INVITED

Context Specific, and a More General Expression of, Relationships on Extensive Cattle Properties

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Abstract Many systems or entities for which computer models have been developed are based on attributes or relationships that are context specific; (that is, relationships that mainly or only apply to the system being modelled). However, some systems are of a wider interest because some of their relationships can be expressed in a more general form that is applicable outside the system being modelled. One such system is the modelling, for decision support, of extensive beef cattle properties in the semi-arid tropics of N E Queensland. This paper outlines some of the relationships in such a system.

1. INTRODUCTION

The modelling of whole farms has been around for many years (see for example France and Thornley, 1984; Rickards, 1968; and Sage, 1983). Some aspects of the discipline have undergone radical change, like for example in computer hardware and software and in the wide range of tools and methods now available to modellers. Other aspects have changed little, like for example the fundamental questions of what are the boundaries to the system to be modelled; what type of model to use; and what is to be the designed use of the model. Many of the more successful whole farm models, similar to models in other areas of modelling, have had relatively focussed tasks, aims or reason for being. In these cases there was usually a relatively clear boundary between what should be in the model and what should not; that is what should be excluded or assumed to be exogenous, or constant, or irrelevant. Basically we have gone from the early whole farm modelling efforts that required considerable resources to get the data and just get the model to work, to the current efforts that can build virtually any type of model but need to spend considerable resources to clarify what is required to achieve the needs or specifications of the main stakeholders. In using modelling to provide answers to problems we usually or always have to choose the problem or prune down the description or boundaries of the problem in order to make it fit into the tools or expertise available. Some early attempts at whole farm models were, by today's standards, very simple but were nevertheless very useful in achieving their design aims. This was largely because the problem under study was tackled in an appropriate way. Today we would still probably tackle the problem in the same way. However, today there are less of these "nice" problems around. Certainly whole farm models are not a panacea. However, they can be one very useful component in a wider process to provide support for decision making, for policy recommendation or for research.

Whole farm models, similar to other types of models, require or use relationships to describe the system to be modelled.

2. CONTEXT SPECIFIC RELATIONSHIPS

Relationships that are specific to the context of extensive beef cattle properties in the highly variable rainfall environment in the semi-arid tropics of N E Queensland represent pasture, cattle, seasonal conditions, and stocking rates (for example see Gillard and Monypenny, 1988, 1990; McIvor and Monypenny, 1995; and Gramshaw, 1995).

Beef production in this context is based on extensive grazing of native pastures. Animal performance is limited by pasture quantity and/or quality. Rainfall and both pasture and cattle growth rates are highly variable. Many properties are managed with very conservative stocking rates. However, many stakeholders in this system are interested in production systems that will overcome pasture limitations. Two options in pasture development are killing trees to increase the quantity of pasture produced and oversowing of native pasture with introduced grasses and legumes to increase the quality of pasture produced. Four alternative pasture development systems are: live trees and native pastures; killed trees and native pastures; live trees and oversown pastures; and killed trees and oversown pastures. Comparison of these four alternatives, as used on basaltic soils, using a spreadsheet model that integrated information from various sources, found that both killing trees and oversowing introduced grasses and legumes increased production and net cash flow (McIvor and Monypenny, 1995).

Decision support (as defined for example in Bidgoli, 1989; Bryceson and White, 1994; Eden, Jones and Sims, 1983; Guariso and Werthner, 1989; and Monypenny, 1992, 1994) was the designed use of the model.

Model output was validated in that it produced output similar to that expected by experienced graziers and scientists. The model was shown to be a useful tool with which to assess, on a whole property basis, the impact of seasonal variation and of alternative pasture development systems on animal production and financial outcome. The model can be used by graziers in making decisions about pasture development and by research workers in assessing the likely impact of potential research output. The greatest increases in production and in net cash flow were with killed trees and oversown pastures. The relative changes in net cash flow over a range of seasonal growing conditions were less with oversown pasture than with native pasture. Systems where trees were killed produced near maximal returns over a wider range of stocking rates than systems with live trees. These results suggest that pasture development using oversown grasses and legumes can be a profitable investment.

However, care is needed when using these results to provide recommendations or to assist with pasture development decisions on specific properties. Stakeholders in the decision making need both to have access to pasture, cattle, seasonal conditions, and stocking rates information for the property and need to be satisfied that the assumptions underlying these results are appropriate for the specific property and to the circumstances under which the decision is to be made.

