE

CASE FARM 2

Milk Price - 32 cents per pound Butterfat

Activity	Name	Plan - Beef Price						
		P_1 $13.50	A_2 $15.50	B_3 $17.50	E_4 $19.50	K_5 $21.50	K_6 $23.50	L_7 $25.50
Milking cows	P_1	162	160	154	151	116	110	37
Milk Production (lbs butterfat)	P_8	52,720	51,861	49,555	44,951	36,428	34,242	8,522
Calves Purchased	P_9	-	-	-	-	33	33	163
Weaners purchased (3 months)	P_{17},P_{18}	-	-	-	-	40	40	74
Store cattle Sold (13 months)	P_{13},P_{17}	-	8	27	40	71	71	125
Beef cattle Sold (18-22 months)	P_{14},P_{18}	-	-	-	12	38	38	110
Permanent labour hired (single man)	P_{30}	1.0	1.0	0.9	0.6	-	-	-
Casual labour hired (c.r.u.)	P_{35}	-	8	27	52	71	71	-
Hay purchased (bales)	P_{20}	1121	1244	1371	1442	1275	1275	1306
Net Revenue	$	14484	14774	15167	15624	16244	17015	18292

Note : 1. Calf rearing units - c.r.u.

The optimum plans in Table 5.16 do not show a marked reduction in milking cow numbers until the beef price is greater than $19.50 at the 32 cent milk price and a predominantly beef policy does not occur until the beef price exceeds $23.50.

Hence, on case farm 2, beef production is relatively less profitable than on case farm 1. This is due, in the first place, to the higher productivity of the milking enterprise on the second farm. For example, on case farm 1, 30 percent replacement heifers are required whereas on this farm only 25 percent are put into the herd. Furthermore, the butter-fat production per cow is 15 pounds greater on this farm. The difference in the performance levels are attributed to the difference in managerial skill on the two farms.

The second important difference between the farms is the amount of permanent labour available 1/. That is, the labour provided by the farmer and his family. The higher the proportion of total farm labour contributed from these sources (farmer and family usually), the greater is the relative profitability of the dairying enterprise. This is because a higher beef price is required before the labour restraint limits cow numbers owing to the fact that the dairying enterprise requires a greater labour input than store or slaughter beef production.

On this farm, the beef cattle tend to be reared on the farm due to the availability of casual labour in the Spring. In plan M_7 the purchase of 163 four day old calves would be difficult unless contractural arrangements could be made with neighbouring dairy farmers.

The net revenue stability limits are given in Table 5.17. These limits are narrow for hay purchases, milk and beef production and if the

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1/ On case farm 2, 247 c.r.u. of Spring labour are available compared with 220 c.r.u. on case farm 1.

price (or net revenue) of one of these activities moves outside the limits given in the table, then a new optimum plan will be derived incorporating an increase or decrease in that activity depending on whether the upper or lower stability limit has been exceeded.

Beef production competes directly with hay production. If the price of bought hay exceeds the upper limit, then hay purchases will be reduced and more hay will be produced on the farm. Correspondingly, the level of a beef enterprise will be reduced.

If the net revenue of the beef enterprises (P_{13} and P_{15} in Table 5.17) falls below the lower limit, then another beef enterprise will substitute for all or part of the activity in the basis. The net revenue stability limits for grazing heifers off the farm indicate that this activity is stable because a large increase in the cost of grazing is required before the level of this activity would be decreased.

The basis values 1/ of the excluded beef activities are given in Table 5.18. In plan K_5, the selling price of three months old weaners (P_{11}) must increase from $32.00 to $37.07 before this activity will enter the basis. In the same plan, the purchase price of three months old weaners must fall from $36.00 to $35.04 before the activity P_{17} 2/ would come into the optimum plan. Generally, the differences between the current purchase or selling prices and the basis prices are small, except for activity P_{19} 3/, indicating that only a small deviation from the prices assumed in Appendix 3 would be required for an excluded activity to enter the basis (except activity P_{19}). As for case farm 1, buying six months old weaners is the least profitable beef policy.

1/ See section 5.3.6

2/ Buying 3 months weaners to be sold as store yearlings.

3/ Buying 6 months weaners to be slaughtered at 18-22 months of age.

TABLE 5.17

NET REVENUE STABILITY LIMITS - CASE FARM 2

Milk Price - 32 cents per pound Butterfat

Activity	Name	Plan	Upper Limit	Current Net Revenue	Lower Limit
Milk (cents per lb butterfat)	P_8	P_1		32.0	29.4
		A_2	33.8	32.0	31.5
		B_3	34.9	32.0	31.0
		F_4	32.2	32.0	31.0
		K_5	32.3	32.0	29.0
		K_6	33.1	32.0	31.0
		M_7	33.4	32.0	30.5
Steer beef ($ per 100 lbs)	P_{15}	E_4	20.0	19.50	19.4
		K_5	24.2	21.50	21.4
		K_6	24.3	23.50	23.0
		M_7	26.9	25.50	25.4
Store cattle ($ per beast)	P_{13}	A_2	53.1	52.5	50.7
		B_3	66.3	58.5	58.3
		E_4	65.7	64.5	63.4
		K_5	84.0	70.5	70.1
		K_6	80.4	76.5	76.3
		M_7	92.1	82.5	81.4
Hay purchases ($ per bale)	P_{20}	P_1	-0.67	-0.50	-0.42
		A_2	-0.62	-0.50	-0.41
		B_3	-0.53	-0.50	-0.25
		E_4	-0.54	-0.50	-0.20
		K_5	-0.59	-0.50	-0.40
		K_6	-0.53	-0.50	-0.22
		M_7	-0.56	-0.50	-0.33
Heifer grazing ($ per heifer per year)	P_{29}	P_1	-58.8	-27.0	+42.9
		A_2	-35.2	-27.0	+ 1.9
		B_3	-58.4	-27.0	-24.8
		E_4	-41.9	-27.0	-24.0
		K_5	-53.1	-27.0	-25.8
		K_6	-40.2	-27.0	+ 6.9
		M_7	-52.3	-27.0	-25.1

TABLE 5.18

BASIS VALUES FOR EXCLUDED ACTIVITIES

CASE FARM 2 ($)

Activity	Excluded Activity	Price or Value	Plans						
			P_1	A_2	B_3	E_4	K_5	K_6	M_7
Selling 3 months weaners	P_{11}	Current Basis	24.0 25.0	26.0 29.3	28.0 31.0	30.0 33.4	32.0 37.7	34.0 40.0	37.0 40.1
Selling 6 months weaners	P_{12}	Current Basis	29.0 40.7	31.0 37.8	33.0 40.1	35.0 35.4	37.0 44.4	39.0 47.7	42.0 48.0
Buying 3 months weaners	P_{17}	Current Basis	28.0 17.2	30.0 25.8	32.0 27.5	34.0 30.0	36.0 35.4	38.0 37.8	41.0 38.9
Buying 6 months weaners	P_{19}	Current Basis	34.0 22.4	36.0 17.9	38.0 2.8	40.0 18.1	42.0 28.4	44.0 20.4	46.0 32.4

Note: 1. The basis price is that required by the policy before the activity will enter basis.
2. The current prices were taken from Appendix 3.

5.4.5 Normative Supply Functions

The normative beef supply response for case farm 2 is given in Figure 5.3. As for the first case farm, this supply response represents the net pounds of beef produced per acre from store and slaughtered beef cattle at each discrete beef price. The supply response is given for three fixed milk prices; 27, 31 and 35 cents per pound butterfat.

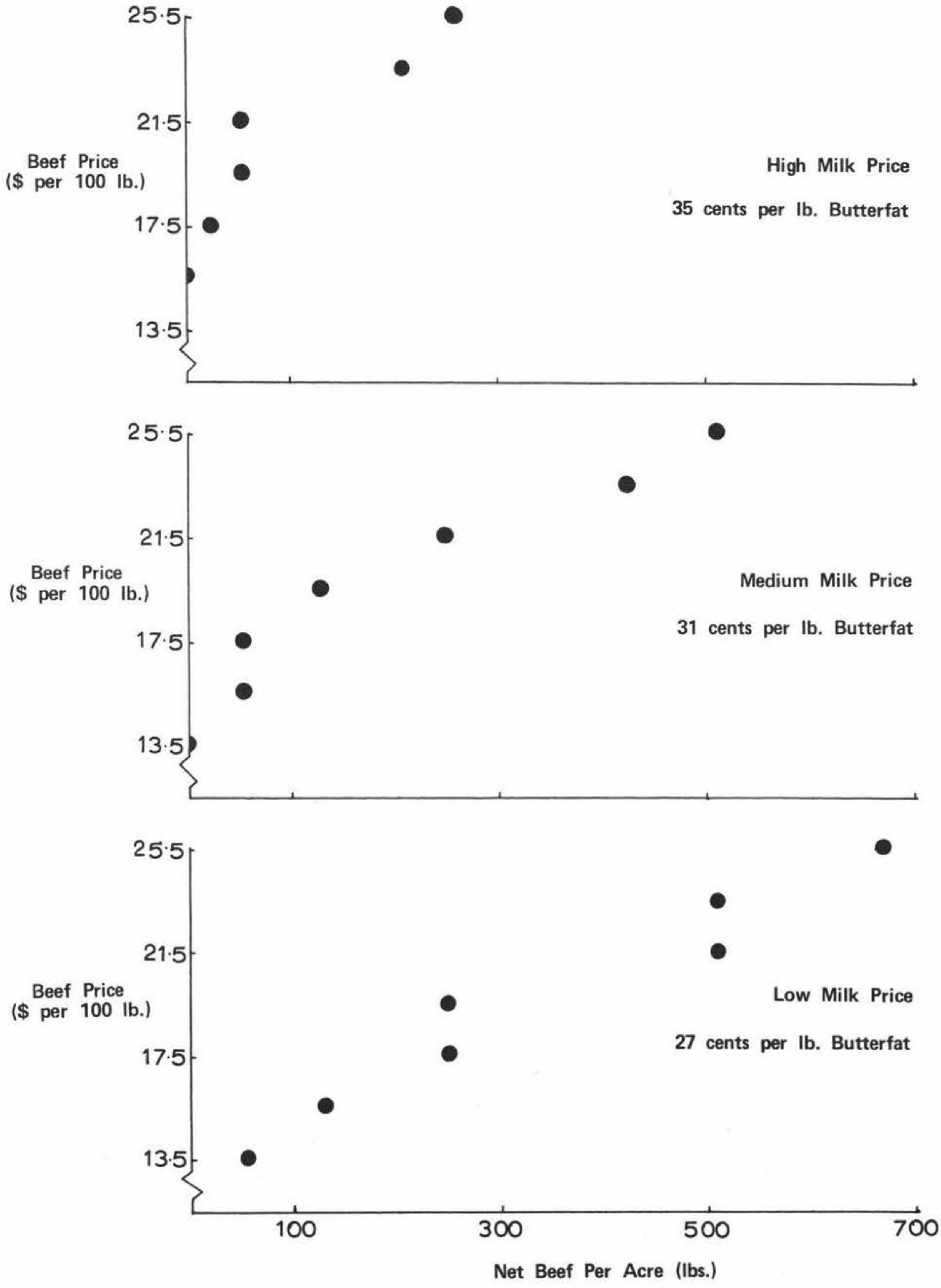
In Figure 5.4 the normative butterfat supply function is given at three beef price levels (including the beef incentive payment). At the second beef price, a supply function is also given excluding the incentive payment of ($10 per beast) from the net revenues of the activities qualifying for the Dairy Industry Beef Scheme P_{13}, P_{14}, P_{17} and P_{18}.

At the $19.50 beef price, the difference between the normative butterfat supply functions, with and without the beef incentive payment, is smaller than one case farm 1. That is, the incentive is "worth" less on this farm. This is due to the higher milking cow productivity and greater amount of permanent labour available on case farm 2. Both these

Figure 5.3

CASE FARM 2

NET BEEF SUPPLY RESPONSE



factors increase the relative profitability of dairying on this farm.

For the beef supply response, this would mean that a larger incentive is required, on case farm 2, to produce a given increase in beef output than would be required to produce the same increased beef output on case farm 1.

Nevertheless, the beef incentive payment does increase the butterfat supply function 1.2 to 5.3 cents per pound butterfat. Alternatively, the presence of the incentive payment causes a significant reduction in butterfat production at any given milk price. For example, at a milk price of 30 cents, butterfat production is decreased 33 percent by imposing the beef incentive payment. It is also clear that as the milk price decreases, the percentage reduction in butterfat output increases. This observation stems from the fact that a normative supply function exhibits increasing returns to price.

