FURTHER TOWARDS A MORE DYNAMIC APPROACH TO FARM PLANNING – A TECHNICALLY BASED MODEL OF THE FARM FIRM

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The writer's experiences in practical management, tends to support the principle of basing a model of the farm firm on the fundamentally endogenous factor of economic technical efficiency, rather than on the partially exogenous factor of profitability. A brief survey of the developments of the farm planning models is given. This seems to indicate dissatisfaction with the neo-classical paradigm of the profit maximising firm for practical research and advisory purposes. The behavioural approach is recognised as an alternative, but a production based approach is favoured in the light of experience. Thus a model is offered which is based on the concepts of the business momentum of a firm, and the target levels of economic technical efficiency, which latter are seen as the fundamental generators and sustainers of this momentum.

A brief survey of the developments of the farm planning models

Analytical models

The developments which have taken place in the field of farm planning techniques basically stem from the introduction and use of the linear programming model, for which much credit is due to Heady.\(^{36}\) The linear programming model of the firm gained rapid acceptance because of its close similarity to that of the neo-classical model,\(^{40}\) even though its introduction caused much controversy, e.g.\(^{11,15}\) Indeed the model still causes much discussion, although now this is more in terms of its mathematical deficiencies and inadequacies, since it is inevitably used as a basis for comparison with newer models, e.g.\(^{20,30}\) The basic mathematics of linear programming involves the maximisation or minimisation of a linear functional over a closed convex polyhedron feasible set.\(^{33}\) This places it into one of the simplest mathematical classes of constrained maximisation problems, and is the basic reason for current dissatisfaction with it, since many of the actual planning problems encountered cannot be satisfactorily squeezed into this mathematical box.

The results of this dissatisfaction with the basic linear programming model has been the investigation of further analytical models for farm planning. Thus Loftsgaard and Heady,\(^{49}\) suggested a dynamic linear programming model to deal with the problem of the inter-relationships of successive production periods. However, as Candler\(^{10}\) demonstrated, this Hicksian model is merely a special case of the linear programming model which is characterised by a block diagonal matrix. The integer programming model, which is becoming more available for general use,\(^{7}\) offers potential solutions to the problems of increasing returns, enterprise set-up costs, and other integer problems.\(^{58,53}\) The assumption of full
information is dropped in the game theoretic models,\cite{1,18,35,51,52} although these are still essentially deterministic. Stochastic problems are theoretically dealt with by the use of quadratic programming,\cite{8,24,50} and discrete programming,\cite{59,61} although it would be misleading in the extreme to suggest that these procedures can handle practical problems of uncertainty, since their application requires heavy assumptions on data measurability, availability and computability. Similar problems have hindered the use and development of dynamic programming models, although these have been strongly recommended.\cite{44} Thus, work published on dynamic programming has been mainly as discussion papers, e.g.\cite{44,55,68} although Brookhouse and Low gave an interesting practical application to egg production.\cite{6}

**Simulation**

The outcome of the difficulties encountered by the analytical models has been the development of the use of simulation techniques. Thus, solution by analysis is replaced by solution by experimentation,\cite{65} and the price of the greater mathematical freedom allowed is that of the concept of the optimal solution.\cite{14} Two branches of simulation have developed.\cite{32} The shorter branch involves the whole farm planning problem, e.g.\cite{20,21,50} and is a deterministic alternative to the analytical models. The longer branch involves the production of information on farming systems, to aid in practical decision making.\cite{13,16,19,29} This is the more interesting development in terms of a move towards a dynamic approach to farm planning, since it involves data production, rather than data consumption.\cite{33}

