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# Measurement of the Human Factor in Farm Management (A summary of a paper)

J. E. BESSELL

*Department of Agricultural Economic, Univeristy of Nottingham, Great Britam*

At two recent Conferences which the author attended, first at the Conference of the Agricultural Economics Society held at the University of Newcastle last July and, secondly at the Conference of the International Association of Agricultural Economists held at the University of Sydney last August, speakers stressed that, in their view, the quantitative measurement of managerial efficiency was the most urgently needed development for the pursuance of understanding of the phenomena contributing to the spectrum of farm management. The author has been interested in such measurement for a number of years and the present paper is a contribution to the study of this problem.

The paper of which this is a summary, discusses the problems surrounding the measurement of efficiency in farming, presents a measurement of efficiency and discusses the context within which its interpretation is valid, formulates an econometric model to explain the behavioural relations in which it is considered that efficiency is generated, obtains a solution of the model for a small group of dairy farmers in the East Midlands of England for 1961, and uses the model to interpret the results of a grassland dairy farmer in South-West England over a period of 8 years, 1959-1966.

Figure 1 presents diagrammatically the roles of the farm, the farmer and the employment of capital in the production process as discussed in the paper. The broken lines connecting environmental factors to efficiency indicate a direction of influence which it has not been possible to assess separately. It is believed that any measure of efficiency of farming must include the influence of the environment of the farm. Consideration of profit is deliberately omitted at this stage.

The factors of production, although broadly classified as land, labour and capital, are frequently subdivided in order to allow differentiation within each class. In order to clarify the concepts used in the paper they are divided into processing units, inputs and environmental factors.