3. A MORE GENERAL EXPRESSION

Context specific relationships of extensive beef cattle properties in the highly variable rainfall environment in the semi-arid tropics of N E Queensland are useful in their specific context. These relationships are more likely to be of use in other contexts if they are expressed in a more general form or expression. Below are five such relationships. Examples from a cattle property are used to help presentation. These examples for cattle properties are not intended as technical recommendations. For technical recommendation please consult Gillard and Monypenny, 1988, 1990; McIvor and Monypenny, 1995; and Gramshaw 1995.

3.1 The variable used to determine the best alternative

In some systems it is appropriate to measure outcome or output in terms of only one variable, or if output is measured by more than one variable, then the same alternative is always the best. However, in other systems the alternative that will lead to the best outcome depends on the output variable used to represent the value or performance of the system. For example on a cattle property, if the variable used to decide between two different stocking rates is accumulated net cash flow over the planning horizon, then the best alternative is to kill the trees and to oversow with improved pastures. However, if the variable used is the level of debt that the property would incur to kill trees and oversow with improved pastures, the best alternative is to oversow improved pastures under live trees.

3.2 Robustness of the outcome

The robustness of the model outcome (as represented for example in figure 1) to changes in one or more input variables, as for example on a cattle property, changes in net cash flow between seasons over the planning horizon, as expressed, for example, by the standard deviation of the distribution of yearly net cash flows, is least when trees are killed; (compared to alternatives where there are live trees). A related issue is the robustness of the model outcome compared to the robustness of the real system.

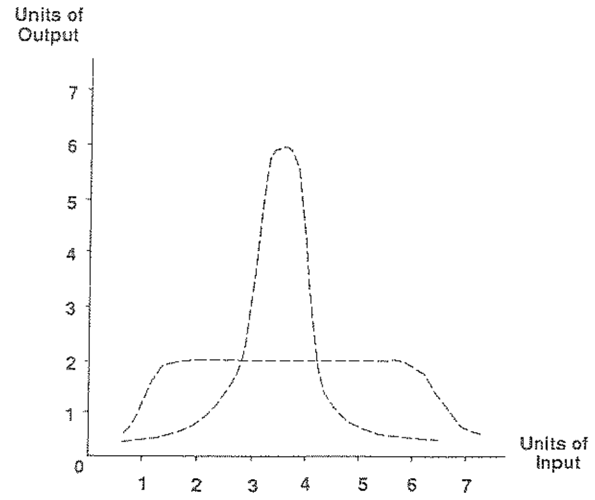

Figure 1: Hypothetical Example of Robustness

More important, is the issue of the robustness of the real system outcome to changes in one or more input variables, or in other words how buffered is the real system? Because unbuffered systems are easier to model than buffered systems. For example a cattle property is a highly buffered system and thus more difficult to model. This is in part because most of the components of the system are highly buffered. For example the soil can store more or less water and nutrients, more or less pasture can remain uneaten, and the cattle can have more or less fat cover.

3.3 Non linearities at the extremes of the range

Many relationships in the real world are non linear. Modellers frequently use linear approximations successfully in their models. Two reasons for using these approximations are poor data and algorithm requirements like for example in the case of linear programming. One important special case of non linearities is that in which they occur at the extremes of the range of the relationship, (as represented for example in figure 2). The events at these extremes are often of infrequent occurrence. Thus the availability of good data for the central part of the relationship is often of little use at the extremes. However, these non linearities can be important in decision making. For example on a cattle property, the non linearities that occur, in drought and in good seasons, at the extremes of the pasture, cattle, and stocking rate relationships. In grazier decision making, these non linearities are important because of the considerable risk of land degradation during drought and the large benefits that accrue in good seasons.

