

AGRICULTURAL  
ECONOMICS  
RESEARCH UNIT



Lincoln College

INVESTMENT ANALYSIS FOR  
FARM IMPROVEMENT

*by*

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## THE AGRICULTURAL ECONOMICS RESEARCH UNIT

THE Unit was established in 1962 at Lincoln College with an annual grant from the Department of Scientific and Industrial Research. This general grant has been supplemented by grants from the Wool Research Organisation, the Nuffield Foundation and the New Zealand Forest Service for specific research projects.

The Unit has on hand a long-term programme of research in the fields of agricultural marketing and agricultural production, resource economics, and the relationship between agriculture and the general economy. The results of these research studies will be published as Unit reports from time to time as projects are completed. In addition, it is intended to produce other bulletins which may range from discussion papers outlining proposed studies to reprints of papers published or delivered elsewhere. All publications will be available to the public on request.

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## P R E F A C E

One of the research projects of the Agricultural Economics Research Unit is concerned with assessing the profitability of land improvement on various classes of farming country in New Zealand. This is an important question since it is insufficient to assess the physical potential of a farm or of an area without considering whether its development is economically justified - whether, in fact, the development pays. But it is also a difficult question to answer, not least because of the rather complex criteria required to measure profitability especially for farm development projects involving long periods of time for completion.

In this paper, Dr Ward is concerned with formulating a basic criterion of profitability and with setting out the basic methods of analysis appropriate to the appraisal of farm development projects.

The paper is part of a larger study which Dr Ward has carried out on the economics of land development in the North Island, the results of which will be published early in 1965. We have decided to publish it separately, since it is perfectly general in nature, being concerned with the basic methods which the Research Unit is adopting in a series of empirical studies to be the subject of later publications.

Lincoln College  
December 1964

B. P. Philpott



# INVESTMENT ANALYSIS FOR FARM IMPROVEMENT<sup>1</sup>

## THE GENERAL ANALYTICAL FRAMEWORK

### Introduction

The Agricultural Development Conference has concentrated attention upon the fact that New Zealand's future growth will depend upon her ability to sell an increasing volume of wool, meat, butter and cheese in overseas markets in order to sustain the rising flow of imports which are essential to support her developing secondary industries. The Targets Committee of the Conference has estimated that in order to secure a modest 2 per cent growth in real income per head per annum it will be necessary to expand total exports from the \$300 million achieved in 1962/3 to \$467 million by 1972/3, an increase of almost 55 per cent.<sup>2</sup> It has also been estimated that only \$24 million of this can be looked for outside the pastoral industries so that our traditional

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<sup>1</sup> This paper covers one aspect of work I have been engaged on at Lincoln College over the last four years. I have benefited not only from specific comments on this paper but also from general discussion with colleagues working in the field of production economics: Professor B.P. Philpott, Dr J.D. Stewart, Mr E.D. Parkes, Mr N.G. Gow, Mr G.A.G. Frengley and Mr A.T.G. McArthur.

<sup>2</sup> Report of the Targets Committee of the Agricultural Development Conference.

exports will have to increase from £282 million to £445 million. Assuming that these additional products can be sold at 1962/3 prices this will necessitate an increase of livestock numbers from 80 million 'ewe equivalents' in 1962 to 114 'ewe equivalents' in 1972/3, representing an average increase, at compound rates, of 3.5 per cent per annum. Details of the composition of the ewe equivalents have not been made available but it is generally accepted that the major emphasis will be on expanding numbers of sheep and beef cattle with a smaller proportionate increase in dairy cattle. Under New Zealand conditions such a policy implies that the major emphasis is to be placed on hill country development.

#### The basis of expansion

In reviewing the prospects for expanding agricultural production, two possibilities may be considered. Firstly, extensive development, that is, bringing new areas of land into production, and secondly, intensive development, that is, increasing output from land already farmed by means of more intensive inputs of capital, in the form of fertilisers, fences, new grasses and labour. Both practices have played a part in increasing agricultural output over earlier decades and both are likely to contribute to future expansion.

Since the Second World War much of the extensive land development has been carried out by the Department of Lands and Survey, primarily for settlement under the Returned Servicemen's Rehabilitation Scheme. In the early postwar years the majority of settlement farms came from Crown land already under development before the war or from grassed properties purchased for settlement, but from 1952 the emphasis changed and settlement was based increasingly on land developed from unimproved tussock, native grasses or scrub. This land had to be cleared and sown to English grasses and clover before subdivision and the later stages of development could follow. Over the past ten years the Department has brought into settlement between 40,000 and 50,000 acres a year, the bulk of it in the North Island, particularly in the districts of Rotorua, Auckland, Te Kuiti and Hawkes Bay.<sup>1</sup> The only development of any significant size in the South Island has been in Southland.

The Department of Lands and Survey has almost one million acres of unimproved or reverted land under various stages of development at the present time while it has been estimated that a further million acres could be

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<sup>1</sup> An analysis of large scale land development by the Department of Lands and Survey has recently been carried out at Lincoln College and the results will be published shortly.

developed immediately if facilities were available and that an additional one and three quarter million acres, while of lower priority, could be developed in the future.<sup>1</sup> Assuming the Department could develop to settlement 50,000 acres of land a year, what would this contribute to reaching our target of expanding agricultural production by 4 per cent per annum? In the course of settlement the better more easily worked land has generally been put down to dairy farms and the more difficult country to sheep farms. A typical pattern for 50,000 acres might be as follows:-

| <u>Acreage</u>                        | <u>Farms</u>     | <u>Production</u>   |
|---------------------------------------|------------------|---------------------|
| 10,000 acres at 150<br>acres per unit | - 67 dairy farms | - 670,000 lbs b/fat |
| 40,000 acres at 500<br>acres per unit | - 80 sheep farms | - 640,000 lbs wool  |
|                                       |                  | 64,000 lambs        |
|                                       |                  | 5,600 cattle        |

The output represents an average level of production soon after settlement; - the potential level of production is greater than this. In terms of physical production these increases represent only a fraction of the annual

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<sup>1</sup> See Annual Reports of Director-General of Lands and Survey.

increase in output required; valued at 1962/3 prices they amount to approximately £450,000, or 0.15 per cent of the total value of agricultural output, which is roughly one thirtieth of the annual target rate of growth. Clearly the great bulk of the increase in output must be sought by intensifying output on land already settled.