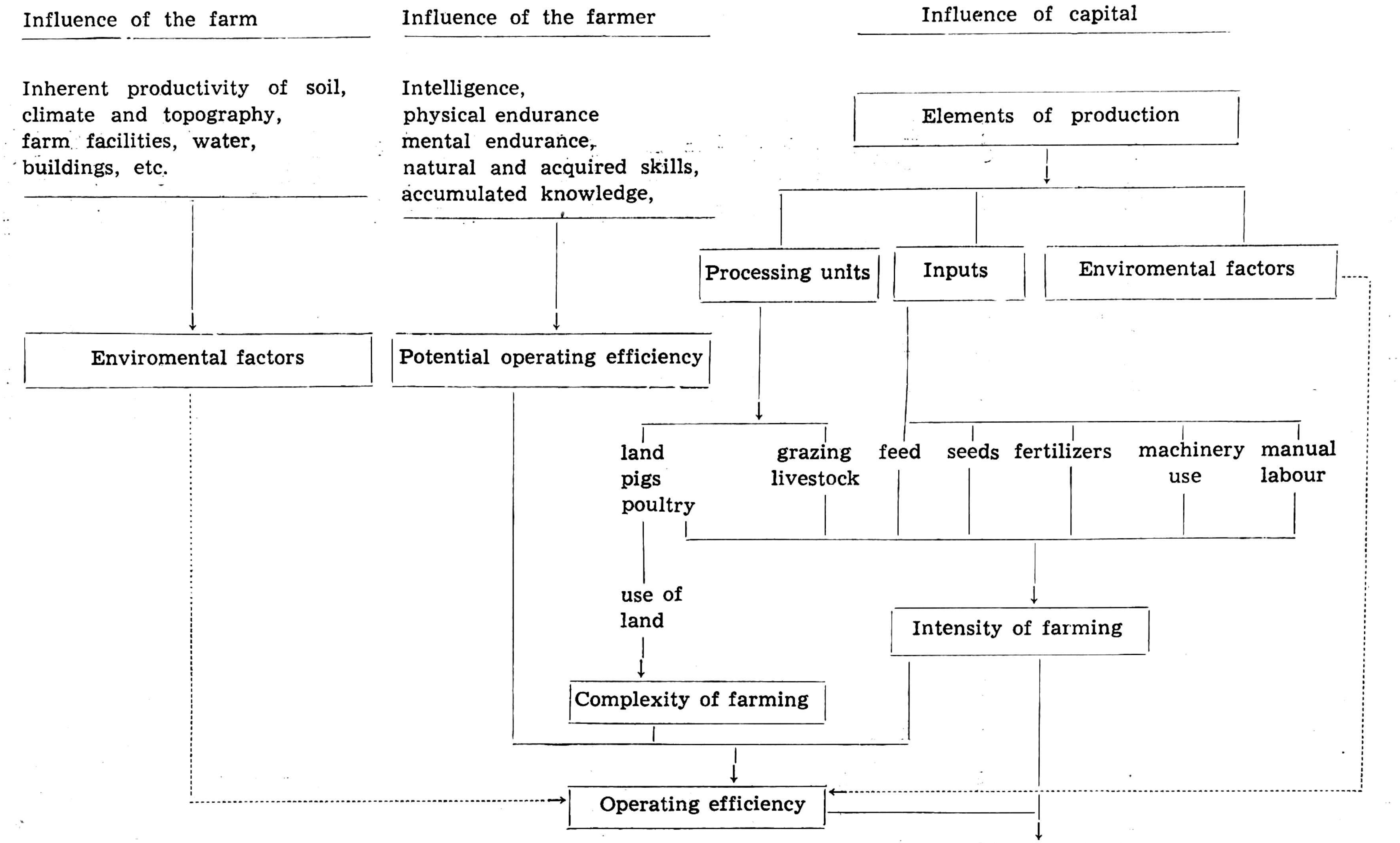


Fig. 1. Diagrammatic interpretation of the roles of the farm, farmer and capital in the agricultural decision-making process as discussed in this paper.

## Definitions

*Processing units*: units of land area and numbers of livestock.

*Inputs*: this term is restricted to manual labour, machinery costs, seeds, fertilizers, and purchased feeds.

*Environmental factors*: topography and inherent fertility of land, climatic conditions, state and usefulness of buildings.

*Operating efficiency*: the technical efficiency of the farmer under the prevailing environmental conditions of his farm.

Since a farmer can make his management task easier or harder simply by changing, for example, the pattern of his crops, or the density of stocking of his grassland, or the quantity of his inputs, any measure of efficiency must be relative to the level of the farming task. A farmer creates a task of a certain degree of complexity and intensity of farming.

## Definitions

*Complexity*: a degree of difficulty created by the diversification of a given area into a number of enterprises, taking into consideration the distribution of the sizes of the enterprises.

*Intensity*: the concentration of inputs into a given area of land and through a given number of livestock in relation to the type of crops being grown and the type of livestock being carried.

*Potential operating efficiency*: the degree of efficiency which a farmer is able to achieve depends on the interaction between the complexity and intensity of farming and the potential operating efficiency of the farmer, i.e. the ability which the farmer can be said to possess before he uses it in controlling a given farm situation.

*Productivity*: output per unit of land, in monetary terms.

The complete paper provides formulae for estimating the concepts of complexity, intensity, productivity, operating efficiency and a modified definition of potential operating efficiency; it also converts all the estimates into indexes using the standardized normal variate to obtain, for each concept, a range of the index numbers asymptotic to the values of 0 and 200. The following model is formulated from the relations presented in Fig. 1 and is interpreted as an interdependent system

$$P_n = a_1' T_n + a_2' M_n + \varepsilon_1'$$
$$M_n = b_1' T_n + b_2' C_n + b_3' S_n + \varepsilon_2'$$

where $P_n$ — productivity index,
$T_n$ — intensity index,
$M_n$ — operating efficiency index,
$C_n$ — complexity index,
$S_n$ — potential operating efficiency index,

and the parameters are estimated by an iterative process using two-stage least-squares (2SLS).

Figure 2 shows the relation found between productivity, intensity of farming and efficiency for the dairy farmers in the East Midlands.

Complexity has only a small direct influence on productivity through the reduced form for the $P_n$ structure and it has been held constant at its