**Discussion**

The above discussion is not presented to suggest by any means that all is solved in the field of farm production economics. All models suffer critically from the common crippling problems of data availability, measurability and computability. Also, the real world problem of farm management is considerably more theoretically complex than even the most comprehensive simulation model is ever likely to be able to represent fully. This point of course does not vitiate the usefulness of these lines of attack on the problem. The real test of any theory is the usefulness and validity of the statements or predictions derived from the behavioural assumptions of the theory.\cite{26} That farm production economists have significantly succeeded in producing useful results is evidenced by the many successful applications of the various models which have been discussed. The ADAS developments of representative linear programming matrices for the South East Region\cite{42} and the I.C.I. development and use of the Mascot programme\cite{5} are examples of very practical and useful applications of linear programming. Butterworth suggests that integer programming algorithms will soon be generally available,\cite{7} while Murphy has suggested a reasonable and practical approach to the treatment of the stochastic problem within a conventional linear programming framework.\cite{56} Hazell\cite{34} has suggested a linear alternative to quadratic and semi-variance programming for farm planning under uncertainty. He has also suggested an interesting extension of the game theory models of McInerney.\cite{35} The more sophisticated models may not be so readily applied. However, their contribution has been the no less important one of pointing out deficiencies in the simpler models, which has led to a more critical application of them. Theory must precede practice in an orderly development of the discipline.

Even so, with all these qualifications in mind, one still must return to the complexity of the triple problems of data availability, measurability and computability, to which the investigation of the farm planning problem within
the neo-classical paradigm of the profit maximising firm has led. Add to this state of affairs the dissatisfaction of some economists with this neo-classical paradigm, and one must consider the need for paradigm change. Thus the Patrick-Eisgruber application of simulation to study the growth problems of the firm was based on a behavioural theory approach. They were concerned with studying how changes in the internal characteristics of the firm, resulting from changes in the relative importance of goals, would cause a firm to respond differently to the same conditions at different times. Their work is worthy of attention because of its fresh approach to the farm planning problem.

The purpose of this article is to offer a dynamic model of the farm planning problem which is based on an attempt to reconcile the above theories with seven year's practical experience in management. Thus, before offering this model, it is perhaps relevant to describe this practical experience briefly, in order to allow a better appraisal of this viewpoint.

Throughout I have been fortunate in having full control of the farms, my principals acting more as bankers, appraising developing projects on the basis of their practical appeal together with budgets and cash flows. I have therefore had the satisfaction of policy making as well as the responsibility of policy implementation. Initially, the Home Farm extended to 660 arable acres with a staff of seven men, including one full-time shepherd looking after 350 ewes. Approximately 220 acres of cereals were taken over from the outgoing tenant. The rest of the farm was in understocked grass for beef production. As a consequence of the estate policy of amalgamating farms rather than creating new tenancies, by 1969 the farms had grown to over 1,660 acres arable. With woodland and rough grazing, the total acreage available for farming is now approximately 2,000 acres. The present system involves 360 outwintered beef cows, run in two herds, the wintering of 520 store cattle, a 400-ewe flock, and the growing of 600–700 acres of cereals, of which approximately 80 per cent is available for sale off the farm. The farm staff is still seven men, including the original full-time shepherd. The system came into full production just before the current rise in beef and cereal prices, which has obviously further improved the level of profitability.

The nature of the area is such that it provides a natural advantage for out-wintered cattle and sheep, by virtue of its undulating character and the abundance of shelter, and a natural disadvantage for extensive arable production because of the small fields enclosed by stone dykes, evidence of the rocky nature of the soils. Given these characteristics and the nature of the finance available to operate the farms, it was quite obvious that they must be developed primarily in beef production with ancillary cereals. No sophisticated analysis was necessary to reach this conclusion. It simply pointed itself out by virtue of all the practical indicators. Thus the system was given in general terms, and the economic problem was reduced to that of resource allocation within the narrowed feasible set of a beef/cereals system.

In the short-term the cereal acreage was extended way past the long-term technically optimum point, in order to cash in on the dormant fertility of the understocked grassland. This provided short-term profits which were not expected to last, but which would serve the purpose of generating cash, both from the cereal sales and from the increased supply of funds from the estate trustees, who were given confidence by their observations of profitability. Longer-term considerations such as the expectation of increased acreages and expanding livestock output, together with the less tangible value of staff confidence, resulted in the decision to keep the staff number at the level taken over. Short-term decisions were always taken with the direction of the fundamental long-term policy of expanding beef production towards the technical
possibilities of the farms. The management problem has been essentially one
of the technical developments of a beef production system.

