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SUBJECTIVE PREFERENCE FUNCTIONS AND CHOICE BEHAVIOUR: SOME COMPENSATORY AND NONCOMPENSATORY MODEL STRUCTURES

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1. INTRODUCTION

Geographers have almost invariably used linear additive or multiplicative model specifications to predict overt choice patterns. Unfortunately, however, the validity of these model specifications has hardly been tested. Consequently, these models might yield invalid insights into the decision-making of individuals. That is, these models imply that individual decision-making is compensatory in the sense that low subjective evaluation scores for some attributes of a choice alternative might at least partially be compensated by high subjective evaluation scores on one or more of the remaining attributes. It is evident that this implication will probably not be appropriate in every choice context. In addition, if these specifications are at variance with individual decision-making and the model is used to predict the likely effects of policy decisions, the model will seriously underestimate or overestimate these policy effects. Hence, an important research question is to assess the predictive validity of alternative model specifications in various choice contexts.

Because geographers generally are not familiar with model specifications other than the linear additive and the multiplicative models, the purpose of the present paper is to give a broad overview of model structures which might be used to account for individual preference functions and choice behaviour. In particular some non-compensatory vis-à-vis the well-known compensatory models will be discussed.

Noncompensatory models describe decision-making processes that do not admit trade-offs between attributes. Alternatives are compared on an attribute-by-attribute basis. In general multiattribute profiles are not collapsed into a single utility or preference value. In contrast compensatory rules describe decision processes in which changes in one attribute can at least partially be compensated by opposite changes in one or more of the other attributes. In general a single utility or preference value is attached to a multiattribute profile. Trade-offs between attributes are admitted.

2. NONCOMPENSATORY MODEL STRUCTURES

Several noncompensatory models might be used to predict individual choice behaviour. In this paper the dominance model, the conjunctive model, the disjunctive model, lexicographic models, the maximin model, the maximax model and the minimax regret model will be outlined respectively.

2.1. DOMINANCE MODEL

The dominance model states that if alternative A_1 is better than A_2 on at least one attribute and not worse than A_2 on any other attribute, alternative A_1 will be chosen. Hence, this model assumes that an individual compares the alternatives within a single attribute; trade-offs are not admitted.

Note that this model does not garuantee that a single choice alternative will be preferred. For example, consider the next hypothetical example. Table 1 gives hypothetical scores on a 9 point scale on three attributes for three choice alternatives. This table illustrates that none of the alternatives is evaluated more positively than the other two alternatives on at least one attribute and at least as good as all other alternatives on any other attribute. Thus, the pattern of subjective scale values does not reveal a dominating choice alternative.

Table 1: A hypothetical example

alternative/attribute	1	2	3
A_1	9	1	9
A_2	5	7	6
A_3	3	8	4

2.2. CONJUNCTIVE MODEL

A conjunctive model states that an alternative will be chosen if it exceeds specific acceptable attribute values which are defined on each attribute. Alternatives that have values outside the acceptable range are rejected as unacceptable, implying that the worst attribute is vital.

For example, if these acceptance criteria for the three attributes are 4, 2 and 3 respectively, it follows that in the case of our hypothetical example alternatives A_3 and A_1 will be rejected and that alternative A_2 will be chosen. Note that the low score of A_1 on attribute 2 is not compensated by the high scores of this alternative on the other attributes. In addition, if the acceptance criteria, of attribute 1 would be 2, it follows that only choice alternative 1 is rejected and that the conjunctive model does not rank the remaining alternatives. Hence, the conjunctive model dichotomises the alternatives in an individual's choice set into pass-fail categories and cannot generally be used to identify the unique most preferred alternative.

2.3. DISJUNCTIVE MODEL

The disjunctive model evaluates alternatives on the bases of their maximum values rather than on their minimum values. An alternative with a good score of one attribute is valued regardless of its score on any other attribute, implying that the best attribute is vital. For example, if in our example the acceptance criterium would be 8 for every attribute, choice alternative A_1 would be chosen irrespectively of its low score on the second attribute. Hence, like the previous model, disjunctive models do not admit trade-offs between the attributes and generally dichotomise alternatives into fail-pass categories.