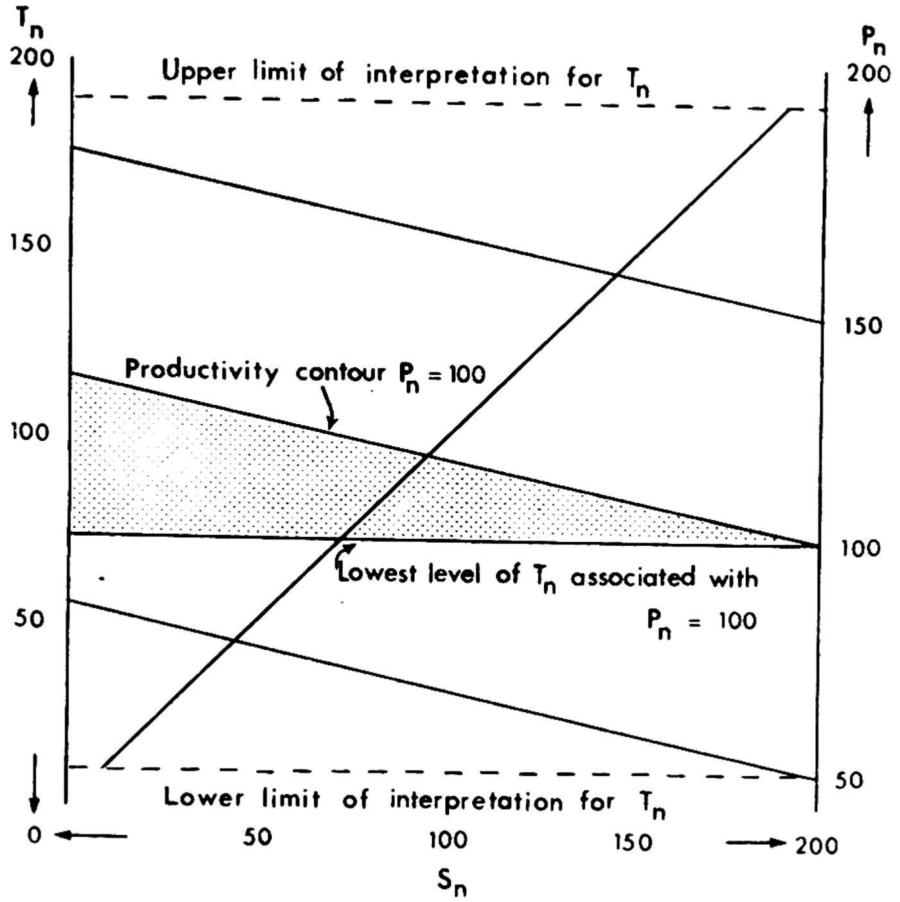


Fig. 2. Relation between productivity, intensity of farming, and efficiency (at average complexity).

average value in order to allow presentation of the model as a two-dimensional figure. The surface of the figure will be referrred to as the "plane of activity". As efficiency increases so the intensity of farming needed to produce a given productivity decreases. But there are limits to the intensity of farming within which it is possible to produce a given level of productivity no matter how good is efficiency. The limits for the productivity contour $P_n = 100$ are shaded in Fig. 2. If an individual farmer's performance falls within the shaded area but below the diagonal representing the $P_n = 100$ contour, then his productivity could be increased to $P_n = 100$ without any change in his intensity of farming simply by increasing his efficiency. It is suggested that the interpretation of the of the analysis should be restricted to farmers falling within the index range of 10 to 190.

Consideration must now be given to farm income. Any increase in efficiency at a constant intensity will result in an increase in productivity and an increase in farm income, since no financial cost is involved in increasing efficiency as it is defined in this paper. If the intensity of farming increases then expenditure will rise and, if efficiency remains unchanged, farm income will fall. It is necessary therefore to be able to relate increases in costs of inputs to $I_n$, and increases in income to $P_n$, and to include the net influences in movements of both indexes in the interpretation of Fig. 2. Because of the definition of productivity, a perfect relationship exists between output and $P_n$ and a high linear relationship