A dynamic model of the farm planning problem

Background

It was mentioned above that dissatisfaction has been expressed with the
paradigm of the neo-classical profit maximising firm in the investigation of the
farm planning problem. The behavioural theory of the firm has been considered
as an alternative. In the opinion of the present writer, there is a case for
another approach which lays emphasis on the technical aspects of production.
This belief is based upon personal experience and observation, and on the
knowledge that many of my farming friends are extremely technically production
minded. In practice, one is always moving towards a continually improving and
adjusting technical efficiency, rather than allocating at a state of technical
efficiency, From this viewpoint, a dynamic model of the farm firm is offered.

A basic concept of dynamic physical systems is that of momentum, which
represents the quantity of motion in a body and which is measured as the
product of mass and velocity, where velocity is speed in a given direction. None
of the dynamic models of the farm firm incorporate an analogous concept to
momentum, yet there is an analogous phenomenon in an actual dynamic farm
business. Businesses are developed in given directions – ours in the direction of
beef production. The components of the momentum which is built up as suc-
cessful development occurs may be divided into analogous concepts with mass
and velocity. The analogous measures of ‘mass’ are such things as the volume of
output of the business, its capital structure and reserves, its credit potential and
goodwill together with the knowledge and expertise of its staff. The analogous
measures of ‘velocity’ are the rates of profitability of its component enterprises,
the rates of increase in scale of these enterprises, and the rates of improvements
in the technical efficiencies towards some target levels of efficiency. These
improvements are the results of the directions of managerial and staff interests
and efforts, and of consequent capital investments.

Obviously this concept of momentum is not directly physically measurable.
However it is a relevant consideration in the planning of a business, since it
represents the summation of past performances and experiences which pushes
the present feasible actions in a given direction. Thus it is something which
should be, and indeed I am sure is, recognised by the farmer and his advisers in
considering future plans. It is more common to find farmers ‘building up to a
herd of X cows’ or ‘expanding cereals storage facilities to Y tons’ than it is to
find them choosing a new farming system.

Another aspect of momentum which is relevant to farm planning is that of
its effect on the feasibility of expanding the farm business. As discounted cash
flow budgets show, it is important to get high returns quickly to have a good
DCF return. However, with a big acreage expansion, or the introduction of a
new enterprise, considerable effort is needed to build up momentum, and it is
important to recognise this in considering the feasibility of the project if cash
flow problems are to be avoided. As well as the obvious factors such as working
capital requirements, capital investment requirements, etc., staff attitudes and
adaptability, and the reactions of the financing agencies to shortfalls in per-
formance are very relevant. The possible magnitude of the initial ‘drag’ of the
new project on the existing momentum of the business must be weighed against
its likely eventual ‘push’ effects. The well established business with a massive
momentum may readily try experimentation with innovating ideas, since the
possible drag effects will be negligible on the momentum. Similarly, the push
effects will be small, but the experience and knowledge gained will allow a
cnfident expansion of the innovation. This will yield an increase in total
momentum, or will at least offset the drag effects of any enterprises with falling
profitability, and will facilitate its removal from the system, if necessary.

The above is merely a description of well known facets of farm business
management using the analogy of momentum. Nothing new is suggested except,
hopefully, a more dynamic framework for appraising the farm business and
analysing its problems. Thus the farm business is seen as being analogous to a
body moving through time in a given direction. The role of management is to
ensure the continuity of this movement by the careful husbandry of the
momentum of the business. Since changing enterprise costs and return structures
cause continuous drag effects on this momentum, the management must
continually provide offsetting push effects, through such factors as the intro-
duction of technical improvements, innovations, staff motivations, enterprise
scale adjustments and the generation of confidence in lending authorities.

Proposed production model

From this background a production model of the farm is constructed on the
basis of the following fundamental axiom.

The continuous search for, development towards, and achievement of
economic technical efficiency are the fundamental problems of practical farm
management.

This axiom is based on the following three propositions, which represent the
distillation of the present writer's attempts to reconcile theoretical farm pro-
duction economics with practical experience. They are:

Proposition I. The basic motivation of the farm firm is to survive in business.
This survival is equivalent to the maintenance of business momentum, which
was discussed above, and which is formally defined below.