2.4. LEXICOGRAPHIC MODELS

Lexicographic models also belong to the class of noncompensatory model structures but are distinguished from the preceding models in that the choice alternatives are evaluated sequentially. That is, the choice alternatives are first compared on the most important attribute. If two or more alternatives are equivalent at this stage, they are compared on the next most important attribute. This process continues until all choice alternatives are weakly ranked or ranked or until all alternatives have been considered.

Thus, if it is assumed that the second attribute is the most important one in our hypothetical example, it follows that choice alternative A_3 would be chosen according to this lexicographic model. Note that this model is noncompensatory in the sense that the remaining attributes are not considered if all alternatives can be ranked with regard to more important attribute.

Actually, this lexicographic model is very strict. It does not account for imperfect discrimination and unreliability of available information. More realistic lexicographic models are therefore the lexicographic semiorder model and the minimum difference lexicographic model. The lexicographic semiorder model assumes that an individual considers the second most important attribute not only if two or more alternatives have equivalent values on the most important attribute but also if the difference in these values is less than or equal to some minimum. The minimum difference lexicographic model can be considered as a generalisation of the lexicographic semiorder model in that it defines a minimum difference for each attribute of the choice alternatives. Thus, if it is assumed that the rank ordering of the attributes on the basis of subjective importance is 2-1-3 and that these relevant differences are 1,2,3 respectively, both of these lexicographic models would predict that choice alternative A_1 will be chosen.

2.5. MAXIMIN, MAXIMAX AND MINIMAX REGRET MODELS

The maximin model stems from game theory. It calls for the identification of the least satisfactory attribute of each choice alternative. The alternative with the highest of these minimum values is preferred. The maximax model in contrast calls for the identification of the most satisfactory attribute of each alternative and predicts that the choice alternative with the highest of these maximum values will be preferred. The minimax regret model assumes that an individual identifies the attribute with the greatest difference in evaluative scores and that he will choose the choice alternative with the highest score on this attribute irrespectively of its scores on any other attribute. Hence, applied to the hypothetical data in table 1, these three noncompensatory models predict respectively that choice alternative A_2,A_1 and A_3 will be chosen.

The noncompensatory models discussed so far constitute only some elements of a wider class of noncompensatory models. They have been applied successfully in the context of clinical judgment, marketing and transportation science (e.g. Goldberg, 1971; Perreault and Russ, 1977 and Foester, 1979). Evidence obtained thus far in the context of spatial choice behaviour suggests that although these model perform satisfactorily,their predictive ability is less than that of compositional compensatory models (Timmermans, 1983),

3. COMPENSATORY MODEL STRUCTURES

The foregoing class of models is noncompensatory in the sense that alternatives

are compared on an attribute-by-attribute basis and that the evaluative values attached to the attributes are not combined into a single overall evaluative score. Hence, the scales of the attributes need not to be commensurate.
In contrast the compensatory models involve calculating an overall evaluative score and hence the scales of the attributes should be commensurate. In this paragraph the weigthed and unweighted linear additive and the weighted and unweighted multiplicative model will be outlined.

.3.1. WEIGHTED AND UNWEIGHTED LINEAR ADDITIVE MODELS

These models assume that an individual will select the choice alternative with the highest score on some linear additive evaluation function. The overall evaluation score equals the (weighted) sum of all evaluative values defined on the attributes. The weighted model assumes that the individual constructs the weighted functions. The model may be expressed mathematically as:

$$E_j = \sum_k w_k e_{jk} \qquad (1)$$

where, E_j is the overall evaluation score of the j-th choice alternative;
w_k is the subjective weight attached to the k-th attribute of the choice alternatives;
e_{jk} is the evaluation score on the k-th attribute of the j-th attribute.

In contrast, the unweighted linear additive model assumes that the compensation is held among the attributes themselves.
This model can be expressed as:

$$E_j = \sum_k e_{jk} \qquad (2)$$

Note that both models allow low scores on some attribute to be compensated by high scores on other attributes. For example, given the data in table 1 equation (1) predicts that choice alternative A_1 will be chosen, implying that the low score of this choice alternative on the second attribute is compensated by its high scores on the other attributes.