Of New Zealand's total area of 66.4 million acres, only 1.4 million acres are under arable production and 17.8 million acres are classified as improved pasture, while 13.2 million acres remain unimproved pasture. Most of the increase in production in recent years has come from the improved land and future expansion will depend upon the intensification of production on this land plus more radical improvement of hill land still under tussock and native grasses. Broad geographical areas in which attention might primarily be concentrated are the hill country of the North Island and the lower tussock country of the South Island. As a guide to policy it is necessary to carry out research into development of these classes of country. This research must combine a technological and economic approach. It is insufficient to assess the physical potential of an area without considering also whether its development would be economically justified. The critical problem that has to be answered is 'Does development pay?'

This question, fundamental though it is, is not quite so simple to answer as it might appear. Apart from the formulation of an appropriate criterion for measuring profitability, with which this paper is primarily concerned, it is necessary to distinguish the point of view from which the question is being asked. Development which may be judged worthwhile from a national point of view, in terms of the increase in output secured in relation to the real resources employed, may not pay from the farmer's point of view, due to the divergence of private costs and benefits from social costs and benefits. If results indicate that development can be worthwhile to the nation but does not provide sufficient inducement to the individual farmer then further studies will be necessary to expose the impediments to private incentive and to discover possible means of overcoming them. Many possible impediments have already been suggested; the disincentive effect of high income tax and high death duties; the shortage of finance through lack of credit facilities; the shortage of labour; the system of land tenure, all have their proponents. Each of these and many other facets will have to be investigated but in the present paper we are concerned solely with the question of how to measure whether development pays from the point of view of the individual farmer.

In view of the vast amount of private improvement that has taken place on New Zealand's farms in the post-war period it may seem surprising, even astonishing, that this question has to be asked. The answer to it is perhaps sufficiently clear in general terms; the increase in stock numbers and the rise in total production over the years are a physical manifestation of successful development of which the financial counterpart is the striking improvement in the income and capital position of the farmer. But we should not be too hasty in attributing all these results to development in the sense we are discussing in this paper - some part of them is due to technological change, to rising product prices and, in the case of the farmer's capital position, to a sustained rise in land values which has accompanied the fall in the real value of the pound. These factors would have benefited many farmers even if they had carried out no physical improvement to their properties at all and one of the difficulties in reviewing past events is in determining exactly what influence various factors have played.

#### The method of analysis

In looking for an answer to this problem the economist must choose the most appropriate method of analysis. One possibility would be a cross sectional

study of a group of farms in a given area at different levels of development; policy recommendation would be based on the assumption that variations in net income observed were primarily attributable to different stages of improvement. Cross sectional analysis of this kind is however subject to logical problems. In particular, the assumption that differences in net income can be ascribed only to the level of development is usually impossible to sustain, because of qualitative and quantitative differences in other causal variables and inter-relationships between them. This paper is therefore concerned with a method of analysing a development programme for an individual farm. Such a programme and its profitability will be strongly influenced by the character, financial position, managerial ability and even family commitments, of the individual farmer. This implies that it cannot be assumed that the results obtained for any one farm would necessarily be repeated on similar farms in the same area. The method of analysis could however be applied to other farms taking into account their own individual features.

Within the case study framework itself two alternative approaches have to be considered. The analysis may be historical (ex post) based upon improvements already undertaken or it may be projected (ex ante) based

on the anticipated results of a proposed development programme. Despite this basic difference the historical analysis and the projection analysis have a number of problems in common. For both of them it is essential that attention should be focussed upon marginal rather than average relationships and that an objective criterion of profitability should be established which incorporates a satisfactory way of handling the dimension of time. Both these points are discussed fully in the later section outlining a projection analysis, although they are equally applicable to an historical study. For the moment I wish to concentrate upon the essential difference between the two types of study; this lies in the fact that an historical study analyses the records of what actually happened as the result of a development programme, whereas a projection study is necessarily based upon estimates as to what is likely to happen in the future. Both of these approaches have their advantages and disadvantages and each will be discussed in turn.

#### The historical analysis

The historical analysis can lay claim to being more scientific in that it deals with factual events rather than estimates. Evidence of the past records the true physical and economic effects that have occurred when a development

programme has been put into operation. Unexpected crop failures, unaccountable losses of stock, the vagaries of the weather and the market and the frailty of management are all embodied in historical records. Or rather they should be. Farm survey work brings home to the investigator the paucity of both financial and physical records and the fact that the primary purpose in keeping accounts is for taxation purposes in general and to minimise assessable income in particular. Their success in this respect is frequently at the expense of their usefulness as guides to management decisions.

A number of particular difficulties arise when the purpose of historical analysis is to evaluate a development programme. Firstly, there are accounting problems. It is extremely difficult to extract from the usual set of profit and loss accounts, even when supplemented with balance sheets, development expenditure as distinct from normal annual expenditure. This is particularly true of items such as fertiliser usage and fencing. In the latter case the taxation procedure under which repairs and maintenance to fences is allowable against taxable income whereas capital expenditure on fences is not, unhappily obscures the picture even further.