The differing responses, of case farms 1 and 2, to the beef incentive payment will be discussed further in Chapter 6.

5.5 CASE FARM 3

5.5.1 General Outline

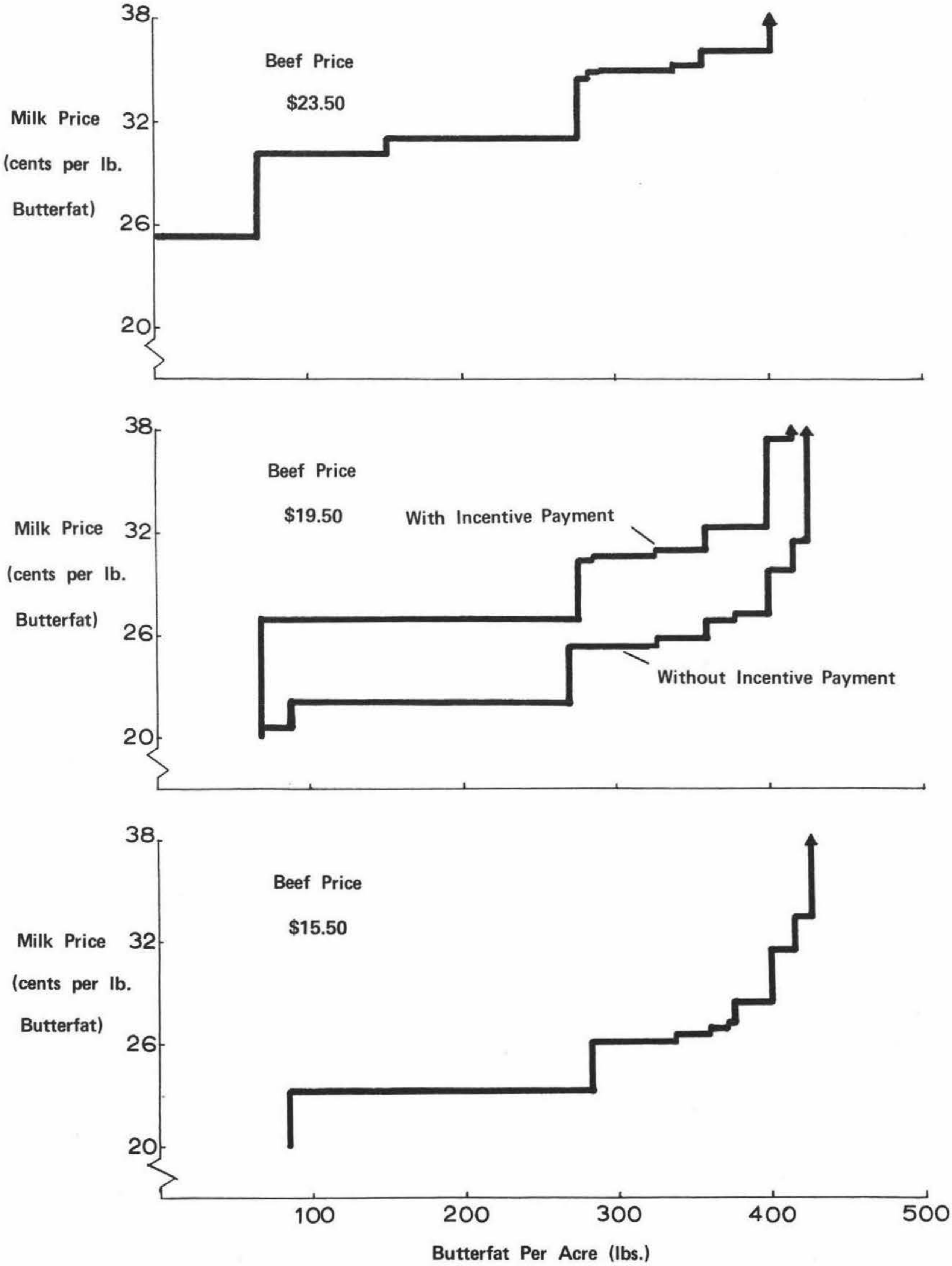
This dairy farm is comprised of 120 acres of Marton silt loam situated six miles east of Palmerston North. The area is made up of 104 acres of which 25 acres is in steep gullies and the balance is flat to moderately rolling. A further 16 acres of runoff is situated half a mile along a main road which forms the access between the two blocks.

The soil is of medium fertility and prone to pugging damage during the Winter. The farm has been extensively mole drained but stock has to be moved off the paddocks during wet periods. The farm has a 30 - 35 inch rainfall in a similar pattern to case farm 2. That is, the farm often has dry spells in the Summer and gets very wet in most Winters.

Figure 5.4

CASE FARM 2

NORMATIVE BUTTERFAT SUPPLY FUNCTION



The stock wintered in the 1968/69 season were as follows:

103 Jersey and Jersey-Friesian cross milking cows and heifers,

22 yearling heifers,

and 2 bulls.

This farm produces 40,000 pounds of butterfat and all the supplementary feed required (1,800 -2,000 bales of hay) is produced on the farm. The buildings include a new house, an eight aside herringbone milking shed, calf feeding shed, a 70 cow capacity concrete feeding platform, a haybarn and two implement sheds.

The milking herd is wintered on the main block with choumoellier, hay and grass using a wintering pad to reduce pugging damage to the paddocks. The yearling heifers are grazed on the runoff during this period. In the Spring, the runoff is included in the grazing rotation for the milking herd and the heifers are grazed on the main block. Four to five acres of old pasture is ploughed for a winter crop of choumoellier in December for feeding off in June, July and August. The paddock is sown back to grass in the Spring.

The labour complement consists of the farmer and his teenage son. The farmer does some contract haybaling for neighbouring farmers.

The farmer, who is in a strong financial position, is contemplating rearing calves for beef production and such a move would not be limited by either labour or capital on this farm.

The milking herd on this farm produces approximately 385 pounds of butterfat per cow at a stocking rate of 0.86 cows per total farm acre. This high per cow performance has been attributed to the high standard of management and milking labour and to better breeding. This assumption was made because herd numbers have been stable on this farm for 10 years and intensive culling for high butterfat production has been carried out, whereas neither case farmer 1 nor case farmer 2 were selecting cows for production. For these reasons, the feed requirements of milking cows on case farm 3 are assumed to be the same as the two previous farms. However, the assumption of the feed requirements of milking cows on this farm is based on a subjective estimate of the relative grass growth stocking rate and managerial ability of the three case farms. If this assumption is incorrect then the feed requirements of milking cows on case farm 3 have been underestimated relative to the previous two farms. The effect of such an error will be discussed in a following section.

Alternations to the General Model for Case Farm 3

(a) Beef Production

The farmer wishes to consider beef production from steers rather than bulls because he considers that the former are more easily managed and should fit into his grazing system more readily than bulls.

(b) Labour

It has been assumed that the present labour force is sufficient for any combination of cows and beef animals within the feed restraints. The labour supply (X_{10}) has been set at 350 calf rearing units as this is the maximum number of calves that could be reared by the farmer and his son, and no hire labour activities were included for this farm.

(c) Input-Output Coefficients

i) Milking cows produce 385 pounds of butterfat.

ii) Hay produced on the farm costs 15 cents per bale because all work is carried out by the farmer.

iii) Twenty-two percent heifer replacements are required.

(d) Feed

Heifer replacements are grazed on the farm and hay may be purchased at 50 cents per bale (delivered to the farm). It has been assumed that the Winter crop will continue to be grown because the farmer wishes to continue with the crop no matter what enterprise is adopted, and this feed transfer has been incorporated into the feed supply. The nurse cow activities (P_6 and P_7) have the same feed requirement pattern as for case farm 2. The monthly feed supply has been calculated as for the previous two farms and the monthly values are given below:

FEED SUPPLY - CASE FARM 3

Month	Feed Supply (lbs D.O.M. per day)
August	1,664
September	2,388
October	2,868
November	2,799
December	2,741
January	2,460
February	2,074
March	1,977
April	2,070
May	1,756
June	917
July	931

5.5.2 Solutions for Case Farm 3

Price parametric solutions were computed in exactly the same way as for the first two case farms. The same price ranges for milk and beef were also used 1/. These parametric solutions are given in Appendix 6.

5.5.3 The Farmer's Future Policy

The farmer considers that the milk price paid by his local company will be at least 33.5 cents per pound butterfat for the 1970/71 season. The present policy is, therefore, compared with the optimum plan at this milk price and beef price level 5 2/ in Table 5.19.

1/ That is, beef $13.50 to $25.50 per 100 lb; milk 20 to 38 cents per lb butterfat.

2/ That is, $21.50 per 100 lb steer beef.

Table 5.19 is different from the tables for case farms 1 and 2 1/ because the optimum plan both with and without the beef incentive payment is the same. That is, plan C is optimum for case farm 3 at beef price level 5 whether the incentive payment applies or not, because no beef incentive qualifying activities are included in the optimum plan. Thus, the Dairy Industry Beef Scheme will only influence the optimum plan in so much as the incentive payment increases the price of three months old weaners.

a) The Feasibility of the Optimum Plan

The farmer considers that the optimum plan is feasible with respect to labour and capital. However, he considers that the optimum plan would require 500 bales of hay purchases more than the present policy, rather than 1023 bales more as shown in Table 5.19. This would be achieved by increasing the carrying capacity in the Spring, (the linear program does not allow this). That is, the introduction of the weaner policy to the present plan would probably result in the more efficient utilization of Spring grass, without reducing the feed available to the milking herd. The adjusted hay purchases and corresponding changes to the net revenues of the optimum, as suggested by the farmer are shown in brackets in Table 5.19.

The implementation of the optimum plan will depend on the availability of 82 calves suitable for rearing beef weaners for sale in November and December.

1/ That is, Tables 5.2 and 5.12.

TABLE 5.19

CASE FARM 3

PLAN COMPARISONS - 1969/70 PRICES

Milk Price - 33.5 cents per pound Butterfat

Activity	Activity Code	With and without the incentive payment	
		Farmer's Plan	Plan C
Milking cows	P_1	102	102
Butterfat Production(lbs)	P_8	38,900	30,546
Beef calves purchased	P_9	-	82
Beef Weaners sold (3months)	P_{11}	-	117
Hay purchased (bales)	P_{20}	303	1326 (803)1/
Net Revenue $	Beef Price Level 5	13938	14047 (14309)1/
Net Revenue	Beef Price Level 6	14162	14259 (14521)
Net Revenue	Beef Price Level 7	14345	14753 (15015)

Note 1. Ex poste adjustments to the optimum plan are in brackets. These changes are described in section 5.5.3.

The beef calves would be reared together with the heifer calves and grazed in groups of 30 - 40 calves. Therefore, during the Spring, the home farm would be grazed by the milking herd and three or four mobs of calves in rotation, whilst the replacement heifers would be grazed alternately on the runoff and the home farm. The extra groups of calves would allow fewer paddocks to be shut for hay owing to the need to have more paddocks available in the grazing rotation than are currently required. That is, a limiting factor to rearing extra calves is the provision of extra paddocks (rather than extra feed) to allow the calves to be rotated around fresh paddocks in the interests of good husbandry practice.

The farm has a calf feeding shed fitted with 40 bails which is more than adequate for rearing the calves required in the optimum plan.

Considering the adjusted net revenue values in Table 5.19, the farmer would only be prepared to adopt plan C at beef price level 7, where the net return per calf reared is $6.25.[1/] The net return is the reward to the farmer for the extra work involved. At this price level, the selling price is $37 per weaner [2/] at three months of age. The farmer considered that this price may increase relative to the beef schedule price as Friesian cattle become more popular for beef production. At the same time, it is not likely that the calf price would increase above $21.[3/] Activity P_{11} is included in Plan C because surplus labour is available in the Spring. If only sufficient labour had been available for milking cows, then weaner production would not have entered the basis in place of milking cows at the assumed prices. The farmer is keen to introduce the beef

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1/ That is, the difference in the net revenues between the plans over the beef weaners sold.

2/ See Appendix 3.

3/ That is, the opportunity cost of the grass made unavailable by the weaner in terms of the purchased hay required to replace this grass which would normally be saved for hay production.

weaner policy onto his farm provided that the margin between the calf cost and the weaner selling price is sufficient to give a net return of at least $6per calf reared.