Proposition II. If all the rates of development of the business, actual and
potential, are equal to zero, then momentum is equal to zero and, by definition,
the business cannot continue.

Proposition III. In the actual business environment of farming today, the
level of profit of the individual farm is fundamentally determined by the
level of economic technical efficiency, which is defined below. This is so for
the particular farm since, unlike product prices and costs, technical efficiency
is fundamentally endogenous to the farm.

To link these three propositions together to reach the conclusion of the
fundamental axiom, definitions of terms must be made.

Define: A target technically efficient point, $T_i^*$, for enterprise $i$, where $i=1,
2, \ldots n$, and $n$ is the number of enterprises in the farming system, is that level
of technical efficiency to which the management is aiming to develop an enter-
prise at the point of time in question. It is measured in terms of a physical rate
of output per unit of that factor of production which seems most limiting to the
management. Thus it is essentially internal to the business in question, although
the target levels set may obviously be based on known performances given by
data from college farms, other farming colleagues, etc. Since it is measured in
terms of a limiting factor it may be thought of as lying on a neo-classical
efficiency frontier. However, it must be stressed that $T_i^*$ is conceived of
essentially as a target. The neo-classical efficiency frontier is too static a concept
for the present purposes. $T_i^*$ is a dynamic concept, changing with improvements
in management, innovations, or with changes in relative costs and prices.
Define: The momentum of a business, \( M \), is a concept analogous to that of momentum in physics. It is equivalent to a measure of the ability of the farm firm to do business. If \( M = 0 \) the firm is unable to survive. By proposition I, the basic motivation of the management is to ensure that \( M \) is always greater than zero.

The business momentum is determined by two different types of factors, those of reserve, \( R \), and the rates of development, the effects of which are represented by \( V \).

Reserve factors. The total effect of the reserve factors is represented by \( R \). Their effect is analogous to that of mass in the determination of momentum in physics. It represents the summation of past business performances and experiences. The main reserve factors are:

(i) The physical capital stock, \( P \), of the farm—buildings, livestock, machinery, etc. This is viewed not as a simple collection of durable goods, but as constituting a system.

(ii) The exogenous capital reserves, \( C \), measured by the supply of the firm's own funds held in non-farming capital.

(iii) The scale of physical operations, \( S \), measured by the annual total physical outputs of the business. \( S \) will obviously be composed of \( n \) component outputs, \( S_i \), for the enterprises of the system. Thus it will be a vector rather than a scalar, due to the heterogeneity of the components.

(iv) The credit worthiness, \( W \), of the business, assessed in terms of the usual balance sheet ratios.

(v) The factor \( E \), representing the expertise, aptitude and attitude of the farm staff. This complex concept is obviously relevant to farm planning. It will have components by enterprise, and may be simply graded good, adequate, or bad for each of these components.

(vi) The value of goodwill, \( G \), which is a measure of the state of the relationships between the business in question, and those with which it deals. Again it is obviously relevant to farm planning, and may be simply graded good, adequate or bad on a subjective basis.

Thus the effect of the reserve factors may be defined symbolically as:

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All these factors, together with the functional relationship, vary with time. They are not subscripted with \( t \) since all factors to be discussed are assumed so to vary.

Rates of Development. The total effect of the rates of development is represented by \( V \). Their effect is analogous to that of velocity in the determination of momentum in physics. The main rates of development are:

(i) The current rates of profitability of the enterprises of the system, \( \partial \pi_i / \partial t \), \( i = 1, 2, \ldots n \). These may be measured in terms of gross margin per unit of output, or in full cost terms, according to the nature of the problem in question.

(ii) The current rates of growth of the enterprises, \( \partial S_i / \partial t \), \( i = 1, 2, \ldots n \). These are measured in terms of the changes in physical output between preceding periods of production and the period in question.

(iii) The current rates of improvements in technical efficiencies, \( \partial T_i / \partial t \), \( i = 1, 2, \ldots n \), where the level of technical efficiency \( T_i \) at any time is measured as a rate on the same unit used to define \( T^* \).
All these rates of development may be actual and potential. The latter are distinguished by an asterisk superscript, e.g. $\partial T^*_i/\partial t$. If all current rates of development are zero, then $M$ is potentially zero. The business can only continue if some potential rates of development are greater than zero, and if the effects of the reserves, $R$, are great enough to allow these potential rates of development to be meaningful. That is, there is sufficient backing to allow an attempt to achieve these positive rates of development which will get the business moving again.