A second difficulty in analysing historical records is that the financial ones, which are the primary source

of information, are subject to the problem that the unit of account changes with the depreciation in the value of money. Expenditure of £1,000 on fencing ten years ago is not comparable with an expenditure of the same amount today. In order to measure the true profitability of development to the individual farmer it is therefore necessary to express costs and returns in constant real terms. One method of doing this is to deflate the time series. The most satisfactory approach is to apply appropriate indices for costs and products but this in turn raises further difficulties because changes in costs and product prices are seldom uniform between different types of farming, so that several indices will be required and, in practice, their suitability and reliability may vary with source and construction.

An alternative approach, which in theory is more satisfactory, is recording historical changes in physical inputs and output and then valuing these at constant prices. Once again however we come up against the paucity of physical records as is evident from field surveys even when individual farmers are subject to budget control, as has been the case with Rehabilitation settlers working under the guidance of the State Advances Corporation. It seems probable that the only really satisfactory way of securing physical data of this kind is to record a develop-

ment programme fully while it is in operation rather than rely upon searching through miscellaneous records after it has been completed.<sup>1</sup>

Finally, a study of past events, even if accurately made, cannot necessarily be taken as a guide to the future, due to the incidence of changes in technology, market conditions, managerial ability and other factors.

#### The projection analysis

An alternative approach is to make a projection analysis based upon the effect it is anticipated a development programme will have upon a property. This avoids some of the problems encountered in an historical study, in that constant (real) prices may be used in the budgets but it is in turn subject to some particular problems. The major one is that the probability of the outcome of the development being exactly as planned is very slight. The pace of development, the physical result of inputs and the relationship between product prices and costs are all unknown subject to the uncertainty imposed

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<sup>1</sup> For a recorded study of an improvement programme see P.R. Barrer and R.C. Stuart, "Results on a Banks Peninsula Demonstration Farm", N.Z. Journal of Agriculture, Vol.101, No.3, September 1960, pp.234-249 and P.R. Barrer and A.G. Barwell "Banks Peninsula Demonstration Farm", N.Z. Journal of Agriculture Vol. 108 No.3, March 1964 pp.255-261.

by climatic, economic and human factors. Experience with development budgeting suggests that the main danger lies in making predictions which are too optimistic, particularly with regard to the speed of development; on the other hand, new scientific and technological advances may bring about revolutionary changes in production in the future. The impact of molybdic superphosphate on the pumice lands of the Central North Island and of D.D.T. in controlling grass grub on the light land of the Canterbury Plains illustrates this point.

Events of this kind cannot be foreseen however and all decisions have to be made in the present on the basis of the best estimate we can make now of the future. Any proposal for improvement of a property must be based on a plan of some sort, however informally and sketchily conceived. It is surely worth taking a little extra trouble to formulate it as precisely as possible, incorporating the experience of the past as a guide, but basing the current decision upon what is anticipated in the future rather than what is known to have happened in the past.

A projection analysis should proceed through three stages

- 1) Drawing up a physical development programme
- 2) Transposing this programme into a financial budget
- 3) Evaluating the results.

The first stage, outlining development by means of a series of annual technical land utilisation and stocking programmes has been the traditional approach to private property development in New Zealand for many years. It has been an integral part of the teaching in farm management at Lincoln College and Massey College and has been widely practised by advisory officers and more recently by Farm Improvement Club advisers.<sup>1</sup> Annual programmes are drawn up in physical terms of areas of land to be ploughed or oversown and topdressed, fencing and water requirements and the build up of stock numbers. An essential feature of the budget has been correct phasing to ensure that the increase in stock numbers is co-ordinated with the developing feed supply. This approach has proved its worth technically in the improvement of large areas in this country and the accompanying increase in stock numbers since the Second World War. The expression of the technical programme in financial terms and its economic evaluation has however been far less satisfactory. This is not to imply that there has been no financial analysis

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<sup>1</sup> This approach has received less attention in the United Kingdom partly because advisory work has been based more on inter-farm efficiency standards rather than the single farm budgeting approach popular in New Zealand and partly because the problem of farm development has not received the same amount of attention there.

of such development programmes; on the contrary published papers and advisory work have almost always followed up the proposed technical programme with a financial analysis, but it is submitted, with full recognition of the sound technical advice that has been given in these matters, that the economic analysis has been inadequate. In particular, it is suggested that the following major points should be taken into account in evaluating the development budget.

- 1) Attention must be focussed on marginal rather than average relationships.
- 2) Some allowance must be made for the uncertainty of both the physical outcome of the programme and the future level of product prices and costs.
- 3) An objective criterion of profitability must be established which incorporates a satisfactory way of handling the fact that returns and costs are spread over time.

It is the last two points involving the incidence of time which raise the greatest problems and which have been most inadequately treated in the past.

1) Marginal relationships

The traditional farm management approach has been to draw up annual budgets for the situation before and

after development and to compute the average rate of return on total capital invested in each situation. This was the method of analysis used by members of the Department of Agriculture in the study of improving a Banks Peninsula farm at Paua Bay to which reference has already been made. The assumption implicit in this approach is that if the average rate of return on the developed stage is satisfactory, (judged in comparison with rates of return computed for farms in a similar state of development in the same area), then the development was worthwhile.