The net return from this weaner production enterprise is illustrated by a gross margin derived from Table 5.19 and given in Table 5.20.

TABLE 5.20

GROSS MARGIN OF BEEF WEANER PRODUCTION

(per weaner sold)

CASE FARM 3

VARIABLE COSTS		
Beef calves (1.05 at $17.0)	=	$17.85
Feed (whole milk)	=	$6.70
Animal health and sundry	=	$1.75
Grazing charge 1/ (4.3 bales hay at 50 cents)	=	$2.15
Total variable costs	=	$28.45
Plus "Profit" required	=	$6.00
Minimum Acceptable Selling Price	=	$34.45

From Table 5.20, it can be seen that when the value of potential beef calves 2/ is $17.0, then this farmer requires a weaner price of at least $34.45 before he will adopt the beef calf rearing enterprise. Table 5.20 shows that the net return per calf is dependent on the difference between the calf price and the weaner selling price. It was shown in section 5.2.8 that the price paid for calves varies considerably within a district and if calves could be bought for less than is assumed

1/ That is, the opportunity cost of the grass made unavailable by the weaner in terms of the purchased hay required to replace this grass which would normally be saved for hay production.

2/ Retained or purchased calves suitable for beef production.

in Appendix 3, then the net return per calf reared would be greater. This weaner production activity may be a profitable supplementary enterprise on other intensive dairy farms. The factors which will probably influence the farmer's decision are the calf cost, the weaner selling price and the capacity of the existing labour force on the farm to rear extra calves.

5.5.4 The Effect of Variation in the Beef Price

In Table 5.21, the optimum plans are outlined at each beef price for a fixed milk price of 33.5 cents per pound butterfat. The same physical plan (plan C) occurs at the first five beef prices and hence only plan C_5 is given in the table.

TABLE 5.21

THE EFFECT OF VARIATION IN THE BEEF PRICE

CASE FARM 3

Milk Price - 33.5 cents per pound Butterfat

Activity	Activity Code	Plan - Beef Price		
		C_5	J_6	E_7
Milking Cows	P_1	102	101	101
Butterfat Production (lbs)	P_8	36,546	37,609	35,911
Beef Calves Purchased (4 days old)	P_9	82	-	92
Beef Weaners Sold (3 months)	P_{11}	117	32	120
Beef Weaners Sold (6 months)	P_{12}	-	-	3
Store Cattle Sold (15 months)	P_{13}	-	6	3
Hay Purchased (bales)	P_{20}	1326	610	1365
Net Revenue	$	14047	14281	14764

From Table 5.21 it can be seen that three months old weaner production is included in the plans at all beef prices owing to the fact that sufficient labour is already available on the farm to rear extra calves. (On the previous two farms, labour would have had to be hired for this enterprise).

The weaner production policy is incorporated into the management system by increasing the amount of purchased hay and not by reducing the size of the milking herd. The implications that can be derived from this farm are that beef production from beef cattle "wintered" on the farm is not profitable enough to substitute for milking cows at the assumed prices in Table 5.21. However, three months old weaner production is included in each of these plans because this activity supplements the milking herd at these levels. If the number of beef calves reared was increased beyond the level in these plans, then this activity would compete directly with the milking herd. The weaner production activity (P_{11}) does not receive the beef incentive payment so that even if the Dairy Industry Beef Scheme was removed these plans would be stable except plan E_7, where store cattle production may be excluded.

The number of beef weaners in plan J_6 is less than in plan C_5 due to the assumed prices for beef calves purchased and three months old weaners sold (see Appendix 3). That is, the correlated prices at beef price level 5 and 6 are such that the net revenue of three months weaner production (P_{11}) is close to a "border" point in plans C_5 and J_6. This is shown in Table 5.22, where the lower net revenue stability limit for activity P_{11} in plan C_5 is only $0.01 below the current net revenue and for the same activity in plan J_6 the upper net revenue stability limit is only $0.27 above the current net revenue.

TABLE 5.22

NET REVENUE STABILITY LIMITS

CASE FARM 3

Milk Price - 33.5 cents per pound butterfat

Activity	Activity Code	Plan	Upper Limit	Current Net Revenue	Lower Limit
Milk (cents per lb butterfat)	P_8	C_5	33.9	33.50	31.3
		J_6	37.3	33.50	31.4
		E_7	34.3	33.50	33.0
3 months Weaners Sold ($ per beast)	P_{11}	C_5	30.94	30.25	30.24
		J_6	32.52	32.25	30.58
		E_7	35.34	35.25	33.38
6 months Weaners Sold ($ per beast)	P_{12}	E_7	42.13	40.00	39.90
Store Cattle Sold 13 months ($ per beast)	P_{13}	J_6	81.50	76.50	72.64
Hay Purchases ($ per bale)	P_{20}	D_4	- 0.50	- 0.50	- 0.42
		J_6	- 0.70	- 0.50	- 0.47
		E_7	- 0.66	- 0.50	- 0.49

The sensitivity of the net revenue for three months old weaner production indicates that the sale price which this dairy farmer receives is quite critical to the number of weaners which he should be prepared to rear.

The production of six months old weaners, store cattle and beef cattle for slaughter do not enter the plans given in Table 5.19 or are present only at low levels. These beef activities (P_{12}, P_{13}, P_{14}, P_{17}, P_{18} and P_{19}), are included at low levels or excluded from the optimum plans of this farm at the 33.5 cent milk price because firstly, labour does not have to be hired to milk the maximum number of cows (102) and secondly, because the milking cow enterprice on this farm is more profitable than on the previous two case farms. The milking cow activity is more profitable because only 22 percent herd replacements are required compared with 30 and 25 percent on case farms 1 and 2 respectively. Further, the milking herd on case farm 3 produces 385 pounds of butterfat per cow as against 315 and 330 pounds on the other farms. This increased butterfat production is attributed to the higher standard of management and higher genetic merit of the herd rather than a lower stocking rate.

TABLE 5.23

BASIS VALUES - CASE FARM 3

$ per beast

Excluded Activity	Activity Code	Price or Value	Plans		
			C_5	J_6	E_7
Selling 6 months weaners	P_{12}	Current	37.0	39.0	42.0
		Basis	47.0	44.8	-
Selling store cattle (15 months)	P_{13}	Current	64.0	70.0	76.0
		Basis	64.1	-	-
Selling beef cattle (18 months)	P_{14}	Current	5.5	5.5	5.5
		Basis	34.0	23.4	11.4
Buying 3 months weaners	P_{17}	Current	36.0	38.0	41.0
		Basis	29.7	31.8	34.7
	P_{18}	Current	36.0	38.0	41.0
		Basis	3.3	15.0	30.8

If, in fact, the higher butterfat production per cow on case farm 3 is due to the higher feed intake of milking cows,[1/] then the relative

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1/ That is, if the feed requirements of milking cows are higher than assumed here.

profitability of all the beef enterprises has been underestimated in the analysis for this farm. If this is the case, beef production would substitute for milk production at a higher milk to beef price ration than is given by the parametric solutions for case farm 3.

Table 5.23 shows that store beef production would enter the optimum plans before the other excluded beef activities should beef prices increase and a small number of store cattle are present in plans J_6 and E_7.

5.5.5 Normative Supply Functions

The normative butterfat supply function for case farm 3 is given in Figure 5.5 for three beef prices: $15.50, $19.50 and $23.50 per 100 pounds of beef. The butterfat supply function excluding the beef incentive payment, is also given at the $19.50 beef price. At the high beef price ($23.50), a significant drop in butterfat production does not occur until the milk price falls to 29 cents. Therefore, beef production from wintered beef cattle is not likely to enter the optimum plan for this farmer, at least for the next two years, because he has a guaranteed total milk payout of at least 33.5 cents for that period.

The effect of the incentive payment on the optimum plans, as shown in the second butterfat supply function, is that the plans are not changed until the milk price falls to 27 cents. Therefore, unless there is a fall in the total milk payout of 6 to 7 cents per pound butterfat, the incentive payment should not affect the optimum plans on this farm.

The net beef supply response is given in Figure 5.6 for two milk prices, 27 and 31 cents per pound butterfat. At the lower milk price, "Wintered" beef cattle are substituted for milking cows when the beef price is greater than $21.50 per 100 pounds.

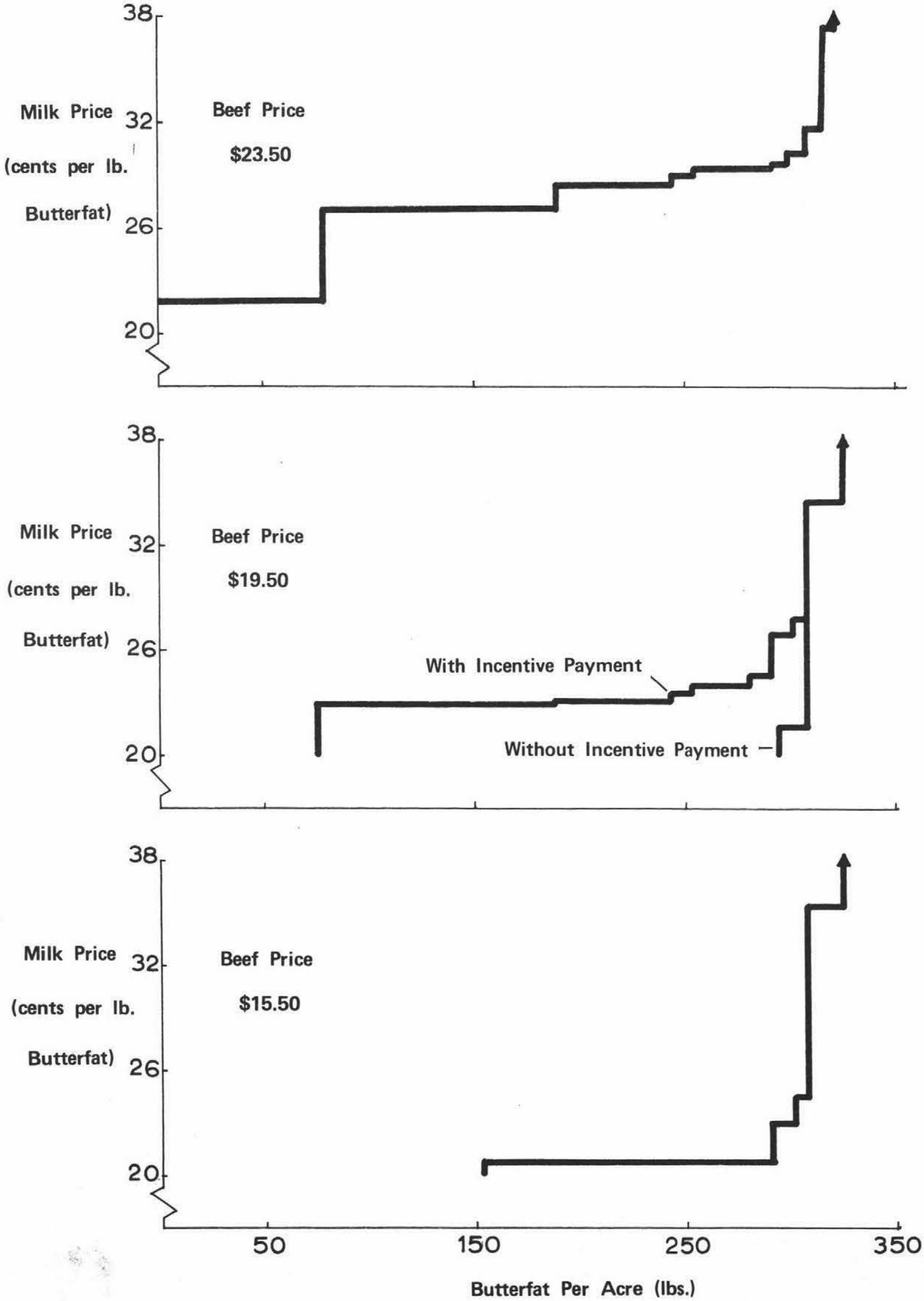
5.5.6 Summary of Case Farm 3

The production of three months old weaners is the most profitable beef enterprise on this farm because the farmer is prepared to rear