As noted before, this type of model has been applied frequently in spatial analysis. However, linear models have been derived mostly from economic theory. It should be stressed however that completely different theories, also involving a linear model, might potentially be adopted in spatial research to account for spatial choice patterns. For example, the expectancy-value approach assumes that the strength of a tendency to act depends upon the strength of the expectancy that the act will be followed by particular outcomes, I(subjective probability, expectancy, perceived instrumentality) and some affected value V, of the outcome. In addition, expectancy value theory specifies that the strength of a tendency to act is a monotonically increasing function of the sum of the product of expectancy and values across outcomes. In formule:

$$A_o = \sum_k I_k V_k \qquad (3)$$

This model is known as Rosenberg's attitude model. (Rosenberg, 1956).

Still another linear additive model is that of Fishbein which is based on behaviour theory principles of mediated generalisation (Fishbein, 1967). The model assumes that an individual's attitude toward a certain object or behaviour is a function of

- the individual's belief (B_k) about that object or behaviour;
- the evaluative aspects of these beliefs (E_k);
- normative beliefs (NB);
- the motivation (M) to comply with these norms.

In formule:

$$B = \left(\sum_{k=1}^{r} B_k E_k \right) W_1 + \left(\sum_{k'=1}^{r'} NB_{k'} (M)_{k'} \right) W_2 \qquad (4)$$

where, B is behaviour;

W_1 and W_2 are empirically determined weights.

It should be noted that although the Rosenberg and the Fishbein models are mathematically equivalent, they require different methodologies to test them. These models have been applied successfully by Thomas (1976), Fishbein and Jaccard (1973) and Wilson et al (1975) in various contexts. Finally, it should be noted that still other linear additive models have been applied successfully in such fields as decision theory, clinical judgment and marketing research (see e.g. Slovic and Lichtenstein, 1971; Wilkie and Pessemier, 1973). Examples include the ideal point model, which assumes that preference is inversely related to some (linear) function of the distance of an alternative from an individual's ideal point (e.g. Lehmann, 1971; Bass, Pessemier and Lehmann, 1972; Hudson, 1976), and the adequacy-importance model (Cohen, Fishbein and Ahtola, 1972), which is mathematically equivalent to expectancy models but differs from these models in that it substitute importance for evaluation in the measurement of the values component and uses object dimensions rather than specific characteristics (Mazis, Ahtola and Klipper, 1975).

3.2. WEIGHTED AND UNWEIGHTED MULTIPLICATIVE MODELS

These models assume that an overall evaluation score is obtained as the (weighted) product of all evaluative values defined on the attributes. The weighted and unweighted multiplicative models can be expressed respectively as:

$$E_j = \prod_k e_{jk}^{w_k} \tag{5}$$

and

$$E_j = \prod_k e_{jk} \tag{6}$$

Note that if one of the e_{jk}-s is equal to zero, the overall evaluation score will also be zero. If, however, these values are greater than zero, compensation is possible. The weighted multiplicative model can be thought of as an compensatory approximation of the conjunctive model (Einhorn, 1970).

It should be noted that the additive and multiplicative models are two ends of the spectrum of multilinear models (Louviere, 1981) and that any combination of additive and multiplicative term may be used to estimate the overall evaluation score (e.g. Timmermans, 1980).

4. FINAL CONSIDERATIONS

The purpose of this paper has been to give a broad overview of compensatory and noncompensatory model structures which may be used to predict individual choice behaviour and/or individual preference structures. As fas as compensatory models are concerned this paper particularly attempted to point at alternative underlying theories, implying that geographical choice modelling no longer is dependent upon economic principles and theories. It should be evident that the various individual decision models outlined in this paper constitute a rich class of alternative model structures the characteristics of which might be more appropriate for particular choice problems than those of existing models. This is enhanced if it is realised that especially the compensatory models may be treated as models of preference orderings which may subsequently be linked to overt choice behaviour in a separate modelling step according to various deterministic and probabilistic choice rules, such as logit, general extreme value, probit and prominence choice model (see McFadden, 1973, 1978; Daganzo, 1979; Smith and Yu, 1982). Ultimately however the success of these model depends on their ability to predict overt choice behaviour. Hence, future research should solve the particular problems associated with estimating these desicion models and assess their predictive ability and generalisability in a variety of contexts. The author hopes to report on these issues in the near future.

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