This approach is subject to the major criticism that it is concerned with average rather than marginal relationship. The critical question that has to be answered is - What is the profitability of the additional capital invested? - not of the total capital.<sup>†</sup> A simple example may help to make this clear. Assume that the total investment on a farm is £20,000 and that the farm surplus, calculated in the usual way as a residual, is £2,000, giving a return on total farm capital of 10 per cent. Now assume that a development plan is put into operation and that it involves additional capital investment in land

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<sup>†</sup> For an earlier discussion of this point see B.P. Philpott "Economic Efficiency in Agriculture - The Individual and National Viewpoints", Proceedings, N.Z. Institute of Agricultural Science Vol. 7, 1961, pp. 113-122.

improvement, stock, etc., of £5,000 so that the total investment becomes £25,000. Now if the annual farm surplus after development is £2,250 this represents an average rate of return on the total farm investment in the new situation of 9 per cent, which would be thought of as good for many classes of property in New Zealand. But the crucial point to consider is the marginal relationship. The investment of an additional £5,000 has resulted in an additional net income of only £250, which represents a marginal rate of return of only 5 per cent, less than the current rate of borrowing. The former approach suggests superficially that the development programme is worthwhile whereas the correct marginal analysis shows clearly that it is not. These figures are summarised in Table 1.

TABLE 1

| Total farm investment | Annual farm surplus | Average return on capital | Additional capital | Marginal return on capital |
|-----------------------|---------------------|---------------------------|--------------------|----------------------------|
| £20,000               | £2,000              | 10%                       |                    | -                          |
| £25,000               | £2,250              | 9%                        | £5,000             | 5%                         |

The example should not lead to the assumption that the marginal return on capital will necessarily be below the average return, in fact in cases where the property is being farmed below its optimum intensity the marginal

return will be higher than the average return. This arises because of the heavy initial fixed costs in farming; once these major costs have been incurred additional investment can result in disproportionately high marginal returns over a phase of development. A hypothetical example is shown in Table 2, in which the average return on total farm capital is just under 6 per cent, slightly below the current rate of borrowing, but the marginal return is 10 per cent, indicating that the investment for development is worthwhile.

TABLE 2

| Total farm investment | Annual farm surplus | Average return on capital | Additional capital | Marginal return on capital |
|-----------------------|---------------------|---------------------------|--------------------|----------------------------|
| £10,000               | £500                | 5%                        |                    |                            |
| £12,000               | £700                | 5 $\frac{1}{3}$ %         | £2,000             | 10%                        |

## 2) Uncertainty of the future

Drawing up a development plan necessarily involves projections of future events which are shrouded in uncertainty. This affects a farm improvement programme in two ways as neither the physical outcome of development nor the price conditions which will be ruling when the increased physical output is put onto the market can be predicted with any degree of certainty. The former is subject to the influence of weather, disease, pests and

the ability of management, while the latter is dependent upon economic forces which lie outside the control not only of the farmer himself but, in New Zealand's case, virtually beyond that of the country as a whole.

While it would be foolish to ignore the serious difficulties that uncertainty places upon any estimates of the future profitability of development, it would be equally foolish to throw up our hands in despair and assume that nothing at all can be done to allow for these factors in making investment decisions. Two basic approaches may be considered for both physical and economic variables.

a) A single valued estimate may be used; the choice of a conservative figure will go some way towards discounting future uncertainty. In the case of physical productivity this estimate should be based on specialised knowledge of farming similar properties in the area and of the managerial ability of the farmer himself. In areas where there is little or no technical knowledge of the physical response that may be expected from land improvement, the degree of uncertainty could be reduced by trials designed to give results of value from the management as well as the scientific aspect. With regard to estimates of future prices and costs a conservative estimate based upon recent values and observed trends may be used. The greater use

of econometric research may provide a more scientific basis for selecting such estimates.

b) Instead of basing the development budgets upon single values a range of probable physical production and of product prices, costs and interest rates, may be used to cover future possibilities. The use of 'parametric budgeting' produces a series of results which gives some indication of the stability of the solutions and their sensitivity to changes in critical variables. Decisions can then be based on estimates of the probable accuracy of the various assumptions. The amount of time required to carry out an analysis of this nature with a desk calculator is prohibitive but it may be reduced to a realistic level by programming the budgets for a computer. Simulation procedures may also be adaptable for this kind of analysis.

### 3) The analysis of profitability over time

In the simple examples used earlier in this paper to illustrate the marginal return on capital the method of calculation implied was to express the additional gross return from the investment minus additional operating costs as a percentage of the initial capital investment. This is the conventional method of measurement widely used by many accountants in general commerce as well as farm

business advisers.<sup>1</sup> Modifications of this approach are to measure the capital investment as the average investment over the life of the asset or as the replacement cost rather than the initial cost; it will be apparent that each concept will give a different result.

Whichever measure of capital investment is employed however the traditional rate of return approach is unsound in that its validity rests upon three assumptions which are seldom justified in practice, especially for a long term project such as land development. They are as follows:

a) That the capital cost of the asset is incurred at one moment of time. This may be appropriate in the case of a firm purchasing a piece of equipment on a given date but it is not correct for an asset whose construction may take several years; it is particularly unsuitable for land development for agriculture.

b) That the annual net return is uniform. If the net return from investing an additional £1,000 in a farm property is £100 in one year, £200 in another and only £50 in a third it is not possible to determine any relevant rate of return. Here again the assumption of

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<sup>1</sup> For a critical discussion of this method and a review of alternative approaches see A.S.Carrington "The Evaluation of Capital Expenditure Projects and Return on Capital", Address to the University of Canterbury 1962 Study Conference on 'Financing New Zealand Business Today'.

constant annual returns is not typical for agriculture where annual net returns vary widely due to fluctuations in physical yield and in product prices, and to the pattern of development, particularly where large and indivisible inputs are involved with technical time lags.

c) That the income stream continues in perpetuity. In the case of short lived assets the wasting of the capital involved invalidates the usual rate of return concept, but this assumption may be realistic in the case of agriculture in that given appropriate management it can be conducted on a 'sustained yield' basis.