Figure 5.5

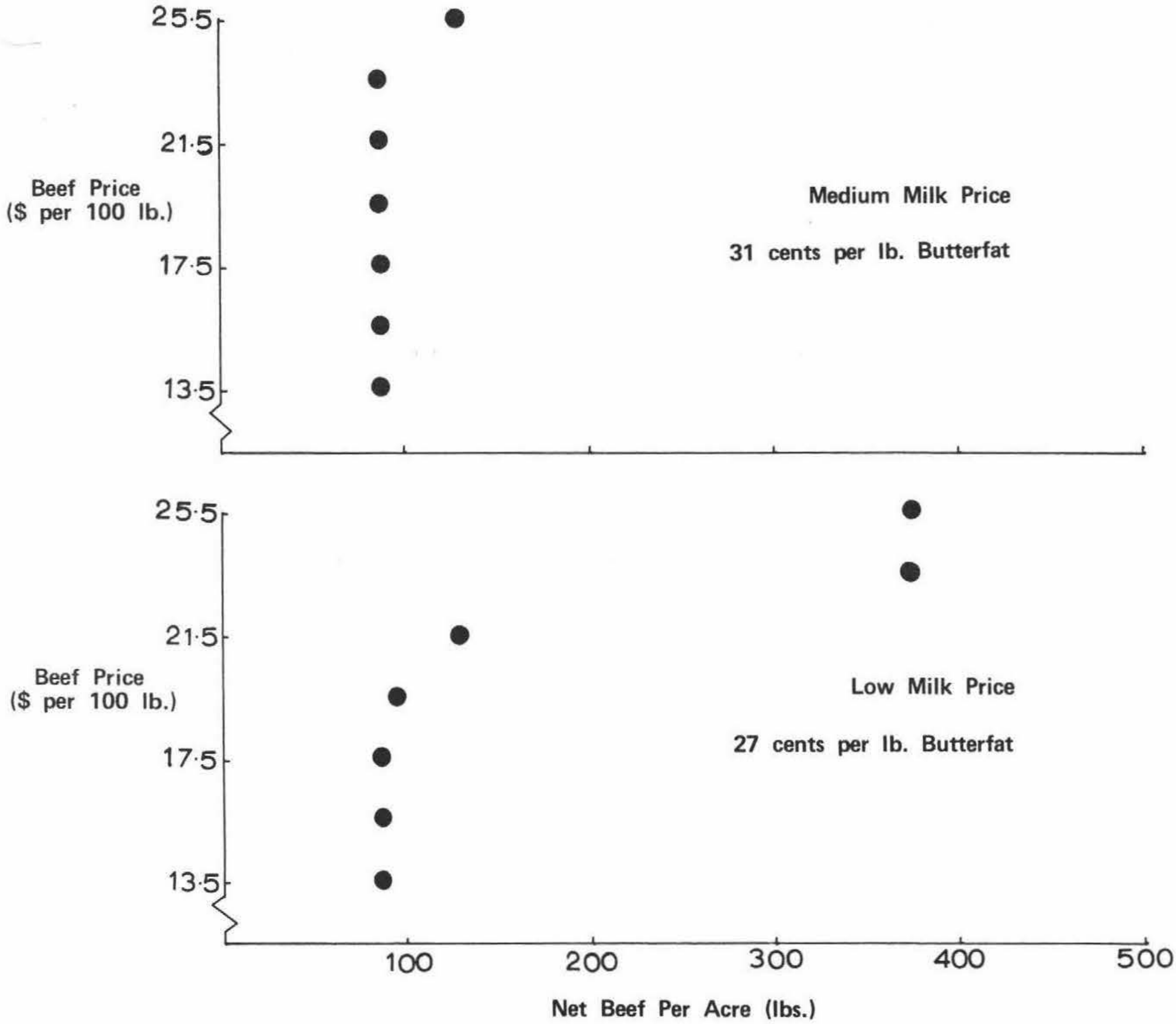
CASE FARM 3

NORMATIVE BUTTERFAT SUPPLY FUNCTION



CASE FARM 3

Figure 5.6 NET BEEF SUPPLY RESPONSE



additional calves with the existing labour force. However, the difference between the calf cost and the weaner selling price must be at least $17 before the farmer would adopt this policy.

On this farm three months old weaner production does not substitute for milking cows but the grass made unavailable by the beef calves, during rearing, is replaced with purchased hay.

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 INTRODUCTION

In this chapter, the main assumptions of the linear programming model are examined and a summary is given of the more important factors affecting the feasibility and profitability of beef production on dairy farms.

6.2 THE ASSUMPTIONS IN THE ANALYSIS

In the linear programming model for the case farms, there are four assumptions which are very important determinants of the results obtained.

6.2.1 Feed Requirement Coefficients

The model contains fixed average coefficients for the feed demanded by the various livestock activities. The feed requirements have been derived from subjective farmer estimates and overseas feeding standards. This approach was necessary because a comprehensive set of New Zealand beef cattle feeding standards were not available. Whilst this might seem to detract from the validity of the results obtained, the fact that the optimum plans derived from the model are realistic and practicable to the farmers concerned, does mean that the feed coefficients used are close to those applicable on the case farms.

Farm management workers will continue to be faced with the problem of deriving feed estimates based on subjective data and overseas research work until further research is done in New Zealand to obtain a more precise set of beef cattle feeding standards.

6.2.2 Variation in Feed Supply

This study has examined the influence of variation in feed supply *ex poste*, by discussing the feasibility of particular optimum plans with the case farmers. The farmer's views of the feasibility of these plans took into account the uncertainty of grass growth at critical times of the year.

6.2.3 The Correlated Beef Prices in the Analysis

The correlated beef prices used in the linear programming analysis are important because the relationships between these prices influence the particular beef policies in the optimum plans. The optimum plans for the case farms are sensitive to small changes in these prices and therefore, care must be taken if the results for these farms are directly applied to other farms. That is, the variation that occurs in beef cattle prices may mean that beef policies not included in these plans can be profitably incorporated into other dairy farming systems.

However, the price stability limits and basis values for the case farms rank the beef activities according to profitability. This ranking provides a guide to the relative profitability of these beef enterprises on similar dairy farms.

6.2.4 The Scope of the Study

The analysis of the case farms was concerned with the feasibility and profitability of substituting beef cattle for dairy cows at a similar stocking rate to that operating on the farm at present. That is, the analysis did not consider a developmental situation for either milk or beef production. The case farms are all well developed and the farmers were not considering increasing the stocking rate.

Many other dairy farmers, however, need to evaluate the profitability of beef production in a developmental context. For these farmers, a different set of costs, revenues and restraints may have to be specified. For example, the developmental cost of increasing beef production may be lower than the cost of increasing milk production on a farm where a new milking shed would be needed for additional dairy cows.[1/]

6.3 SUMMARY OF RESULTS

6.3.1 Beef Weaner Production on Dairy Farms

It is shown in Chapter 5 for case farm 3 (and other dairy farms with similar resource structures) that three months old weaner production is a profitable supplementary enterprise to dairying. Furthermore, the profitability of this enterprise is not directly affected by the beef incentive payment but depends on the weaner selling price and the opportunity cost of the calf reared to the weaner stage.

However, the beef incentive payment may increase the price dairy farmers receive for three to four months old weaners. This is because dairy farmers who purchase three months old weaners can qualify for the beef incentive payment of $10 per head. Overall, this stimulus to the weaner price may not be great because not all dairy bred weaners are purchased by dairy farmers. Sheep and beef farmers who purchase these weaners, do so in relation to the expected beef schedule price. Therefore, provided the beef schedule remains at a high level, say $20 per 100 pounds or greater, the demand for dairy bred weaners should continue.

A large number of dairy farms may have similar resource structures to case farm 3. These are dairy farms which have sufficient labour available to rear extra calves or farms where the manager is prepared to work harder during the Spring in order to increase the net farm profit. At present prices, beef weaner production would be a profitable supplementary enterprise to dairying on these farms. However, dairy farmers will only adopt this enterprise if the price difference between bobby calves and weaners is

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1/ See section 4.3.

sufficient to give the farmer a "reasonable" return for the extra work. For case farm 3, the "reasonable" margin required by the farmer was $17. In 1969, the actual difference between the calf and weaner price was $22-25. Therefore, provided the demand for dairy bred weaners continues, beef weaner production is expected to be adopted by an increasing number of dairy farmers.

6.3.2 Beef Production on Dairy Farms

It has been shown that a mixed beef-dairy farming system is feasible for two particular dairy farms (case farms 1 and 2).

By reducing dairy cow numbers, retaining surplus calves for rearing and purchasing additional store beef cattle (calves, and weaners) a beef production enterprise can be introduced. On both case farms 1 and 2, the change from all dairying to mixed beef-dairy farming results in a reduction in the amount of hired labour on the farm.

a) The Advantages of a Mixed Beef-Dairy Policy

Dairy farmers are accustomed to a guaranteed butterfat price and they may be unwilling to accept the uncertainty associated with the beef schedule price for their total output. The mixed beef-dairy policy enables a farmer to remain in a flexible position and devote, say, 30 percent of the farm to beef production and take advantage of the current high beef schedule price.

The second advantage is that the farmer does not have to buy large numbers of bobby calves or weaners in order to adopt a beef enterprise. Buying large numbers of bobby calves may become an increasing problem as dairy bred calves become more popular for beef production. However, if the "dairy-beef" weaner sales in November-December continue to expand, then the problem of buying three months old weaners will diminish.

Many dairy farmers view the mixed policy as a transistional stage where they can "experiment" with beef production without having to rely completely on the profit from this enterprise to meet their fixed charges.

b) The Disadvantages of a Mixed Beef-Dairy Policy

The difficulties associated with this policy arise mainly from having two separate enterprises on the one farm; milk and beef production. The allocation of feed between the two enterprises is perhaps the most difficult aspect. Some of the grazing management techniques that can be employed to overcome this problem have been outlined in the study.

c) An All Beef Production Policy

A change to all beef farming is feasible on the three case farms studied, if sufficient calves and/or weaners can be obtained. This system results in a lower net farm revenue than is currently being earned at 1969/70 prices 1/. Therefore, the farmer must be prepared to accept a lower net income if he adopts an all beef policy. However, the single enterprise (all beef production) would require a smaller managerial input from the farmer than a two enterprise system. This should enable the farmer to spend more time buying and selling beef cattle which may increase the net revenue obtained. This increase was not estimated because it depends so much on the marketing skills of the individual farmer. In contrast, the mixed beef-dairy farmer may have to rely on contract sales and purchases of cattle, because he may not have the time available to be present at many stock sales.

As was pointed out in section 3.2.4 the farmer's decision of whether to accept the lower net revenue but perhaps less effort associated with all beef farming, will also depend on the level of fixed charges and presumably his age. For example, a semi-retired farmer with few committments may be prepared to accept a lower net income from beef production than he was previously earning from dairying.

1/ That is, milk: 32-33.5 cents per lb butterfat and beef: $21.50 per 100 lb.

One problem associated with beef production is the difficulty in getting stock slaughtered at the time the farmer wishes to sell them. This difficulty in getting stock killed arises owing to shortages of killing space and the industrial unrest that exists in the meat processing industry which is almost unknown in milk processing factories.

The linear programming evaluation for case farms 1 and 2, shows that these farmers could increase their net revenue by adopting a mixed beef-dairy policy at 1969/70 prices. However, the increase in net revenue that could be obtained by making the change is not great. The sensitivity of the optimum plans to changes in the net revenues of the beef activities means that managerial skill is a very important determinant of profit, especially with regard to buying and selling beef cattle.

The management factor is also important in ensuring that beef cattle are in saleable order to maintain management flexibility. This flexibility with beef cattle policies is most important on mixed beef-dairy farms. Poor grass growth at a critical time of the year may cause competition between the milking herd and the growing beef cattle. In this situation, some beef cattle may have to be sold in store condition or slaughtered at light weights to avoid penalizing the production performance of the remaining stock.

The beef incentive payment is "worth" a great deal to the dairy farmer changing partly or entirely over to beef production. However, it is uncertain whether the Dairy Industry Beef Scheme will be continued beyond the 1970/71 season and this factor together with the uncertainty regarding the future beef to milk price ratio may have a large influence on the enterprise combination adopted by the case farmers. If the beef incentive payment is removed and the beef schedule price increases above $21.50 to compensate, then the optimum plans for case farms 1 and 2 at 1969/70 prices 1/

1/ See Tables 5.2 and 5.12 (including the beef incentive payment).

would not markedly change. That is, if the beef schedule price increased to $25.50 or greater, and the incentive payment is removed, then it would still be profitable to make a marginal shift of beef for milk production on these farms. However, this statement assumes that the milk price remains at approximately 32 cents per pound butterfat. If the milk price increased above this figure, then milk production would tend to become relatively more profitable than beef production 1/.