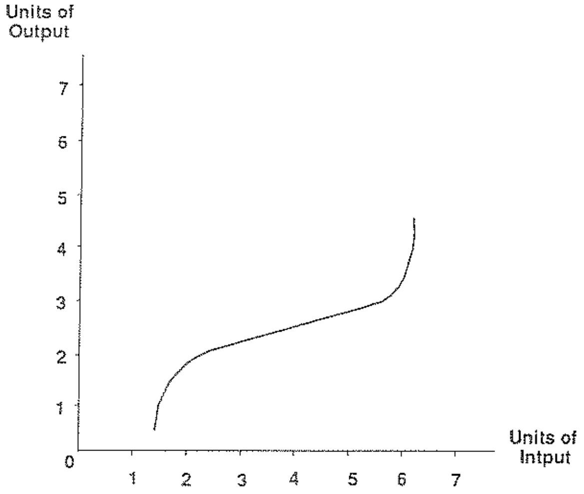

Figure 2: Hypothetical Example of Non- linearities

3.4 Large range of the relationships

When a relationship covers a large range in input variables, the variable with the major influence, or the limiting factor, in the relationship may change. For example on a cattle property, for the pasture and the cattle relationships, when rainfall is low, water is the limiting factor in cattle growth rates. However, when rainfall is high, protein is the limiting factor. A related issue is when events or technology move to the extremes, or even outside the range of input variables for which the existing rules of thumb, the accepted local good practice, or the local experience, will hold. In this case modelling can be a very useful tool to develop and evaluate revised rules or good practice. For example on cattle properties in N E Queensland when Brahman cattle were introduced and normal death rates moved to the lower end of the relationship; and when supplementary feeding with urea and molasses started and normal stocking rates moved to the upper end of the relationship.

3.5 Partitioning of the model

In whole farm models the modeller usually has to first determine the underlying relationships of the system to be modelled before work can start on the way these relationships can be modelled in order to represent the system in question and to achieve the designed use of the model. The magnitude of this problem formulation task may not always be apparent at the outset. One important special case is that in which the value or magnitude of input variables and/or output variables are determined by more than one factor. Of special interest is the case where one or more context specific factors dominate the underlying process by which inputs relate to outputs. Partitioning or decoupling the model through the judicious use of a link concept can provide considerable practical benefits (Monypenny, 1991). For example on a cattle property and using weight-gain per animal as a link concept, the modelling of the relationships relating rainfall to live-weight gain can be partitioned from the modelling of the relationships between live-weight gain and net cash flow. Partitioning may be between inductive (for example parametized least squares) and deductive (for example spreadsheet) parts of the model; or between different logical units of the model (for example soil, pasture, cattle and cash flow).

3.6 Some advantages of a more general expression

The advantages for modellers of being aware or reminded of these more general forms of some relationships will vary from individual to individual. The likely existence of one or more of these relationships will probably arise during problem formulation. Once identified they are relatively easy to incorporate into model design. For example 3.1 and 3.2 relate to the design of model sensitivity analysis; 3.3 relates to data collection and relationship specification; 3.4 is likely to be difficult because of interactions and dynamics within the system; 3.4 is specially difficult when equations are used to specify relationships rather than directly using data like for example in spreadsheet lookup tables; 3.5 is most likely to be the most difficult because the "right" answer is often only apparent with the benefit of hindsight.

4. THE CHALLENGE

The challenge for whole farm models and modellers is to deliver on time to client satisfaction, to get it right. This is both reinforced by the need for quality assurance, accountability and end user consultation and emphasised by the current limits on funding. It is far easier to state the challenge than it is to actually deliver on time to client satisfaction, to get it right. This difficulty is in large part because of the often time consuming process required to get answers to the following questions: Get what right? Right for what? Right for who? Right at what point in time?

Given this challenge and the experience to date in the modelling of extensive beef cattle properties in the semi-arid tropics of N E Queensland, it would appear that the future of the discipline of whole farm modelling, in general, and of specific models and projects, will depend first on the extent of consultation among the stakeholders, and the ability of the consultation process to arrive at, or to make, the right choice. That is, to arrive at the choice, that with hindsight, is seen to be the right choice. Second, on the ability of stakeholders to distinguish between and to provide appropriate leadership and management. That is, leadership that clearly identifies what is to be achieved and management that delivers agreed outcomes using agreed processes. In other words, the ability of stakeholders to distinguish between and provide for, on the one hand, the big picture, the what to model, and on the other hand, the detail of the model, the how to model.

In conclusion, the outlook for whole farm models would appear to be positive and guardedly optimistic. Whole farm modelling has come of age over the last 30 or so years. Whole farm modellers have a large and varied range of tools currently at their disposal. Whole farm models are not a panacea, there are many problems which are intractable with the current tool kit. Furthermore, inappropriate use of these tools is likely to end at best in disappointment and more likely in disaster. However, appropriate and expert use of these tools will provide success. Will bring success defined as having a whole farm model as one of the very useful components in a wider process to provide support for decision making, for policy recommendation or for research.

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