In order to find a criterion of profitability which is more suitable for handling the difficulties raised by these points it is necessary to consider the time profile of revenue and costs. In the course of land development the costs and returns involved will not relate to the same time period. Development from scrub or tussock to well established pastures covers several years and it may be several more before the potential carrying capacity of the newly developed land has been fully achieved and integrated into the existing farm business. We are therefore faced with the dual problem that the majority of costs will be incurred some years before the full benefit of returns is reaped, while the costs themselves and the future returns will also be spread out over time.

Now it is a matter of common observation that a return of £100 in five years' time is not worth as much as a return of £100 here and now. In economic terms we talk of a time preference for the present over the future but the philosophical reflections behind this need not concern us here; we may merely note that if a man receives £100 today he can invest it in one of several ways which will ensure that it is worth more than £100 in five years' time. If he invests it in a government bond yielding 5 per cent he can draw £5 a year over each of the next five years and still have his £100 at the end of that time. This is the concept of simple interest. Alternatively he may reinvest his interest each year (assuming he can do so at the same rate of interest) and allow the capital and interest to accumulate over the five years when it will have reached a value of £127. 10s.<sup>1</sup> This introduces the concept of compound interest which is the fundamental element required for handling investment over time.

The basic relationship between a single value at the present time and the future value may be represented

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<sup>1</sup> No allowance has been made for the depreciation of the value of the pound due to inflation. With an annual rate of inflation of around  $2\frac{1}{2}$  per cent, £127.10. in five years would be worth approximately £113 in real terms, still significantly greater than the original £100.

by the formula

$$S = P(1+i)^n \quad \dots\dots (1)$$

where

S - future value of the investment

P - present value of the investment

i - market rate of interest

n - number of years over which the investment is contemplated.

An alternative way of comparing a future return with a present cost is by discounting the former to its present worth. In this case we have to calculate what is the present sum which would accumulate to the given future value at a certain rate of interest. By simple rearrangement of the first equation we have

$$P = \frac{S}{(1+i)^n} \quad \dots\dots (2)$$

and we say that P is the discounted value of S, while

$\frac{1}{(1+i)^n}$  is defined as the present worth factor. Applying

this concept to our first example we could say that a sum of £127. 10s. offered in five years' time has a present worth of £100 if it is discounted at 5 per cent (i.e. the market rate of interest is 5 per cent).

Discounted cash flow

So far we have considered the case of 'single input-single output' only. This is useful in practice when the comparison to be made is between a single cost incurred in purchasing an asset in a given year with its anticipated realisation price some years later, for example in purchasing a block of land for subsequent resale. In the usual case of developing a farm however we have to handle not single values but a stream of anticipated costs and returns. This may be done by using a 'discounted cash flow analysis' in which all future costs and returns are discounted, at the selected rate of interest, to their present value. The difference between the present value of returns,  $V$ , and the present value of costs,  $C$ , is known as the present worth of the investment. In general form

$$V = \frac{R_1}{(1+i)} + \frac{R_2}{(1+i)^2} + \frac{R_3}{(1+i)^3} + \dots + \frac{R_n}{(1+i)^n} \quad \dots (3)$$

$$\text{and } C = \frac{C_1}{(1+i)} + \frac{C_2}{(1+i)^2} + \frac{C_3}{(1+i)^3} + \dots + \frac{C_n}{(1+i)^n} \quad \dots (4)$$

where,

- $R_{1 \dots n}$  - anticipated additional returns in years 1 ... n
- $C_{1 \dots n}$  - anticipated additional costs in years 1 ... n
- $i$  - market rate of interest
- $n$  - number of years additional costs and returns are anticipated

The general criterion of profitability using the discounted cash flow analysis is that  $V - C$  should be positive. This implies that the proposed programme could meet all costs at the market rate of interest and still return a surplus or profit, the present worth of which is measured by  $V - C$ . An alternative criterion is provided by measuring the relationship between the discounted income stream and discounted cost stream in terms of a ratio,  $V/C$ . The criterion of profitability is that the ratio  $V/C$  should be greater than 1. This 'profitability index' is extensively used in cost/benefit analysis of irrigation, conservation and river basin development projects in the United States.<sup>1</sup> It is primarily of use for ranking projects and as such is less appropriate than the 'present worth' criterion for assessing a development programme on an individual farm.

The 'discounted cash flow' approach has the advantage that no compounding is involved so that the number of calculations is kept to a minimum. On the other hand it has the defect that as costs are not compounded forward it is not possible to draw up a capital profile, which is

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<sup>1</sup> See O. Eckstein 'Water Resource Development: The Economics of Project Evaluation', Harvard University Press 1961.

a vital consideration in considering how to finance a development programme. A secondary disadvantage is that it does not provide an indication of the future worth of the improvement, in relation to the cost of carrying it out, since all values are expressed in discounted terms. A method of analysis which overcomes these difficulties is suggested in the second part of this paper.

#### The internal rate of return on capital

It has been pointed out that the conventional method of assessing rate of return on capital investment is invalid because of its inadequate treatment of the dimension of time but that this particular problem may be surmounted by using discounted cash flow analysis. This will give an answer to the question 'Is this particular development programme worthwhile when the borrowing rate of interest is (say) 6 per cent?', but it will not give an answer to the more general question 'What is the rate of return yielded by this particular programme?'. The question therefore arises as to whether it is possible to use compound interest techniques to derive a true rate of return on capital.

The general answer is that calculating a true 'internal rate of return' in this way is subject to a

number of conceptual and computational difficulties, which have led most authorities in this field to discard it in favour of the 'present worth' analysis based upon a market rate of interest. It is not the purpose of the present paper to review the controversy that has arisen over the relative merits of these two specific criteria as an extensive literature already exists on the subject;<sup>1</sup> I wish merely to consider how the internal rate of return concept may be applied to a farm development programme and to discuss some of the problems that arise.