There is a marked difference in the beef to milk price ratio at which a significant change from milk to beef production occurs on the three case farms as shown by the beef supply responses. This is because the relative profitability of beef and dairy production depends on a large number of factors which vary considerably between farms. These factors include:

1. The suitability of the whole of the present dairy farm for milking cows.
2. The presence of any labour or capital restraints to increased milk production as compared with increased beef production.
3. The rate of transformation of beef production per acre for milk production per acre in relation to the ability of the particular farm manager.

These factors imply that each farmer must evaluate the place of beef production on his own farm with its own particular resource structure.

6.4 THE EFFECT OF THE BEEF INCENTIVE PAYMENT

The price stability limits for the mixed beef-dairy plans of case farms 1 and 2 indicate that the proportion of beef cattle in the plans is sensitive to changes in the beef price. Therefore, if the Dairy Industry

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1/ In June 1970, a 5 percent increase in the guaranteed butterfat price was announced. Therefore, the total milk payout for the 1970/71 season is likely to exceed 32 cents per pound butterfat.

Beef Scheme is removed, the qualifying conditions altered, or the incentive payment increased, dairy farmers may react sharply to the change. That is, some dairy farmers may be at a "border" point where a small decrease in the milk to beef price ratio will cause a reduction in the number of cows milked. It is likely that the surplus capacity on these farms would be used in beef production.

The aim of the Dairy Industry Beef Scheme is to cause a marginal shift of dairy production into beef production. That is, the intention was for only increased grassland capacity on dairy farms to be diverted to beef production. This is very difficult, if not impossible, to achieve with an incentive scheme which is available to all dairy farmers. This is because the great variation in the resource structure of dairy farms will induce some dairy farmers to change entirely over to beef production while many others would find increased milk production a more profitable enterprise.

If the beef incentive payment is removed in 1971, after being in operation for only two seasons, it will markedly lower the net revenue of dairy farm beef enterprises. It is, also, very difficult for a farmer to plan ahead with confidence unless the scheme is going to remain in operation for at least five years.

Therefore, an enterprise incentive such as the Dairy Industry Beef Scheme has the capacity to cause marked changes in farm prices and policies. This emphasises the need to plan very carefully to ensure that the true objective of the scheme will in fact be met both by the amount of the incentive payment and the qualifying restrictions imposed.

6.5 CONCLUSIONS

The results for case farm 1 indicate that at present prices, this farm should continue to operate a mixed beef-dairy policy.

However, the financial incentive for case farmer 2 to reduce milk production and increase beef production at 1969/70 prices, is not sufficient to warrant him adopting another enterprise. Nevertheless, if the beef incentive payment continues to be available and the beef schedule price increases to $25.50, then this farmer would consider adopting a mixed beef-dairy policy.

Beef weaner production will be adopted on case farm 3 so long as the good demand for weaners continues, but a large reduction in the milk to beef price ratio would be necessary before this farmer could profitably substitute milking cows with beef cattle.

The case farm analysis shows that beef production can be increased on dairy farms but that there is a marked difference in the milk to beef price ratio at which the farmers can profitably make the change. If product prices tend to favour beef production in the future, then it can be expected that some dairy farmers will change partly or entirely over to beef production. The first farms to change will be those where capital and labour restrictions make the substitution profitable at relatively high milk to beef price ratios. However, on farms where these resources restrictions are less critical (for example case farm 3) then a much lower price ratio may be required to enable the farmers to substitute beef cattle for milking cows without lowering the total net revenue from the farm.

To summarize, many dairy farmers are in a flexible position in that they are able to move partly or entirely from milk production to beef production from surplus calves. The time required to make the changeover varies from one to two years depending on the beef policy adopted. Therefore, these dairy farmers can adopt milk and/or beef producing enterprises according to the expected milk to beef price ratio, resource restrictions and input costs applicable to their particular farms.

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APPENDIX I

MONTHLY FEED REQUIREMENTS OF CATTLE

A1.1

a) The monthly feed intake for Jersey-Friesian cross milking cows on seasonal supply, with a mean liveweight of 1000 pounds, producing 300-330 pounds butterfat in a 280-300 day lactation and a mid-point of calving on 1 August, is assumed to be as follows:

Month	Feed Intake (lb D.O.M. per day)1/
June	11.0
July	15.9
August	19.0
September	21.1
October	20.3
November	19.4
December	18.6
January	17.7
February	16.8
March	15.7
April	14.4
May	13.1

b) The monthly feed requirements (grass and hay) of Friesian beef cattle born in August and growing to slaughter at 18-22 months of age at 425 pounds carcase weight are assumed to be as follows:

1/ Pounds Digestible Organic Matter (Coop, 1961).

Month	Feed Intake (lbs D.O.M. per day)
August	0
September	0.6
October	1.7
November	2.5
December	3.1
January	3.5
February	4.0
March	4.4
April	5.2
May	5.6
June	5.8
July	6.2
August	6.9
September	9.1
October	11.4
November	12.5
December	13.6
January	14.8

A1.2 THE DERIVATION OF CATTLE FEED INTAKE

A.1.2.1 Dairy Cows

The feed intake of dairy cows has been documented for New Zealand pastoral conditions. Coop (1965) has summarized the research work of Wallace (1961) and Hutton (1962) in estimating the monthly feed intake of Jersey and Friesian cows.

There is, however, no New Zealand data available on the feed intake of Jersey-Friesian cross cows and it has been assumed 1/ that the feed intake of these crossbred cows is mid-way between the feed intake of the Jersey and Friesian cows as defined by Coop (1965).

1/ The assumption was suggested by Wilson (1969)

Culling Adjustment

The monthly feed intake of a Jersey-Friesian cross cow estimated from the above work was adjusted for the sale of cull cows according to the monthly culling distribution of Case farm 1 and these monthly cull cowssales have been tabulated as follows:

Month	Percentage Cull Cows Sold
October	5
November	15
December	12
January	5
February	5
March	8
April	20
May	30
	100 percent

The monthly feed intake of a crossbred cow estimated in this way is given on page 1 of this appendix.

A.1.2.2 Beef Cattle

The estimation of feed intake for beef cattle has been the most difficult task in this study because only a limited amount of research evidence is available on the feed intake of beef cattle grazed under New Zealand conditions.

New Zealand research data was available from only one trial which was being conducted at Ruakura Agricultural Research Centre, and the relevant data from that trial is presented in table A.1.

In this trial, Joyce (1969) measured the apparent dry matter intake of Friesian steers, grazed at three stocking rates, from weaning at 10 weeks of age until slaughter at 18-22 months of age.

TABLE A.1

Stocking Rate (Beasts per acre)	2½	2	1½
Carcase Wt per Beast at slaughter (lbs)	364	394	418
Apparent Dry Matter Intake per Beast (lbs)	5304	6433	6802

Source: Joyce (1969)

The monthly feed intake distribution from this trial was not available and hence the data presented is only relevant to steers which folow the same growth pattern and attain the same carcase weight at slaughter as the trial animals.

In view of the paucity of scientific data available, the author used overseas feeding standards of Morrison (1959); Garrett, Meyer and Lofgreen (1959; Anon. (1958) and Anon. (1965), to estimate the monthly feed intake of Fresian beef cattle which grew to a carcase weight of 425 lbs when slaughtered at 18 - 22 months of age. The total feed intake, so estimated, was compared with the results obtained by Joyce for animals with a similar growth pattern. It was found that the overseas feeding standards for stall fed beef cattle were approximately 20 percent lower than those estimated from the work of Joyce and were increased accordingly. This increased requirement is expected since stall fed cattle have a lower maintenance than animals which are free-grazing (Joyce, 1969). Besides the adjustment made on the basis of New Zealand research evidence, the feed intake distribution was compared with subjective estimates of the substitution rate between dairy cows and beef animals at various times of the year. These subjective estimates were obtained from the farmers surveyed and from Farm Officers in each district. The 'theoretical' distribution of feed intake falls within the range of "practical" estimates of the substitution rate of beef cattle for milking cows obtained from the farmers. Hence the distribution was assumed to be a realistic estimate of the monthly feed intake of Friesian beef cattle growing under New Zealand pastoral conditions to the specified slaughter weight. The farmer's estimated substitution rates of beef animals for crossbred milking cows is given below:

Age of Beef Animal (months)	Substitution Rate (beef animals per crossbred milking cow)
4	6 : 1
6	4 : 1
10	2 : 1
18-20	1 : 1

A1.3 SUMMARY

The feed intake for cows and beef animals has been estimated from theoretical data but at the same time considerable care was taken to ensure that the derived feeding standards were substantiated by the observations of farmers and farm advisers.

Cross-checking was carried out between the scientific and subjective estimates of feed intake to ensure that the ratio of feed intake of cows and beef animals was realistic.

APPENDIX 2

THE LINEAR PROGRAMMING MATRIX - CASE FARM I

Row Name	Restraint	Resource Availability (B column)	Relationship	P_1 Milking Cow (1 cow)	P_2 Replacement heifer (1 heifer)	P_3 Cow Beef Sales (1 lb. beef)	P_4 Light Bobby Sales (1 calf)	P_5 Light Bobby Sales (1 calf)	P_6 Nurse cow 2 calves sold 15 mths. (1 cow)	P_7 Nurse cow 2 calves sold 10 mths. (1 cow)	P_8 Milk Sales (1 lb. b'fat)	P_9 Buy Beef Calf (4 day old) (1 calf)	P_{10} Buy Milk Powder b'fat (1 lb.eq.)
	Net Revenue ($)			-9.3	-2.0	0.17	9.0	9.0	12.6	98.0	0.38	-17.0	-0.38
Reconciliations													
X_1	Heifer Replacements	0 heifers	≥	0.3	-1.0				0.3	0.3			
X_2	Beef calves	0 calves	≥	-0.4					1.76	1.74		-1.0	
X_3	Heifer calves	0 calves	≥	-0.4	1.09		1.0		-0.4	-0.4			
X_4	Total milk	0 lb.b'fat[1]	≥	-315.0	16.4						1.0		-4.0
X_5	Cow beef	0 lb. beef	≥	-88.0		1.0			-88.0	-88.0			
X_6	Bobby calves	0 calves	≥	-0.15				1.0	-0.15	-0.15			
X_7	Beef	0 lb. beef	≥						-900.				
X_8	Calf feed	0 units milk[2]	≥	-5.0	0.82								-0.05
X_9	Heifer grazing	0 heifers	≥		-1.0								
Labour Restraint													
X_{10}	Spring labour	220 c.r.u.[3]	≥	2.0	1.0				2.0	2.0			
Feed Reconciliations													
X_{11}	August	2109 lb.D.O.M.[4] per day	≥	14.4	5.4				3.8	17.6			
X_{12}	September	4102 lb. "	≥	19.1	8.6				42.7	22.5			
X_{13}	October	4315 lb. "	≥	20.3	11.3				50.3	25.3			
X_{14}	November	5020 lb. "	≥	19.4	12.7				52.8	25.6			
X_{15}	December	5154 lb. "	≥	18.6	13.7				25.6	25.6			
X_{16}	January	4342 lb. "	≥	17.7	14.7				25.7	25.7			
X_{17}	February	3709 lb. "	≥	16.8	15.4				25.6	25.6			
X_{18}	March	3247 lb. "	≥	15.7	16.5				26.1	26.1			
X_{19}	April	3900 lb. "	≥	14.4	17.5				25.6	25.6			
X_{20}	May	2938 lb. "	≥	11.1	4.1				21.3	22.7			
X_{21}	June	1396 lb. "	≥	7.7	3.1				8.4	-			
X_{22}	July	1909 lb. "	≥	12.6	3.5				22.4	12.6			
Hay Reconciliation		D.O.M.											
X_{23}	May	0 lb.per day	≥	2.0	0.7				1.4	-			
X_{24}	June	0 lb. "	≥	3.1	2.0				4.0	-			
X_{25}	July	0 lb. "	≥	3.3	2.0				7.3	3.3			
X_{26}	August	0 lb. "	≥	2.6	2.0				6.6	2.6			
X_{27}	September	0 lb. "	≥	2.0	1.3				4.6	2.0			