By proposition II, if all rates of development, both actual and potential, are zero, the momentum is zero and the business cannot meaningfully continue. It will last only as long as its capital reserves, once this point has been reached.

With these components, the total effect of the rates of development may be expressed as:

$$V = V ((\partial \pi_i/\partial t); (\partial S_i/\partial t); (\partial T_i/\partial t))$$

where there are $3n$ variables for $i = 1, 2, \ldots n$. Thus we have,

$$M = M (R, V).$$

Since $R$ is conceived of as being essentially a measure of past business performances (accepting that it may also be a measure of exogenous wealth) $R_t$ will in part be determined by past profits. Therefore,

$$R_t = R_t (\pi_{t-1}, \pi_{t-2}, \ldots \pi_{t-m})$$

where $t$ represents total profit at period $t$.

By proposition III we have the basic empirical assertion of this theory:

$$\pi_t = \pi_t (T_t) \quad i = 1, 2, \ldots n.$$ 

Thus

$$\partial \pi_i/\partial t = P_i (\partial T_i/\partial t) \quad i = 1, 2, \ldots n.$$ 

Hence

$$R = \phi (T_{t-1}, T_{t-2}, T_{t-3}, \ldots T_{t-m})$$

and

$$V = \psi (\partial T_i/\partial t, \partial T_{i+1}/\partial t, \ldots \partial T_n/\partial t).$$

Thus

$$M = \mu (T_{t-1}, T_{t-2}, \ldots T_{t-m}; \partial T_i/\partial t \ldots \partial T_n/\partial t).$$

Thus momentum and therefore business survival depend fundamentally upon economic technical performance, and we reach the conclusion that the search for, development towards, and achievement of economic technical efficiency is the fundamental problem of practical farm management.

Discussion

As was mentioned above, this is a conclusion based on practical experience. The technical development of our farming system has been and continues to be one's fundamental management concern. Thus considerations of technical potential and efficiency weigh heavily in one's decision making for resource allocation and enterprise expansion. Therefore it seems proper to base a model of the farm firm on technical considerations, as has been done above. The joint purposes of the model are to offer a more dynamic framework for the analysis of farming problems; and to support the direction of farm management research towards the investigation of the technical aspects of farm systems and enterprises, e.g.(6,13,16,17,19,29) It is hoped that it may be useful in three broad areas:
(i) As a conceptual framework for use by a farm planning adviser as an aid in making an appraisal of the problem in question. The concept of the momentum of the business is seen as being crucial in defining the feasibility of development projects. One may make the analogy of a heavy ship travelling in a given direction at a significant speed. It is impossible for it to make acute turns abruptly. Similarly, if the same ship is almost stationary, it may be turned in any direction almost on the spot.

(ii) The model could also be used to develop quantitative measures of momentum. These would be used in the usual way, for comparisons between similar farming systems. There does not seem to be any theoretical reason to prevent this, and in practice, little extra work would be needed over and above that which would be required for a normal appraisal of the business for planning purposes.

(iii) The measure of momentum obtained in (ii) above would provide a workable and realistic measure of the size of the business. This would then allow a more practical study of the growth of the farm firm (cf. Renborg(62)).

The basic assertion of the model is that, in practice, the fundamental aim of business survival is better achieved by an emphasis on the endogenous factor of economic technical efficiency, rather than on the partially exogenous factor of profitability. The achievement of technical efficiency leads to profit, and a concern with technical efficiency is a concern with the fundamental endogenous determinant of profit. Prices are given to farmers, and are usually at a level which allows the average farmer to survive. Economic technical efficiency is achieved by the farmer himself, and determines the viability of his business.

This technically based approach to the farm management problem does not nullify the usefulness of the neo-classical planning models. Although this approach denies the feasibility of meaningfully representing the dynamic efficiency frontier in a computer, it does not deny the usefulness of representing current target frontiers for purposes of investigating enterprise substitution, in order to test hypotheses on directions of development. Thus there is room for the use of the standard analytical planning models for information production within this technically based framework.