The 'internal rate of return' is in effect Keynes' 'marginal efficiency of capital' for a particular type of capital asset.<sup>2</sup> Adapting Keynes' original definition we may define the internal rate of return in relation to farm development, as "that rate of discount which would make the present value of the series of net returns expected from the improvement just equal to its supply price". Where, as with farm improvement, the supply

<sup>1</sup> For a general review of investment criteria see F.A. and V. Lutz "The Theory of Investment of the Firm", Princeton, New York, 1961, also E.L. Grant and W.G. Ineson "Principles of Engineering Economy", The Ronald Press, New York 1960. For more specific references see in particular H.J. Bailey "Formal Criteria for Investment Decisions" Journal of Political Economy, Vol. LXVII, No. 5, 1959, G. Mills "Marginal Efficiency of Capital and the Present Value Rule" Yorkshire Bulletin of Economic and Social Research Vol. 12, No. 1, 1960, P.H. Karmel "The Marginal Efficiency of Capital" The Economic Record Vol. XXV No. 72, Dec. 1959 and many related articles.

<sup>2</sup> J.M. Keynes "The General Theory of Employment Interest and Money", Macmillan, 1936, p. 135.

price of an asset is not a single payment incurred at one moment of time but a series of costs extending over the development period, we have from equations 3 and 4;

$$\frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \dots + \frac{C_n}{(1+r)^n} = \frac{R_1}{(1+r)} + \frac{R_2}{(1+r)^2} + \dots + \frac{R_n}{(1+r)^n} \dots (5)$$

which may be simplified in the form of the net income flow and set to zero;

$$\frac{A_1}{(1+r)} + \frac{A_2}{(1+r)^2} + \dots + \frac{A_n}{(1+r)^n} = 0 \dots (6)$$

where,

A - the annual net return R - C

r - not the market rate of interest,  $i$ , (except as a special case) but the unknown internal rate of return for which the equation has to be solved.

Solving equations of this nature for  $r$  is subject to the mathematical difficulty that they are polynomial functions with up to as many roots as there are years in the development programme; in other words there may be a number of 'break even' rates of interest rather than a unique one. In practice, the incidence of multiple real positive solutions appears to depend upon the nature of the equation and, in particular, the number of changes of sign in a series expressed in the form of

Equation 6. Empirical studies have shown that the expected form for a development programme where a series of net costs in the early years is succeeded by a series of positive returns in later years will yield a single real solution.

An equation of this nature may be solved with the aid of a desk calculator by a process of successive approximation. The procedure consists of obtaining approximate values for  $r$  and then interpolating to obtain the final answer.<sup>1</sup> A more accurate solution may be obtained, with less tedious work if a number of equations have to be solved, by using a computer programme.

Even where the mathematical problems are overcome and a unique solution is obtained for the internal rate of return the question still remains as to whether it has a significance meaning in practice. The internal rate of return applies to negative as well as positive values in the equation; this implies that the farmer borrows at the same rate of interest as is yielded by the asset. Obviously this would only occur as a special case; in a year when costs exceed returns the farmer must borrow to cover the net cost and he will in fact borrow at the rate

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<sup>1</sup> A different procedure for solving for  $r$  is given in Brockie and Grey "The Marginal Efficiency of Capital and Investment Programming", *Economic Journal*, December 1956.

of interest charged by his trading bank or stock firm. There is no reason at all why this borrowing rate should coincide with the yield on his investment. For this reason, reinforced by the other criticisms mentioned above, it is suggested that the internal rate of return is not a suitable criterion for assessing investment in private development. It is submitted that the most appropriate form of analysis is to compare the anticipated increase in income or equity with the cost of making the improvement, by using compound interest techniques incorporating a market rate of interest. This modified version of 'discounted cash flow' is discussed in the second part of this paper.

## THE CRITERION OF PROFITABILITY - DEMAND PRICE : SUPPLY PRICE

In order to overcome these difficulties a modified form of 'discounted cash flow' is suggested as the most appropriate form of analysis for farm improvement programmes. This embodies compound interest techniques to determine the 'supply price' and 'demand price' of the programme. The supply price is defined as the total net cost of implementing the programme up to a certain point in time and the demand price as the value of the improvement at that time. The point of time may be taken as that year in which the additional returns from the improvement first exceed the additional costs. The former will consist of the value of additional sales of wool, stock or butterfat off the property and the latter of additional inputs of fertiliser, fencing, stock, labour and other costs.

The supply price

For farm improvement the major benefits will be an increase in output which is concentrated after the development phase is complete but there will also be some change in production during the initial phase. In the first year or two output may actually fall as the farmer retains stock to build up his numbers, but by the third or fourth year the major part of this will have been achieved and

he can then look to an increase in output. Additional revenue generated during this early phase of development may be introduced into the analysis by incorporating it with costs; any fall in revenue (due to stocking up) in the early years will increase the cost of improvement while increases in revenue in the later years of development will decrease the net cost of improvement. The net amount outstanding each year may be compounded over the period of development to allow for the incidence of time. In general form;

$$S = (C_1 + R_1)(1+i)^{n-1} + (C_2 - R_2)(1+i)^{n-2} + \dots + (C_n - R_n) \dots (7)$$

which may be summarised as;

$$S = \sum_{j=1}^n (C_j - R_j) \cdot y^{n-j} \dots (8)$$

where,

S - supply price of the improvement

$C_j$  - additional costs in the jth year

$R_j$  - additional revenue in the jth year

i - market rate of interest

y - (1+i) - the compounding factor

n - number of years of the improvement programme.