Row Name	P_{11} Sell 3 mths. Beef Weaner (1 weaner)	P_{12} Sell 6 mths. Beef Weaner (1 weaner)	P_{13} Sell 13 mths. beef Yearling (1 yearling)	P_{14} Sell 18 mths. Beef (1 beast)	P_{15} Beef Sales (Steer or Bull) (1 lb. beef)	P_{16} Sell Beef Calf (4-day old) (1 calf)	P_{17} Buy 3 mths. sell 13 mths. beef yearling (1 yearling)	P_{18} Buy 3 mths. sell 18 mths. beef (1 beast)	P_{19} Buy 6 mths. sell 18 mths. beef (1 beast)
Net Revenue ($)	28.25	33.0	64.5	5.5	0.195	15.0	29.25	-27.95	-49.8
X_2	1.05	1.06	1.08	1.09					
X_4	21.0	21.2	21.5	21.8					
X_7				-425.0	1.0			-425.0	-425.0
X_8	1.05	1.06	1.08	1.09					
X_{10}	1.0	1.0	1.0	1.0					
X_{11}	0.6	0.6	7.7	7.7			7.1	7.1	7.1
X_{12}	1.7	1.7	11.8	11.8			10.1	10.1	10.1
X_{13}	2.5	2.5	2.5	15.0				12.5	12.5
X_{14}	1.8	3.5	3.1	16.7				13.6	13.6
X_{15}		4.0	3.5	18.3			3.5	18.3	14.8
X_{16}		4.4	4.0	17.6			4.0	17.6	13.6
X_{17}		2.6	4.4	14.6			4.4	14.6	10.2
X_{18}			5.2	13.2			5.2	13.2	13.2
X_{19}			5.6	11.1			5.6	11.1	11.1
X_{20}			5.1	8.1			5.1	8.1	8.1
X_{21}			4.2	4.2			4.2	4.2	4.2
X_{22}			4.9	4.9			4.9	4.9	4.9
X_{23}			0.7	0.7			0.7	0.7	0.7
X_{24}			2.0	2.0			2.0	2.0	2.0
X_{25}			2.0	2.0			2.0	2.0	2.0
X_{26}			2.0	2.0			2.0	2.0	2.0
X_{27}			1.3	1.3			1.3	1.3	1.3

Row Name	P_{20} Make Hay: Buy Hay (1 bale)	P_{21} Make Hay: Sept., Oct. (1 bale)	P_{22} Make Hay: Oct., Nov. (1 bale)	P_{23} Make Hay: Nov., Dec. (1 bale)	P_{24} Make Hay: Dec., Jan. (1 bale)	P_{25} Hay Transfer: May, June (1 lb.D.O.M. per day)	P_{26} Hay Transfer: May, July	P_{27} Hay Transfer: May, Aug.	P_{28} Hay Transfer: May Sept.	P_{29} Buy heifer Grazing (1 heifer)	P_{30} Buy Labour (1 single man)	P_{31} Feed Transfer: April, May (1 lb.D.O.M. per day)	P_{32} Feed Transfer: May, June	P_{33} Feed Transfer: June, July	P_{34} Feed Transfer: July, Aug.
Net Revenue ($)	-0.6	-0.3	-0.3	-0.3	-0.3	0	0	0	0	-24.0	-1560.0	0	0	0	0
X_9										1.0					
X_{10}											-145.0				
X_{11}										-5.0					-1.0
X_{12}		0.33								-7.2					
X_{13}		0.33	0.33							-9.5					
X_{14}			0.33	0.33						-10.2					
X_{15}				0.33	0.33					-10.8					
X_{16}					0.33					-11.4					
X_{17}										-11.9					
X_{18}										-12.3					
X_{19}										-13.0		1.0			
X_{20}										-4.1		-1.0	1.0		
X_{21}										-3.1			-1.0	1.0	
X_{22}										-3.5				-1.0	1.0
X_{23}	-0.66	-0.66	-0.66	-0.66	-0.66	1.0	1.0	1.0	1.0	-0.7					
X_{24}						-1.0				-2.0					
X_{25}							-1.0			-2.0					
X_{26}								-1.0		-2.0					
X_{27}									-1.0	-1.3					

Note: 1. Butterfat.

2. The units of milk are expressed as a proportion of 20 pounds butterfat as whole milk or its equivalent.

3. Calf rearing units.

4. The feed is expressed in terms of the feeding standard Digestible Organic Matter.

APPENDIX 3

BEEF PRICE LEVELS AND ACTIVITY NET REVENUES

Seven discrete beef schedule prices for ox and bull beef were chosen ranging from $13.50 to $25.50 per 100 pounds of beef in $2 intervals. At each of these prices for beef, a price was assumed for cow beef, bobby calf and weaner purchases and weaner and yearling cattle sales. These prices were obtained from the survey of farmers described in Chapter 4. The beef and cattle prices were then used to calculate the net revenues of the beef producing activities (by deducting the variable costs; freight, animal health and losses, etc.), at each beef price level.

For convenience, the ox beef schedule prices $13.50 to $25.50 have been numbered 1 to 7. That is, beef price level 4 implies an ox or bull beef schedule of $19.50 per 100 pounds. Both terms of reference are used synonymously in the text. The correlated purchase and sale prices are given in the following Table A.3.1.

The gross revenue, variable costs and net revenues of each activity for case farm 1 are given in Table A.3.2. Those activities producing beef have been listed at price level 5; $21.50 per 100 pounds.

TABLE A.3.1

Class	Activity	Units	BEEF PRICE LEVEL						
			1	2	3	4	5	6	7
Ox or bull beef	P_{15}	$ per 100lb	13.5	15.5	17.5	19.5	21.5	23.5	25.5
Cow beef	P_3	$ per 100lb	11.0	13.0	15.0	17.0	19.0	21.0	23.0
Purchases									
Bobby calves	P_9	$ per beast	10.0	12.0	14.0	16.0	18.0	20.0	21.0
Weaners (3 months)	P_{17},P_{18}	$ per beast	28.0	30.0	32.0	34.0	36.0	38.0	41.0
Weaners (6 months)	P_{19}	$ per beast	34.0	36.0	38.0	40.0	42.0	44.0	46.0
Sales									
Weaners (3 months)	P_{11}	$ per beast	24.0	26.0	28.0	30.0	32.0	34.0	37.0
Weaners (6 months)	P_{12}	$ per beast	29.0	31.0	33.0	35.0	37.0	39.0	42.0
Yearlings (13 months)	P_{13},P_{17}	$ per beast	40.0	46.0	52.0	58.0	64.0	70.0	76.0

Note: The beef incentive payment has not been included in the above prices.

TABLE A.3.2

NET REVENUES - CASE FARM I

Beef Price Level 5

Activity	Activity Code	Units	Gross Revenue $	Variable Costs $	Net Revenue $
Milking cows	P_1	1 cow	-	9.3	-9.3
Heifer replacements	P_2	1 heifer	-	2.0	-2.0
Cow beef sales	P_3	1lb beef	0.19	-	0.19 1/
Light calf sales	P_4, P_5	1 calf	9.0	-	9.0
Nurse cows (16mths)	P_6	1 cow	20.0	7.4	12.6
Nurse cows (10mths)	P_7	1 cow	104.0	6.0	98.0
Milk sales	P_8	1lb b.fat	0.34 2/	-	0.34
Buy calf	P_9	1 calf	-	19.0	-19.0 1/
Buy calf feed	P_{10}	1lb b.fat equiv.	-	0.38	-0.38
Sell 3mths weaner	P_{11}	1 weaner	32.0	1.75	30.25 1/
Sell 6mths weaner	P_{12}	1 weaner	37.0	2.0	35.0 1/
Sell store yearling	P_{13}	1 beast	74.0	3.5	70.5 1/
Sell 18 mths beast	P_{14}	1 beast	10.0	4.5	5.5
Beef sales	P_{15}	1lb beef	0.125	-	0.215 1/
Heavy calf sales	P_{16}	1 calf	17.0	-	17.0 1/
Buy weaner sell yearling	P_{17}	1 beast	74.0	40.75	33.25 1/
Buy weaner sell 18mths beast	P_{18}	1 beast	10.0	39.95	-29.95 1/
Buy 6mths weaner sell 18mths beast	P_{19}	1 beast	-	46.5	-46.5 1/
Buy hay	P_{20}	1 bale	-	0.6	-0.6 3/
Make hay	P_{21-24}	1 bale	-	0.3	-0.3 3/
Hay transfers	P_{25-28}	1lb D.O.M. 4/ per day	-	-	-
Buy heifer grazing	P_{29}	1 heifer	-	24.0	-24.0 3/
Buy Labour	P_{30}	1 single man	-	1560.0	-1560.0 3/
Feed transfers	P_{31-34}	1lb D.O.M. per day	-	-	-

1/ Beef price level 5 only.

2/ This price varies between 20-38 cents per lb butterfat.

3/ Peculiar to case farm 1.

4/ Digestible organic matter.

5/ Cost and Revenue items not directly assigned to an activity, but reconciled by restraints, have not been included.

APPENDIX 4

PARAMETRIC SOLUTIONS

The parametric solutions for the case farms (1,2 and 3) are given in the following appendices 4,5 and 6 respectively.

Seven sets of solutions are given for each farm, one for each beef price level, being $13.50 to $25.50 per 100 pounds beef in $2 intervals.

The parametric solutions are given with respect to variation in the milk price expressed in cents per pound butterfat. Every solution within each set is optimum over a range of milk prices. The upper limit of that range is called the "border" milk price and is shown above each solution. The lower milk price of that range, for any solution, is 0.1 cents 1/ above the "border" milk price of the following solution except for the last solution of each set, where the lower limit is 20.0 cents per pound butterfat.

1/ In the computational procedure, the milk price was expressed in dollars, hence 38 cents was $0.380. Theoretically, the lower limit is a very small decimal, say $0.0000001, above the following "border" price but owing to the computational error involved with some solutions, the computer program was only sensitive to a change of $0.001 and, hence, this degree of accuracy has been used here.

PARAMETRIC SOLUTIONS - CASE FARM I

Beef Price Level 1

($13.50 per 100 lb)

Plan			A	C	M	F	G	H	
"Border" Milk Price (cents per lb.butterfat)			38.0	25.6	25.1	24.7	24.2	24.1 →	20.0
Activity	Activity Code	Units							
Milking Cows	P_1	1 cow	186	150	86	68	38	28	
Milk Production	P_8	1lb butter-fat	57,726	46,590	24,882	20,704	9,575	6,020	
Nurse Cows	P_6	1 cow	-	-	12	23	17	16	
Beef Calf Purchases	P	1 calf	-	-	76	25	117	146	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	75	81	153	155	152	
Store Cattle Sold (13 months old)	P_{13}, P_{17}	1 beast	-	32	83	79	136	144	
Beef Cattle Slaughtered (15 months old)	P_2, P_6	1 beast	-	-	24	46	54	32	
Beef Cattle Slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	40	78	79	108	121	
Hay made	P_{21-24}	1 bale	3723	3880	4106	4122	4334	4338	
Permanent labour hired	P_{30}	1 single man	1.44	0.87	0.61	-	-	-	
Total Net Revenue	Z - C	$	13,387	11,241	11,020	10,930	10,834	10,826	

PARAMETRIC SOLUTIONS - CASE FARM I

Beef Price Level 2

($15.50 per 100lb)

Plan			A	B	C	K	L	D	E	F	G	H
"Border" Milk Price (cents per lb. butterfat)			38.0	28.7	28.2	28.0	27.8	27.6	27.4	27.2	26.2	25.8→20.0
Activity	Activity Code	Units										
Milking Cows	P_1	1cow	186	173	150	137	135	85	73	68	38	28
Milk Production	P_8	1lb butter fat	57726	53613	46590	41335	40879	26188	22498	20704	9775	6020
Nurse Cows	P_6	1cow	-	-	-	-	-	19	23	23	17	16
Beef Calf purchases	P_9	1 calf	-	-	-	-	-	-	11	25	117	146
Beef Weaner purchases (4 months old)	P_{17},P_{18}	1weaner	-	25	75	53	54	143	155	153	155	152
Store cattle sold (13 months old)	P_{13}, P_{17}	1 beast	-	-	32	49	50	68	74	79	136	144
Beef Cattle slaughtered (15 months old)	2.P_6	1 beast	-	-	-	-	-	38	46	34	34	32
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	24	40	51	52	70	76	79	108	121
Hay made	P_{21-24}	1 bale	3723	3724	3880	3944	3948	4068	4103	4122	4334	4338
Permanent Labour hired	P_{30}	1 single man	1.4	1.2	0.9	1.0	1.0	0.1	-	-	-	-
Total Net Revenue	Z - C	$	18789	13425	13167	13080	12998	12924	12875	12831	12634	12597

PARAMETRIC SOLUTIONS - CASE FARM I

Beef Price Level 3

($17.50 per 100 lb)

Plan "Border" Milk Price (cents per lb.butterfat)			A 38.0	B 31.8	K 30.9	L 30.5	D 30.1	E 29.8	F 29.1	G 28.2	H 27.5	→ 20.0
Activity	Activity Code	Units										
Milking Cows	P_1	1 cow	186	173	137	135	85	73	68	38	28	
Milk Production	P_8	1lb butter-fat	57726	53613	41555	40879	26188	22498	20704	9575	6020	
Nurse Cows	P_6	1 cow	-	-	-	-	19	23	23	17	16	
Beef Calf purchases	P_9	1 calf	-	-	-	-	-	11	25	117	146	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	25	53	54	143	155	153	155	152	
Beef Cattle slaughtered (15 months old)	$2.P_6$	1 beast	-	-	-	-	38	46	46	34	32	
Store Cattle Sold (13 months old)	P_{13}, P_{17}	1 beast	-	-	49	50	68	74	79	136	144	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	24	51	52	70	76	79	108	121	
Hay made	P_{21-24}	1 bale	3723	3747	3944	3948	4068	4103	4122	4334	4338	
Permanent Labour hired	P_{30}	1 single man	1.4	1.2	1.0	1.0	0.1	-	-	-	-	
Total Net Revenue	Z - C	$	19191	15616	15146	14981	14838	14762	14607	14454	14369	

PARAMETRIC SOLUTIONS - CASE FARM 1

BEEF PRICE LEVEL 4

($19.50 per 100 lbs.)