The system and enterprise simulation models have much more of a natural place within the technical production based theory of the farm firm. Their development may readily be interpreted as an expression of dissatisfaction with the neo-classical paradigm. Thus for example, Charlton and Thomson(14) came out explicitly against profit optimisation, and Charlton(13) has produced a model for pig production which is extremely technically based, and which would seem to fit well into the above analysis via his concern with variations in the net worth of the business according to the levels of technical performance achieved. Similarly, work by Dalton(16) in considering the specification of farm investment plans shows a recognition of the relevance of the reserve factor, P, in his appreciation that 'The physical matching of an investment to existing equipment becomes an important problem'.(16) His work in investigating the harvest machinery investment problem is very technically based, being essentially concerned with the estimation of technical parameters. This is as it should be, since prices of products and of factors of production are readily available and are only one side of the gross output and cost calculations.

Work along the line suggested by such workers as Dalton and Charlton, involving interdisciplinary studies of the technical process being examined are most welcome to practical managers and fit well into a technical production
theory framework. Such work may seem academically mundane, restricted, and less intellectually exciting than the grand consideration of whole farm profit optimisation problems. However it is right down on the ground, investigating the fundamental problems of farm management. One may best conclude this discussion by borrowing Dalton’s last paragraph, and widening his reference from that of investment appraisal to the whole farm planning problem.

‘The [technical production based] approach, as outlined, provides the farm management specialist with [an analytical procedure] which will enable him to play a more positive role in [realistic dynamic farm planning]. Not only will new technology be assessed more accurately, but suggestions about the development of such technology may be forthcoming’.(16)

References


VERS UNE MÉTHODE PLUS DYNAMIQUE DE PLANIFICATION DES EXPLOITATIONS AGRICOLES – UN MODÈLE DE L'ENTREPRISE AGRICOLE FONDÉ SUR LA TECHNIQUE

L'expérience pratique de l'auteur dans les techniques de gestion tend à soutenir le principe consistant à concevoir un modèle d'entreprise agricole reposant sur le facteur fondamentalement endogène de l'efficacité technique économique, plutôt que sur le facteur partiellement exogène de la rentabilité. L'auteur nous donne un rapide aperçu de l'évolution actuelle dans le domaine des modèles de planification des entreprises agricoles. La conclusion apparente indiquerait un manque de satisfaction envers le paradigme néo-classique de l'entreprise à maximisation des bénéfices pour la recherche pratique et les activités consultatives. Le behaviourisme est admis comme solution d'alternance, mais l'auteur est plus favorable, à la lumière de son expérience, à une méthode basée sur la production. Un modèle nous est donc soumis, fondé sur les concepts de l'impulsion commerciale d'une entreprise, et sur le niveau des objectifs d'efficacité technique économique, qui sont considérés comme l'élément fondamental engendrant et soutenant cette impulsion.

Die Erfahrungen des Verfassers im praktischen Management führen dazu, dem Prinzip rechtzugeben, dass ein Modell für die Farmunternehmung eher auf den fundamentalen endogenen Faktoren der wirtschaftlichen technischen Effizienz als auf dem teilweise exogenen Faktor der Einträglichkeit basiert. Es wird ein kurzer Überblick über die Entwicklung der Farmplanungsmodelle gegeben, der eine Unzufriedenheit mit dem neoklassischen Paradigma der auf Gewinnmaximierung ausgerichteten Farm für die praktische Forschung und für beratende Zwecke zu zeigen scheint. Das Verhaltensmodell wird als eine Alternative erkannt, aber einem Modell, das auf der Produktion basiert, wird vor dem Hintergrund der praktischen Erfahrung der Vorzug gegeben. Daher wird ein Modell angeboten, das auf dem Konzept der eigenen Triebkraft einer Unternehmung und den Zielniveaus wirtschaftlich technischer Effizienz basiert, wobei diese Zielniveaus als die fundamentalen Generatoren und Aufrechterhalter dieser Triebkraft angesehen werden.