In calculating the additional annual costs to the property owner it is essential to take the farmer's annual tax position into account as, up to statutory limits,

development costs may be offset against income tax. Changes in his tax commitments due to the improvement programme must be incorporated into the cash flow analysis as they represent an integral part of the net cost or return of development to the individual farmer. The supply price,  $S$ , may be thought of as the overdraft which the farmer would incur by the end of the development period if he financed the improvement by bank credit. It may be compared with the 'demand price' or future value of the improvement which we must now consider.

#### The demand price

The demand price, or future value of the development, may be thought of in terms of income or capital increment; in both cases we are concerned with additional rather than absolute values and have to envisage the position with and without the improvement programme. It should not prove difficult to ask farmers to consider whether income or capital is their major aim. Many of them invest outside farming and will be aware that the first question a share-broker asks a client seeking advice on investment is 'Are you looking for income or capital gain?', and in some respects investment in land development is directly comparable to investment in equity stock.

Increase in net income

Where the major consideration is the income effect, we have first to consider the stream of additional net income which may be anticipated from the end of the development phase i.e. when additional returns first exceed additional costs, to the beginning of the year when the additional net income becomes stabilized. This may be expressed as;

$$A_{n+1} + A_{n+2} + A_{n+3} \dots + A_n \dots (9)$$

The present worth at the beginning of year  $n+1$  of this income stream may be obtained by summing the discounted value of each item;

$$\frac{A_{n+1}}{(1+i)} + \frac{A_{n+2}}{(1+i)^2} + \frac{A_{n+3}}{(1+i)^3} + \dots + \frac{A_m}{(1+i)^{m-n}} \dots (10)$$

This may be summarised in the form;

$$\sum_{j=n+1}^m A_j \cdot x^{j-n} , \dots (11)$$

where,

$$A_j = R_j - C_j$$

$m$  - year when additional net income becomes stabilized

$x = \left[ \frac{1}{1+i} \right]$ , the discounting factor

$i$  - market rate of interest.

Now assume that the additional net income does become stabilized ( $A'$ ) when the full potential of the improvement

$$A_m^v + A_{m+1}^v + A_{m+2}^v \dots A_p^v \dots (12)$$

where,

$$A_m^v = A_{m+1}^v = A_{m+2}^v \dots = A_p^v = A^v$$

The present worth of this stream in the year m is given by;

$$V_m = \frac{A^v}{i} \left[ 1 - \frac{1}{(1+i)^{p-m}} \right] \dots (13)$$

where,

$V_m$  - the additional capitalized value at the beginning  
of the year m

$m \dots p$  - the number of years the uniform income flow is  
expected to continue.

When, as with most cases of development, it is anticipated that the increase in the annual income can be maintained in perpetuity we have the limiting case of the traditional valuation formula;

$$V_m = \frac{A^v}{i} \dots (14)$$

since  $\left[ 1 - \frac{1}{(1+i)^{p-m}} \right]$  tends to 1 as p approaches infinity.

By discounting the capitalized value given in equation 14 we can determine its present value at the beginning of the year n+1:

$$V_n = \frac{A^v}{i(1+i)^{m-n}} \dots (15)$$

which may be expressed in the earlier notation as;

$$V_n = \frac{A^v}{i} \cdot x^{m-n} \quad \dots (16)$$

Adding this value to the discounted value of the non-uniform income flow over the consolidation period we can determine the demand price,  $D$ , of the improvement at the beginning of year  $n+1$ ;

$$D = \sum_{j=n+1}^m A_j \cdot x^{j-n} + \frac{A^v}{i} \cdot x^{m-n} \quad \dots (17)$$

By using the concepts developed in this section it is possible to assess the profitability of a farm improvement programme. Where income is the major consideration, the development programme will be worthwhile if the demand price (the capitalized value of the anticipated increase in annual net income) is greater than the supply price (the compounded cost of the programme). In terms of the previous equations the improvement programme will be worthwhile where;

$$\sum_{j=n+1}^m A_j \cdot x^{j-n} + \frac{A^v}{i} \cdot x^{m-n} > \sum_{j=1}^n (C_j - R_j) \cdot y^{n-j} \quad \dots (18)$$

The present worth,  $PW$ , of the investment programme at the time when the initial decision whether to put the programme into operation has to be taken, will be the discounted value of the difference between the demand and supply price;

$$PW = \left\{ \left[ \sum_{j=n+1}^m A_j \cdot x^{j-n} + \frac{A^v}{i} \cdot x^{m-n} \right] - \left[ \sum_{j=1}^n (C_j - R_j) \cdot y^{n-j} \right] \right\} x^n \quad \dots (19)$$

### Asset increment

An alternative way of viewing the profitability of a development programme is in terms of its effect upon the value of the assets owned by the farmer which is termed his equity. This will be affected in a number of ways by the programme; the value of the property itself will increase with improvement, stock numbers will rise and there may also be a change in plant and equipment. In addition, the programme will affect the farmer's financial position with regard to liquid capital and degree of indebtedness. In evaluating the programme it is necessary to take all such changes into account.

The effect of the programme upon the capital value of the property should be assessed in terms of the likely market value with and without the development, ignoring the possibility of any general change in land values due to inflation. This assessment of additional value should be based wherever possible on comparative market sales i.e. what a developed farm of this type would be likely to fetch in comparison with an undeveloped farm of similar type in the same area. This reliance upon market values contrasts with the income capitalization method suggested in the previous section where the critical question is not the enhanced capital value of the property and stock but the additional income it will return to the present owner as

a going concern. The two approaches will not normally give the same result because open market values placed on developed properties in many parts of New Zealand do not generally reflect the additional earning power of the development. The reasons for this are not entirely clear but three major possibilities may be considered. In the first place, a developed property commands a higher absolute price and therefore it is more difficult to finance its purchase; secondly, in the opinion of experienced valuers, any additional value created in the property will always be less than the cost of the improvements because the purchaser could make such improvements himself if he wished to do so; and finally it may be surmised that the return on developing a property, particularly when this can be financed out of taxable income, is thought to be greater than the return on a developed farm.