Plan "Border" Milk Price (cents per lb butterfat)			A 38.0	B 34.7	C 33.4	D 32.7	E 32.1	F 31.3	G 30.3	H 29.2	I 23.1	J 21.4→	20.0
Activity	Activity Code	Units											
Milking cows	P_1	1 cow	186	173	150	85	73	68	38	28	14	-	
Milk Production	P_8	1lb.butterfat	57726	53613	46590	26188	22498	20704	9575	6020	5035	-	
Nurse Cows	P_6	1 cow	-	-	-	19	23	23	17	16	14	12	
Beef Calf purchases	P_9	1 calf	-	-	-	-	11	25	117	146	187	229	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	25	75	143	155	153	155	152	144	136	
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	-	-	32	68	74	79	136	144	156	169	
Beef Cattle Slaughtered (15 months old)	$2.P_6$	1 beast	-	-	-	38	46	46	34	32	28	24	
Beef Cattle Slaughtered (18 - 22 months old)	P_{14}, P_{18}	1 beast	-	24	40	70	76	79	108	121	138	156	
Hay made	P_{21-24}	1 bale	3723	3747	3880	4068	4103	4122	4334	4338	4343	4348	
Permanent Labour hired	P_{30}	1 single man	1.4	1.2	0.9	0.1	-	-	-	-	-	-	
TOTAL NET REVENUE	Z - C	$	19661	17768	17077	16815	16626	16445	16244	16139	15772	15720	

PARAMETRIC SOLUTIONS - CASE FARM 1

BEEF PRICE LEVEL 5

($21.50 per 100lb)

Plan			A	B	C	D	E	F	G	H	I	J	
"Border" Milk Price (cents per lb butterfat)			38.0	37.7	35.9	35.1	34.5	33.2	32.3	30.8	25.9	24.2→	20.0
Activity	Activity Code	Units											
Milking Cows	P_1	1 cow	186	173	150	85	73	68	38	28	14	-	
Milk Production	P_8	1lb butter-fat	57726	53613	46590	26188	22498	20704	9575	6020	3035	-	
Nurse Cows	P_6	1 cow	-	-	-	19	23	23	17	16	14	12	
Beef Calf purchases	P_9	1 calf	-	-	-	-	11	25	117	146	187	229	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	25	75	143	155	153	155	152	144	136	
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	-	-	32	68	74	79	136	144	156	169	
Beef Cattle slaughtered (15 months old)	$2.P_6$	1 beast	-	-	-	38	46	46	34	32	28	24	
Beef Cattle Slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	24	40	70	76	79	108	121	138	156	
Hay made	P_{21-24}	1 bale	3723	3747	3880	4068	4103	4122	4334	4338	4343	4348	
Permanent labour hired	P_{30}	1 single man	1.4	1.2	0.9	0.1	-	-	-	-	-	-	
TOTAL NET REVENUE	Z - C	$	20144	19974	19018	18665	18512	18221	18043	17905	17612	17563	

PARAMETRIC SOLUTIONS - CASE FARM 1

BEEF PRICE LEVEL 6

($23.50 per 100 lb.)

Plan			C	D	E	F	G	H	I	J	
"Border" Milk Price (cents per lb.butterfat)			38.0	37.5	36.9	35.3	34.3	32.6	28.8	27.0→	20.0
Activity	**Activity Code**	**Units**									
Milking Cows	P_1	1 cow	150	85	73	68	38	28	14	-	
Milk Production	P_8	1lb butterfat	46590	26188	22498	20704	9575	6020	3035	-	
Nurse Cows	P_6	1 cow	-	19	23	23	17	16	14	12	
Beef Calf purchases	P_9	1 calf	-	-	11	25	117	146	187	229	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	75	143	155	153	155	152	144	136	
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	32	68	74	79	136	144	156	169	
Beef Cattle slaughtered (15 months old)	$2.P_6$	1 beast	-	38	46	46	34	32	28	24	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	40	70	76	79	108	121	138	156	
Hay made	P_{21-24}	1 bale	3880	4068	4103	4122	4334	4338	4343	4348	
Permanent labour hired	P_{30}	1 single man	0.9	0.1	-	-	-	-	-	-	
TOTAL NET REVENUE	Z - C	$	20771	20553	20399	20039	19844	19682	19456	19405	

PARAMETRIC SOLUTIONS - CASE FARM 1

BEEF PRICE LEVEL 7

($25.50 per 100lb)

Plan "Border"Milk Price (cents per lb. butterfat)			G 38.0	H 35.9	I 34.3	J 32.7→	 20.0
Activity	Activity Code	Units					
Milking Cows	P_1	1 cow	38	28	14	-	
Milk Production	P_8	1lb butterfat	9575	6020	3035	-	
Nurse Cows	P_6	1 cow	17	16	14	12	
Beef Calf purchase	P_9	1 calf	117	146	187	229	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	155	152	144	136	
Store cattle sold (13 months old)	P_{13}, P_{17}	1 beast	136	144	156	169	
Beef Cattle slaughtered (15 months old)	$1.P_6$	1 beast	34	32	28	24	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	108	121	138	156	
Hay made	P_{21-24}	1 bale					
Permanent Labour hired	P_{30}	1 single man	-	-	-	-	
TOTAL NET REVENUE	Z - C	$	22039	21841	21755	21708	

APPENDIX 5

PARAMETRIC SOLUTIONS - CASE FARM 2

BEEF PRICE LEVEL 1

($13.50 per 100lb)

Plan			P	A	B	C	Q	R	G	S	T	
"Border" Milk Price (cents per lb.butterfat)			38.0	29.1	27.8	25.9	24.9	24.7	24.6	22.1	21.2→	20.0
Activity	Activity Code	Units										
Milking Cows	P_1	1 cow	162	160	154	148	144	137	110	109	35	
Milk Production	P_8	1lb butter-fat	52720	51861	49555	47013	46038	43656	33523	33505	8148	
Beef Calf purchases	P_9	1 calf	-	-	-	-	-	7	69	68	217	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	-	-	-	-	-	-	-	-	
Beef Weaner sales (6 months old)	P_{12}	1 weaner	-	-	-	14	-	-	-	-	-	
Beef Cattle Sold (10 mths old)	$2.P_7$	1 beast	-	-	-	-	-	6	3	20	80	
Store Cattle Sold (13 months old)	P_{13}, P_{17}	1 beast	-	8	27	40	47	53	62	65	117	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	-	-	-	-	-	42	22	32	
Hay purchases	P_{20}	1 bale	1121	1244	1371	1395	1095	954	1549	1142	146	
Permanent Labour hired	P_{30}	1 single man	1.0	1.0	1.9	0.8	0.7	0.6	-	-	-	
Casual Labour hired	P_{35}	1 c.r.u.	-	8	27	53	47	59	105	107	72	
TOTAL NET REVENUE	Z-C	$	17634	12945	12273	11334	10864	10773	10699	9894	9622	

PARAMETRIC SOLUTIONS - CASE FARM 2

BEEF PRICE LEVEL 2

($15.50 per 100lbs)

Plan			P	A	B	C	D	U	F	G	H	
"Border" Milk Price (cents per lb.butterfat)			38.0	33.7	31.4	28.4	27.3	27.0	26.8	26.4	23.1→	20.0
Activity	Activity Code	Units										
Milking Cows	P_1	1 cow	162	160	154	148	147	141	132	110	47	
Milk Production	P_8	1lb butterfat	52720	51861	49555	47031	46606	44951	41679	33526	10839	
Beef Calf purchases	P_9	1 calf	-	-	-	-	-	-	20	69	207	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	-	-	-	-	-	-	-	-	
Beef Weaner sales (6 months old)	P_{12}	1 weaner	-	-	-	14	13	-	-	-	-	
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	-	8	27	40	40	48	48	62	102	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	-	-	-	2	5	19	42	106	
Hay purchases	P_{20}		1121	1244	1371	1395	1402	1192	1486	1549	1765	
Permanent Labour hired	P_{30}	1 single man	1.0	1.0	0.9	0.8	0.7	0.6	0.5	-	-	
Casual Labour hired	P_{35}	1 c.r.u.	-	8	27	53	55	52	67	104	67	
TOTAL NET REVENUE	Z - C	$	17916	15654	14459	12981	12464	12326	12239	12079	10988	

PARAMETRIC SOLUTIONS - CASE FARM 2

BEEF PRICE LEVEL 3

($17.50 per 100 lb)

Plan			A	B	C	D	E	F	G	H	M	
"Border" Milk Price (cents per lb. butterfat)			38.0	34.9	30.9	29.9	29.4	28.9	28.2	25.0	22.5 →	20.0
Activity	Activity Code	Units										
Milking Cows	P_1	1 cow	160	154	148	147	141	132	110	47	37	
Milk Production	P_8	1lb.butterfat	51861	49555	47031	46606	44684	41679	33526	10839	8522	
Beef Calf purchases	P_9	1 calf	-	-	-	-	-	20	69	207	163	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	-	-	-	-	-	-	-	74	
Beef Weaner sales (6 months old)	P_{12}	1 weaner	-	-	14	13	-	-	-	-	-	
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	8	27	40	40	40	48	62	102	125	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	-	-	2	12	19	42	106	110	
Hay Purchases	P_{20}	1 bale	1244	1371	1395	1402	1442	1486	1549	1765	1306	
Permanent Labour hired	P_{30}	1 single man	1.0	0.9	0.8	0.7	0.6	0.5	-	-	-	
Casual Labour hired	P_{35}	1 c.r.u.	8	27	53	55	52	67	104	67	-	
TOTAL NET REVENUE	Z - C	$	18211	16607	14628	14158	13927	13708	13427	12358	12092	

PARAMETRIC SOLUTIONS - CASE FARM 2

BEEF PRICE LEVEL 4

($19.50 per 100 lb)

Plan "Border" Milk Price (cents per lb.butterfat)			A 38.0	B 37.4	E 32.3	F 30.9	J 30.5	K 30.3	M 26.8 →	20.0
Activity	Activity Code	Units								
Milking Cows	P_1	1 cow	160	154	141	132	113	110	37	
Milk Production	P_8	1lb butter-fat	51861	49555	44684	41679	35356	34242	8521	
Beef Calf purchases	P_9	1 calf	-	-	-	20	29	33	163	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	-	-	-	36	40	74	
Beef Weaner sales (6 months old)	P_{12}	1 weaner	-	-	-	-	-	-	-	
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	8	27	40	48	69	72	125	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	-	12	19	35	38	110	
Hay purchases	P_{20}	1 bale	1244	1371	1442	1486	1284	1275	1306	
Permanent Labour hired	P_{30}	1 single man	1.0	0.9	0.6	0.5	0.1	-	-	
Casual Labour hired	P_{35}	1 c.r.u.	8	27	52	67	69	71	-	
TOTAL NET REVENUE	Z - C	$	18591	18285	15758	15135	14976	14906	13726	

