

BEEF PRODUCTION MODELS IN MANAGEMENT SYSTEMS

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Summary

Building simulation models of production systems is a useful endeavour in itself, whether or not the models are further included as a sub-model in a large management system. 'This is illustrated with reference to a study of an intensive feed cropping and beef feedlot unit in New Zealand.

I. INTRODUCTION

Simulation models of animal production relationships have been used successfully in conjunction with feed production models to provide management information. Due to their ability to represent dynamic and stochastic relationships, simulation methods have a particular advantage in providing tactical management information, that is, information useful for day-to-day decision making. However, much management information, especially for decisions of a long-term strategic nature, can be obtained more cheaply and directly by other methods of evaluation, for example, budgeting and linear programming.

Whether or not an animal production model proves useful as a sub-model of a management system, it may be useful in other ways. First, it provides a convenient summary of known parameters and relationships and their interactions in the system. Secondly, in building a model, omissions in data and gaps in the logical framework are revealed. Thirdly, sub-system production models are useful for making inferences about unknown parameters or relationships. Ackoff (1962) notes that "In some cases we may be able to construct a model, but not to evaluate all its parameters because of lack of data. We may, however, have good and plentiful data on past outcomes and values of the controlled variables. In such cases we can by simulation try out a large number of possible values of the parameters, together with known past values of the controlled variables, until we obtain one or more sets of values which yield outcomes that correspond well with the known past outcomes. The same kind of procedure can be used to explore alternative functional forms of the model". In another sense, this can be regarded as a means of testing hypotheses about unknown relationships.

II. THE PRODUCTION MODEL

These useful features became apparent in a study (Greig 1971) of a management system proposed for New Zealand in which a beef feedlot was to be based on an intensive feed cropping and storage unit. High-yielding summer maize and winter ryegrass forage crops stored in tower silos were to provide a high-quality silage and haylage diet which would be supplemented, if necessary, by purchased

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grain. Because of the technical uncertainty and lack of data which faced an analysis of the proposed system, the approach adopted was to indicate the minimal conditions for profitability and the parts of the system having most influence on profit.

A beef production sub-model was synthesised to trace liveweight gains and feed intakes over time. There were three main requirements for data. The limit on dry matter intake was recognized as being a function of liveweight of the animal and of digestibility of the feed. However, available data were fragmented and inadequate, providing few clues as to the nature of the operative restriction. Data showing how the dry matter intake limit varied with liveweight were found for only a few discrete values. The limit on dry matter intake as a function of feed digestibility was only implicit in the available feed-intake data for beef cattle. Data were needed also on requirements for maintenance expressed in terms of digestible organic matter (DOM). Even though this relationship was usually expressed as some function of liveweight to the power of about 0.73, estimates of requirements varied considerably. The third important data requirement was for the relationship between DOM intake and liveweight gain. That this is a function of liveweight, rate of liveweight gain and digestibility is implied in available (discrete) feeding tables, but the relationship did not appear to have been stated explicitly in functional form.

Functional expressions for these relationships were derived arbitrarily for the simulation model being used to generate liveweight gain and feed intake data based on pasture feeding, for which ample experience of beef cattle performance inclusion in a simulation model. This phase of systems synthesis proceeded with what was available. The model was tested, altered, and the adaptive process repeated until results were produced consistent with the subjective appraisal of an experienced animal scientist. With some knowledge of the relationships involved, and after some experience with changing these relationships in the model, it soon became apparent which parameters had to be altered in order to impose desired characteristics on the time pattern of simulated feed intakes and liveweight gains. For example, in order that maximum attainable liveweight gains decreased as liveweight increased beyond a certain size, it was found, within reasonable limits, that it was necessary to represent both the proportionate restriction on intake and the DOM required per unit liveweight gain as an increasing function of liveweight. Although the derived relationships were restricted to simple linear functions, which facilitated the synthesis phase, they were later shown to be adequate for the purposes of the model.

Using the model so derived, the feed characteristics were changed to those of maize silage and ryegrass haylage and further performance data stimulated. By way of validation, these gains were then compared with the results of a few available experiments in which beef cattle had been fattened on a silage or silage-haylage diet. The correspondence was sufficiently close to indicate that the model was probably satisfactory for the immediate purpose.

III. RESULTS

Because the range of results that can be produced by such a model is almost unlimited, only some results which illustrate its versatility in relation to cattle

feeding are presented here. Briefly, the system indicated positive net profits under optimistic assumptions but not an acceptable return to capital invested. Although feedlot profitability depends to a large degree on the margin between purchase and sale prices for beef, this important aspect of feedlot operation is not discussed here.

The preferred feeding policy that was determined can be stated, with reservations, as being one of feeding silage and haylage as the sole diet. For an assumed digestibility of 0.65 liveweight gains of about 0.70 kg/day were calculated. Both this policy and profits proved sensitive to the level of digestibility assumed for the