Changes in the stock and plant on the property, attributable to the programme, should be assessed on the basis of market prices and not book values used for taxation purposes, which do not reflect the true change in the capital values of these items. Finally, changes in the degree of indebtedness of the farmer must be assessed: this should take into account any change in long term debt i.e. new mortgage commitments or alteration in existing ones, as well as changes in the current position

i.e. bank overdraft or surplus, stock and station account etc.

Where appreciation in the equity position of the property owned is the major consideration the criterion of profitability becomes

$$E' > \sum_{j=1}^n (C_j - R_j) \cdot y^{n-j} \quad \dots (20)$$

where,

$E'$  - change in farmer's equity position attributable to the improvement programme.

The present worth of the improvement programme will now take the form:

$$\left[ E' - \sum_{j=1}^n (C_j - R_j) \cdot y^{n-j} \right] x^n \quad \dots (21)$$

In practice, it seems likely that farmers will not be concerned solely with either additional income or appreciation in their equity position but will consider a development programme with both elements in mind.<sup>1</sup> One case which may be considered for analysis introduces anticipated income and capital change in a specific manner.

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<sup>1</sup> Recent field experience amongst a group of farmers interested in development in the Cheviot area of North Canterbury indicates that the relative importance attached to these two considerations varied with the age, financial position, family commitments and temperament of individual farmers. A report on proposed farm development programmes in this area is to be published shortly by Lincoln College.

A man may contemplate farming his property for a given number of years after introducing a development programme and then settling for retirement. For example, a man of thirty five may think of a five year development programme followed by ten years' farming at a higher income and retirement at fifty.<sup>1</sup> In this case the criterion may be expressed in the form;

$$\sum_{j=n+1}^p A_j \cdot x^{j-n} + E'_p \cdot x^{p-n} > \sum_{j=1}^n (C_j - R_j) \cdot y^{n-j} \quad \dots (22)$$

The present worth of the improvement programme then takes the form;

$$\left\{ \left[ \sum_{j=n+1}^p A_j \cdot x^{j-n} + E'_p \cdot x^{p-n} \right] - \left[ \sum_{j=1}^n (C_j - R_j) \cdot y^{n-j} \right] \right\} x^n \quad \dots (23)$$

where p is the number of years the farmer contemplates farming after development and before selling the property.

It is only in this particular case that income and capital considerations can be evaluated together. Where a farmer's planning horizon is indefinite so that he does not contemplate selling the property, because he intends to go on farming it himself or hand it on to his son, the income approach should be applied. To include both together, except in the case illustrated by equation above,

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<sup>1</sup> Such a time horizon is by no means untypical in New Zealand although it may appear strange in many overseas countries.

would be to become involved in double counting, because the farmer may only continue to enjoy the increased income from the property (together with the initial income) as long as he does not sell it; while on the other hand he can only secure the improvement in his equity position if he does sell.

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#### A note on the rate of interest

In this paper it has been suggested that the rate of interest used for compounding and discounting streams of costs or returns should be the market rate. In tackling empirical problems we are however faced with the question "Which market rate?", since there is no single rate of interest but a structure of rates.

With regard to compounding costs the answer is fairly straightforward in that the individual farmer will incur interest at the borrowing rate in the market when he draws on bank overdraft or credit facilities of his stock firm in order to finance his improvement programme. Where he finances the development, in part or whole, out of his own income, as is frequently the case, he should charge the opportunity cost of his own capital, that is the return it would yield him in alternative investment. For reasons

which are discussed below, it is suggested that the rate of interest charged on his own funds 'lent' to the development programme should be the same as that charged by the trading banks if they were financing the programme; that is, we should regard the farmer as an individual lending to the farm business at the market rate of borrowing.

In discounting a future stream of incomes and, in particular, in capitalizing a uniform net income in perpetuity the rate of interest used has a pronounced effect upon the demand price of the improvement. An additional net income stream of £500 a year, expected to begin in five years' time, has a future value, at the beginning of the fifth year, of £8,333, and a present worth of £6,600 when discounting at 6 per cent. If a rate of 3 per cent is used the future value becomes £16,666 and the present worth £14,800.

In valuation for statutory purposes it is customary to base the discount rate on the yield on government stock, or the mortgage rate on real property. The experience of twenty five years of inflation indicates however that investment in farm property is regarded by the market as more akin to an equity than a fixed interest investment. This suggests that the average yield on ordinary stock, which reflects the capital appreciation of equities during inflation, would be a more appropriate rate to use.

Theoretically, the rate of discount used for evaluating the profitability of an individual farm improvement plan should be subjective rather than an objective one. More precisely, it should be the minimum rate of return the farmer is prepared to accept on his investment taking into account his own position with regard to capital, liquidity, taxation, alternative investment opportunities and also his personal motives in wishing to develop the property.

The last two points suggest that the rate of interest used in discounting future returns would be considerably lower than that used in compounding costs of development. This would have the effect of enhancing the demand price of an improvement programme in comparison with the supply price. In effect we would be writing the anticipated incidence of inflation on property values and the personal inclination of an owner for improvement into our analysis. This may be the correct thing to do but I believe that it would incur the danger of double counting. If a farmer is told that an investment would be worthwhile on an economic basis, he is likely to make some subjective allowance for personal preferences, and also possibly for the prospects of future appreciation in land values. It may therefore be better in practice to use the same rate of interest, namely the market rate of borrowing, for

discounting future returns and for compounding costs.  
The error involved would be on the side of conservatism,  
which is a desirable feature in a programme of land  
improvement which is subject to a considerable element  
of risk.

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