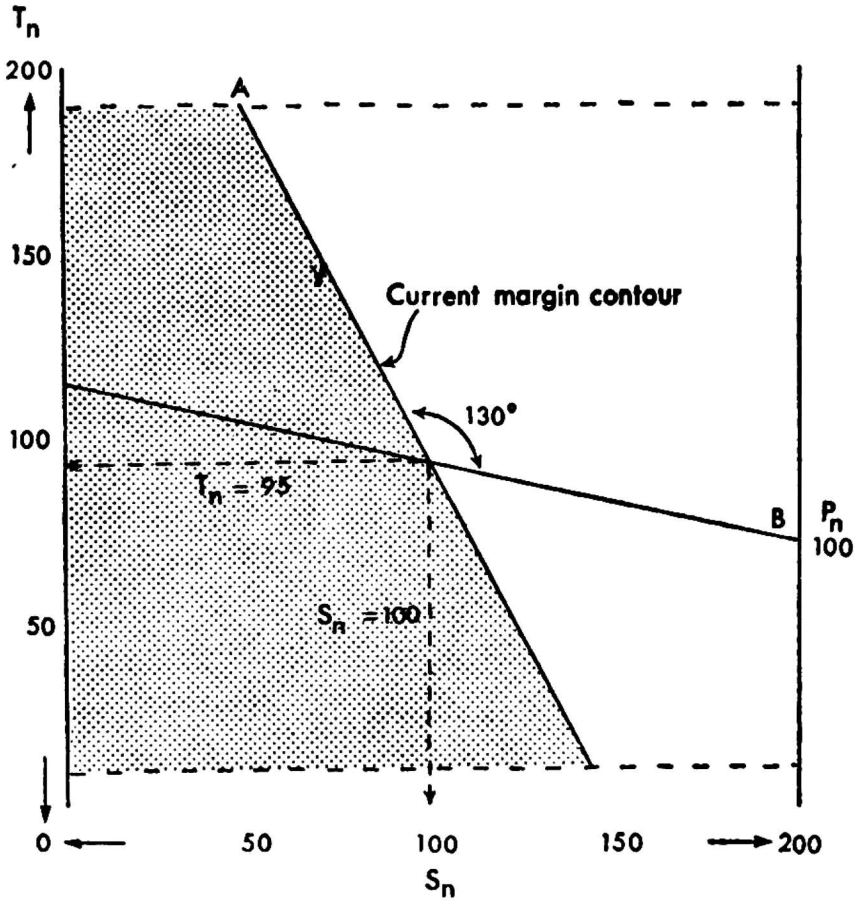


Fig. 3. Contours of productivity and current margin.

also exists between $T_n$ and costs ($r = 0.96$) for index values between 10 and 190. Based on 1961 results a unit increase in $P_n$ yielded £ 0.3365 while every unit increase in $T_n$ cost £ 0.2552. The ratio between the unit increase in costs and a unit increase in income enables a contour of "current margin" to be constructed across the productivity contours of Fig. 2. This is shown in Fig. 3. The broken lines indicate the critical levels of interpretation for $T_n$, i.e. 10 and 190. The current margin contour can be freely moved along the productivity contour until it rests on the current position of a particular farmer's performance. Such a performance is indicated in Fig. 3 at $T_n = 95$ and $S_n = 100$, yielding a productivity of $P_n = 100$. Any movement along the margin contour will maintain the margin at the current level. Any movement suggested for this farmer in a plan or budget must be into the unshaded area if the margin is to be increased. Any movement into the shaded area will decrease income. The slope of the current margin contour in relation to the productivity contour will change over time as changes occur in the ratio of prices to costs. The cost of inputs on the farms studied was, on average, 88% of total costs, so any change in the margin between output and the inputs will also reflect the change in farm income.

If a farmer's efficiency is high in relation to his intensity of farming it should pay him to intensify his production further. Conversely, if his intensity is high and his efficiency low, the intensity of farming should be decreased. If the intensity and efficiency indexes are in equilibrium, or approximately so, as in the example used in Fig. 3, then the farmer should consolidate his present position before risking a further intensification of his farming. Generally, a farmer should aim to move across the surface of Fig. 3 to the ultimate limit when both $T_n$ and $S_n$ approach 200, and one policy is to follow the diagonal from $T_n = S_n \to 0$ to $T_n = S_n \to 200$, a policy which will have a low risk if no knowledge is available about the farmer's individual performance. As the management analysis is applied to an individual farmer's results over a period of time, a limit to his optimum performance will become apparent, and this may reveal a path away from the main diagonal. The individual's optimum performance, and the path and the speed by which it is reached, will depend on the ultimate capability (and/or desire) of the farmer and on the environmental conditions within which he is farming.

Results for the farm in the South-West of England are presented in the paper in a number of ways. A plane of activity is drawn for each year showing the contour of current margin for that year and the path across the plane actually taken the following year. These planes, therefore, only record the historical performance of the farmer. In practice it is necessary to be able to suggest a movement across the plane which is likely to increase his performance and, hence, his income. If the farmer is being newly investigated, no evidence will be available to allow a movement in farm planning to be suggested from a trend of performance. In this situation, a change in intensification can be planned, based on the average distance betwen the farmer's position on the current margin contour and the intersection of the contour with the main diagonal across the plane of activity. Such a movement would only maintain margin at the current rate. It is likely that the farmer's efficiency will be greater than that required to maintain the margin and his performance will move into the unshaded area of the plane. The next year, the current margin contour will be moved to the farmer's new position and a further estimate made of the level of intensification at which he is likely to farm successfully. After a few years the actual performance can be plotted against time in order to reveal a trend towards the optimum position for the farm and farmer. Figure 4 shows such a graph for the dairy farmer in the South-West of England. This figure also is historical only: the farmer did not attempt to control his farming activities according to the "planned" values of $I$ shown in the figure. The planned values of $T$ and $S$ have been calculated in the manner suggested above. The interesting feature is the trough between 1961 and 1964. Is it reasonable that a farmer with a high degree of efficiency and a relatively low intensity, as was the situation in 1961, should fail so badly in 1962 with the increase in the intensity of farming which actually took place? Experience, which the author has gained in using previous analyses of this kind, suggest that it is not. It is indicative of the fact that the farmer is attempting to intensify his farming in an unsuitable environment. The lack of a sufficiently good environment may be due to a number of causes but is most likely to be associated, on a grassland dairy farm, with too low a density of stocking, either because of the lack of capital to purchase additional livestock or because of inadequate buildings or other facilities to handle additional livestock. Both these conditions prevailed on this farm and it was not until 1964 that the poor environmental conditions were improved. The immediate effect on the results may be seen in the figure.