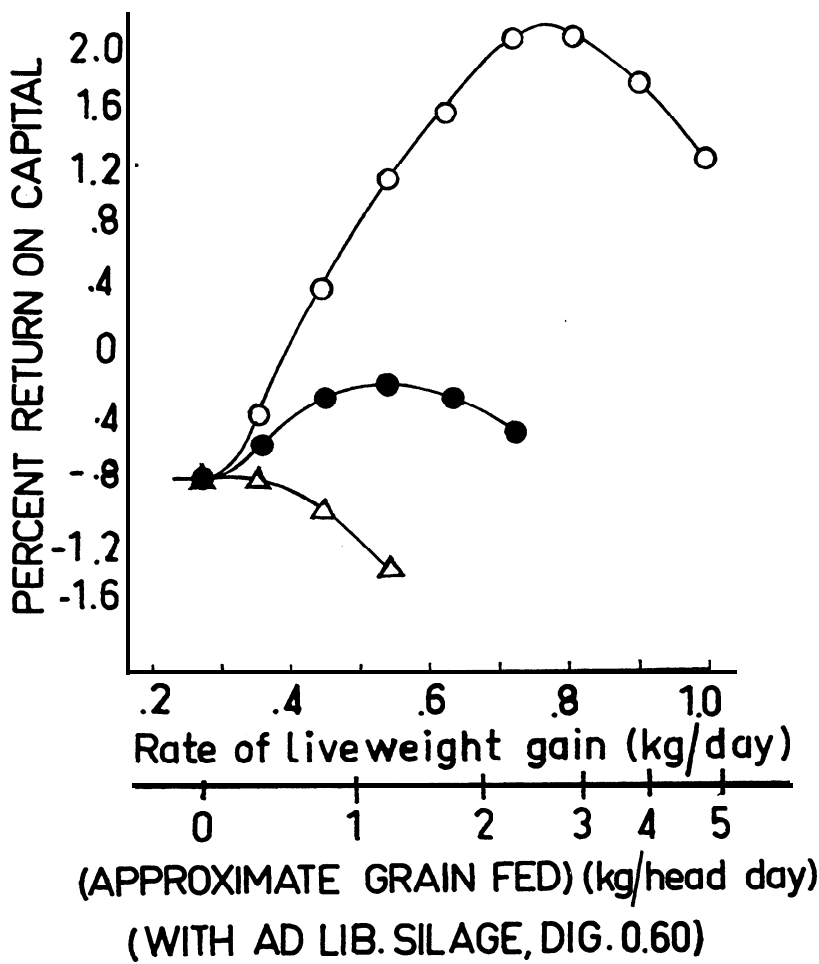


Fig. 1.—The relationship between rate of liveweight gain, purchased feed price and profit.

- Grain at 4.4 cents per kg
- Grain at 5.5 cents per kg
- △—△ Grain at 6.6 cents per kg

stored forage. This was illustrated by arbitrarily changing digestibility from 0.65 to 0.64. Liveweight gains were reduced by about 0.07 kg/day, and for a feedlot of 600 head capacity, profit was reduced from \$8,000 by about \$1,300. This sensitivity made an accurate specification of digestibility important, although this was difficult to do in practice because available data were experimental rather than derived under operational conditions. On the other hand, sensitivity of liveweight gains to digestibility meant that validation of the model could be relatively precise. The cropping area and feed storage facilities needed to support a feedlot of given size also varied markedly for different assumptions about digestibility. For a given percentage change in digestibility, cropping area changed by almost twice this percentage. Being able to determine the economic consequences of such marginal changes in feed quality means that a comparison of methods of feed harvesting and storage is possible, given adequate data on feed losses and quality. Such data were not available in New Zealand. The value of an analytical technique which can realistically show the marginal effects of small changes in the parameters is clearly evident.

Under conditions which favoured a relatively high level of grain feeding, namely low grain prices and low silage quality, profits were shown to be sensitive to the rate of liveweight gain. For example, under one set of assumptions and close to the optimal rate, profits for the system were shown to decrease by up to \$1,000 for a change in the rate of liveweight gain of 0.09 kg/day. For a given level of silage digestibility, the relationship between rate of liveweight gain, grain price and profits is further illustrated in Figure 1.

The study demonstrated the ease with which the sensitivity of system design to various factors could be determined; Design, which is the organisation of components within a system, varied with such factors as stored forage quality, crop yields and feeding policy. In contrast to the usual problem of evaluation with respect to fixed resources, in non-operational systems all resources can be regarded as variable quantities. In the present example, the ways in which investment in feedlot, storage facilities and cropping area varied in relation to each other were readily determined from the simulation output. Variation in design was most influenced by stored forage quality and the feeding policy adopted. This implies that further evaluation of feeding policies would be desirable before such a system was made operational. An analogous use of simulation in planning capital investment was noted by Dent (1971) in his analysis of the influence of assumptions about stock performance on efficient investment in pig breeding and fattening units.

IV. CONCLUSIONS

Apart from the contribution of the production sub-model to the overall management model, the benefits derived from this modelling exercise were three-fold, and by themselves probably justify the endeavour. First, a medium was provided whereby an investigator with little previous pertinent knowledge could assemble the known relevant relationships in a logical and consistent fashion. Secondly, it showed how critical deficiencies in available data were and where effort would be served best in improving available information. Thirdly, it was possible to make inferences about properties of the different parameters and functional forms. To validate output from the model against past outcomes, modifications had to be

made which, although often only implied in published data, were sometimes found to be necessary to impart the appropriate characteristics to the performance of the model.

Modelling is thus seen as a potentially valuable aid to organized research. A useful vehicle is provided for inter-disciplinary co-operation, where current knowledge can be assessed and where learning can be readily summarised in context. As deficiencies in existing data or knowledge are recognized, priorities for research can be established depending on how critical is the data shortage. Wright (1970) has proposed a dual teaching-research role for sub-system modelling, and recognition of the value of such models for teaching purposes is a logical next step.

V. REFERENCES

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