PARAMETRIC SOLUTIONS - CASE FARM 2

BEEF PRICE LEVEL 5

($21.50 per 100 lb)

Plan			B	E	I	J	K	L	M	N	
"Border" Milk Price (cents per lb.butterfat)			38.0	34.2	32.9	32.7	32.3	28.9	28.4	22.5 →	20.0
Activity	Activity Code	Units									
Milking Cows	P_1	1 cow	154	141	116	113	110	59	37	-	
Milk Production	P_8	1lb butter-fat	49555	44684	36428	35356	34242	16693	8521	-	
Beef Calf purchases	P_9	1 calf	-	-	24	29	33	100	163	268	
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	-	34	36	40	89	74	47	
Beef Weaner sales (6 months old)	P_{12}	1 weaner	-	-	-	-	-	-	-	-	
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	27	40	66	69	71	115	125	142	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	12	33	35	38	86	110	150	
Hay purchases	P_{20}	1 bale	1371	1442	1287	1284	1275	1122	1306	1618	
Permanent labour hired	P_{30}	1 single man	0.9	0.6	0.1	0.1	-	-	-	-	
Casual labour hired	P_{35}	1 c.r.u.	27	52	67	69	71	-	-	-	
TOTAL NET REVENUE	Z - C	$	19022	17142	16566	16495	16354	15201	15129	14631	

PARAMETRIC SOLUTIONS - CASE FARM 2

BEEF PRICE LEVEL 6

($23.50 per 100 lbs)

Plan			B	E	F	I	J	V	K	L	M	N
"Border" Milk Price (cents per lb.butterfat)			38.0	36.1	35.3	35.0	34.9	34.3	33.0	31.0	30.2	25.2→20.0
Activity	Activity Code	Units										
Milking cows	P_1	1 cow	154	141	132	116	113	110	110	59	37	-
Milk Production	P_8	1lb butter-fat	49555	44684	42088	36428	35356	34296	34242	16693	8522	-
Beef Calf purchases	P_9	1 calf	-	-	-	24	29	31	33	100	163	268
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	-	20	34	36	43	40	89	74	47
Beef Weaner sales (6 months old)	P_{12}	1 weaner	-	-	-	-	-	-	-	-	-	-
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	27	40	48	66	69	72	72	115	125	142
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	12	19	33	35	38	38	86	110	150
Hay Purchases	P_{20}	1 bale	1371	1442	1323	1287	1284	1254	1275	1122	1306	1618
Permanent Labour hired	P_{30}	1 single man	0.9	0.6	0.5	0.1	0.1	-	-	-	-	-
Casual Labour hired	P_{35}	1 c.r.u.	27	52	49	66	69	69	72	-	-	-
TOTAL NET REVENUE	Z - C	$	19462	18526	18171	18049	18012	17838	17357	16680	16550	16132

PARAMETRIC SOLUTIONS - CASE FARM 2

BEEF PRICE LEVEL 7

($25.50 per 100 lbs)

Plan			F	O	J	K	L	M	N
"Border" Milk Price (cents per lb butterfat)			38.0	37.8	37.7	37.2	33.8	33.3	30.4 → 20.0
Activity	**Activity Code**	**Units**							
Milking Cows	P_1	1 cow	132	116	113	110	59	37	-
Milk Production	P_8	1lb butterfat	42088		35356	34242	16693	8522	-
Beef Calf purchases	P_9	1 calf	20	28	29	33	100	163	268
Beef Weaner purchases (4 months old)	P_{17}, P_{18}	1 weaner	-	31	36	40	89	74	47
Beef Weaner sales (6 months old)	P_{12}	1 weaner	-	-	-	-	-	-	-
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	48	66	69	72	115	125	142
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	19	33	35	38	86	110	150
Hay purchases	P_{20}	1 bale	1486	1311	1284	1275	1122	1306	1618
Permanent Labour hired	P_{30}	1 single man	0.5	0.1	0.1	-	-	-	-
Casual Labour hired	P_{35}	1 c.r.u.	67	69	69	71	-	-	-
TOTAL NET REVENUE	Z - C	$	19915	19837	19802	19626	18477	18404	18170

APPENDIX 6

PARAMETRIC SOLUTIONS - CASE FARM 3

BEEF PRICE LEVEL I

($13.50 per 100 lb)

"Border" Milk Price (cents per lb. butterfat)			38.0	37.3	35.8	28.7	22.5	21.3	20.4 →	20.0
Activity	Activity Code	Units								
Milking Cows	P_1	1 cow	102	102	102	102	101	98	98	
Milk Production	P_8	1lb butterfat	39010	38123	36546	36406	35911	34728	34444	
Beef Calf purchases	$P_{11,12}$, $P_{17,18}$	1 calf	-	3	82	88	92	99	101	
Weaners sold (3 months old)	P_{11}	1 weaner	-	42	117	123	120	112	110	
Weaners sold (6 months old)	P_{12}	1 weaner	-	-	-	-	3	10	12	
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	-	-	-	-	3	10	11	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	-	-	-	-	-	-	
Hay purchased	P_{20}	1 bale	303	646	1326	1391	1365	1344	1326	
TOTAL NET REVENUE		$	14885	14614	14043	11448	9191	8761	8045	

PARAMETRIC SOLUTIONS - CASE FARM 3

BEEF PRICE LEVEL 2

($15.50 per 100 lbs)

"Border" Milk Price (cents per lb. butterfat).			38.0	36.9	35.3	28.2	24.2	23.0	21.4	20.8 →	20.0
Activity	Activity Code	Units									
Milking cows	P_1	1 cow	102	102	102	102	101	98	98	61	
Milk Production	P_8	1lb butterfat	38191	38123	36546	36406	35911	34728	34444	18515	
Beef Calf purchases	$P_{11,12,17,18}$	1 calf	-	3	82	88	92	99	101	206	
Weaners sold (3 months old)	P_{11}	1 weaner	39	42	117	123	120	112	110	22	
Weaners sold (6 months old)	P_{12}	1 weaner	-	-	-	-	3	10	12	119	
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	-	-	-	-	3	10	11	74	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	-	-	-	-	-	-	-	
Hay purchased	P_{20}	1 bale	619	646	1326	1391	1365	1344	1326	-	
TOTAL NET REVENUE		$	15100	14680	14071	11477	10021	9591	9036	8852	

PARAMETRIC SOLUTIONS - CASE FARM 3

BEEF PRICE LEVEL 3

($17.50 per 100 lb)

"Border" Milk Price (cents per lb. butterfat)			38.0	36.4	34.8	27.7	26.0	24.8	22.3	21.8	21.5 → 20.0
Activity	Activity Code	Units									
Milking cows	P_1	1 cow	102	102	102	102	101	98	98	61	52
Milk Production	P_8	1lb butterfat	38191	38122	36546	36406	35911	34728	34444	18515	14816
Beef Calf purchases	$P_{11,12,17,18}$	1 calf	-	3	82	88	92	99	101	206	230
Weaners sold (3 months old)	P_{11}	1 weaner	39	42	117	123	120	112	110	22	23
Weaners sold (6 months old)	P_{12}	1 weaner	-	-	-	-	3	10	12	119	123
Store cattle sold (13 months old)	P_{13}, P_{17}	1 beast	-	-	-	-	3	10	11	74	80
Beef cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	-	-	-	-	-	-	-	9
Hay purchased	P_{20}	1 bale	619	646	1326	1391	1365	1344	1326	-	-
TOTAL NET REVENUE		$	15319	14708	14100	11505	10887	10456	9589	9437	9387

PARAMETRIC SOLUTIONS - CASE FARM 3

BEEF PRICE LEVEL 4

($19.50 per 100 lbs)

"Border" Milk Price (cents per lb. butterfat)			38.0	35.9	34.3	27.6	26.5	24.2	24.1	23.7	23.5	23.3>20
Activity	Activity Code	Units										
Milking Cows	P_1	1 cow	102	102	102	101	98	94	85	81	64	33
Milk Production	P_8	1lb butterfat	38191	38123	36546	35911	34728	33441	30446	29148	22619	9287
Beef Calf purchases	$P_{11,12,17,18}$	1 calf	-	3	82	92	99	86	56	59	70	144
Weaners sold (3 months old)	P_{11}	1 weaner	39	42	117	120	112	78	-	-	-	-
Weaners sold (6 months old)	P_{12}	1 weaner	-	-	-	3	10	18	37	32	-	-
Store cattle sold (13 months old)	P_{13}, P_{17}	1 beast	-	-	-	3	10	21	47	47	53	70
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	-	-	-	-	-	-	6	35	75
Hay purchased	P_{20}	1 bale	619	646	1326	1365	1344	1112	556	617	787	978
TOTAL NET REVENUE		$	15538	14736	14128	11680	11287	10489	10458	10338	10287	10261

PARAMETRIC SOLUTIONS - CASE FARM 3

BEEF PRICE LEVEL 5

($21.50 per 100 lbs)

"Border" Milk Price (cents per lb.butterfat)			38.0	33.9	28.9	28.3	27.0	26.9	26.3	26.1	25.2 →	20.0
Activity	Activity Code	Units										
Milking cows	P_1	1 cow	102	102	101	98	94	85	81	64	33	
Milk Production	P_8	1lb butterfat	38168	36546	35911	34728	33441	30446	29148	22619	9287	
Beef Calf Purchases	$P_{11,12,17,18}$	1 calf	-	82	92	99	86	56	59	70	144	
Weaners sold (3 months old)	P_{11}	1 weaner	39	117	120	112	78	-	-	-	-	
Weaners sold (6 months)	P_{12}	1 weaner	-	-	3	10	18	37	32	-	-	
Store Cattle Sold (13 months old)	P_{13}, P_{17}	1 beast	-	-	3	10	21	47	47	53	70	
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	-	-	-	-	-	6	35	75	
Hay purchased	P_{20}	1 bale	616	1326	1365	1344	1112	556	617	787	978	
TOTAL NET REVENUE		$	15757	14193	12367	12152	11701	11669	11489	11459	11248	

PARAMETRIC SOLUTIONS - CASE FARM 3

BEEF PRICE LEVEL 6

($23.50 per 100 lbs)

"Border" Milk Price (cents per lb. butterfat)			38.0	37.3	31.3	30.2	30.0	29.7	29.0	28.8	27.0	21.9 →2(
Activity	Activity Code	Units										
Milking cows	P_1	1 cow	102	101	102	101	98	85	81	64	33	-
Milk Production	P_8	1lb butter-fat	38168	37609	36546	35911	34728	30446	29148	22619	9287	-
Beef Calf purchases	$P_{11,12,17,18}$	1 calf	-	-	82	92	99	56	59	70	144	220
Weaners sold (3 months old)	P_{11}	1 weaner	39	32	117	120	112	-	-	-	-	-
Weaners sold (6 months old)	P_{12}	1 weaner	-	-	-	3	10	37	32	-	-	-
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	-	6	-	3	10	47	47	53	70	87
Beef Cattle slaughtered (18-22 months old)	P_{14}, P_{18}	1 beast	-	-	-	-	-	-	6	35	75	116
Hay purchased	P_{20}	1 bale	616	610	1326	1365	1344	556	617	787	978	1173
TOTAL NET REVENUE		$	15977	15706	13454	13053	12982	12881	12669	12614	12226	11761

PARAMETRIC SOLUTIONS - CASE FARM 3

BEEF PRICE LEVEL 7
($25.50 per 100 lbs)

"Border" Milk Price (cents per lb. butterfat)			38.0	34.3	33.0	32.3	31.1	30.1	26.3 →	20.0
Activity	Activity Code	Units								
Milking cows	P_1	1 cow	102	101	98	96	95	33	-	
Milk Production	P_8	1lb butterfat	36406	35911	34728	33943	33444	9287	-	
Beef Calf purchases	$P_{11,12,17,18}$	1 calf	88	92	99	104	105	144	220	
Weaners sold (3 months old)	P_{11}	1 weaner	123	120	112	121	120	-	-	
Weaners sold (6 months old)	P_{12}	1 weaner	-	3	10	2	-	-	-	
Store Cattle sold (13 months old)	P_{13}, P_{17}	1 beast	-	3	10	8	9	70	87	
Beef Cattle slaughtered (18-22 months)	P_{14}, P_{18}	1 beast	-	-	-	5	7	75	116	
Hay purchased	P_{20}	1 bale	1391	1365	1344	1430	1438	978	1173	
TOTAL NET REVENUE		$	16397	15050	14585	14343	13936	13612	13265	