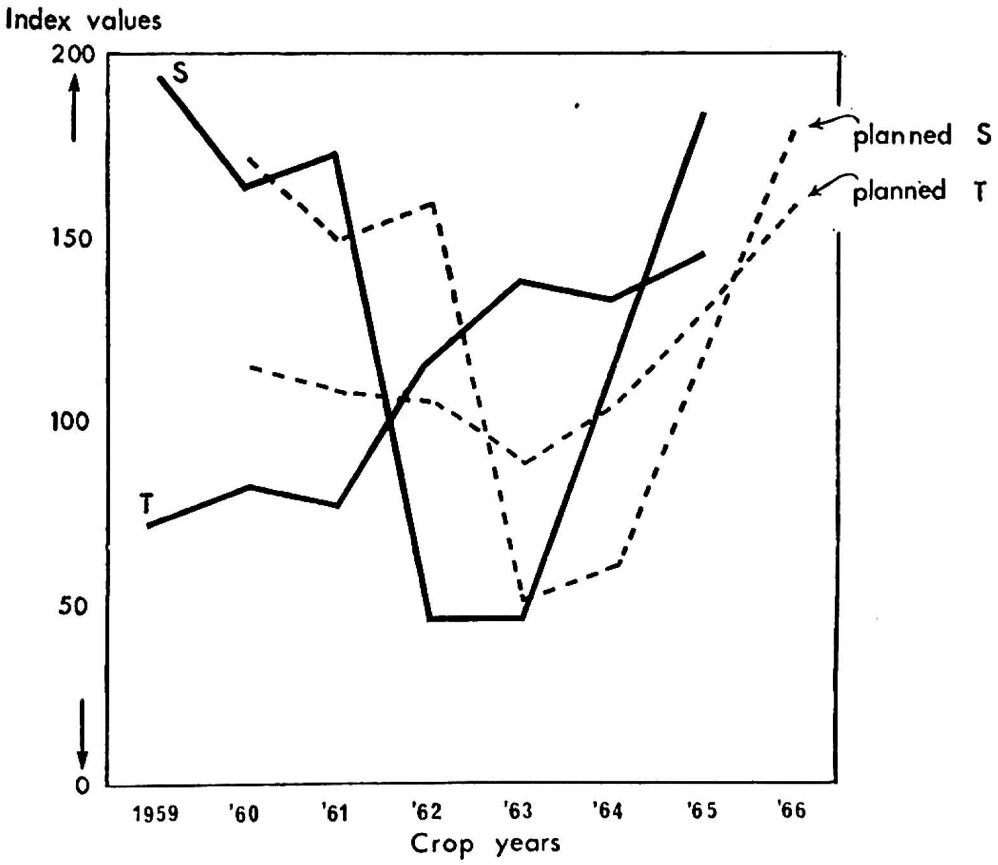


Fig. 4. Paths of intensity and efficiency for a dairy farmer in South-West England.

Any general measure of efficiency will not diagnose the ills (or virtues) of bad (or good) management. The estimation of efficiency can only be the first, or primary stage, of a two-stage analysis if the measurements are to be fully interpreted and utilized. The secondary stage will consist of the investigation into successful farming at all stages of intensification in order to diagnose the virtues of good management and to give guidance about the patterns of farm development from low to high intensity, with the associated measures of complexity, intensity and efficiency being used as yardsticks of an individual farmer's stage of development. Models will need to be constructed for different types of farming and re-examined yearly in order to detect any radical movements in efficiency generally which would require a new basis to be calculated for the indexes of efficiency.