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When should we use simple decision models? A synthesis of various research strands[☆]

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ABSTRACT

Many decisions can be analyzed and supported by quantitative models. These models tend to be complex psychologically in that they require the elicitation and combination of quantities such as probabilities, utilities, and weights. They may be simplified so that they become more transparent, and lead to increased trust, reflection, and insight. These potential benefits of simplicity should be weighed against its potential costs, notably possible decreases in performance. We review and synthesize research that has used mathematical analyses and computer simulations to investigate if and when simple models perform worse, equal, or better than more complex models. Various research strands have pursued this, but have not reached the same conclusions: Work on frequently repeated decisions as in inference and forecasting—which typically are operational and involve one or a few decision makers—has put forth conditions under which simple models are more accurate than more complex ones, and some researchers have proposed that simple models should be preferred. On the other hand, work on more or less one-off decisions as in preference and multi-criteria analysis—which typically are strategic and involve group decision making and multiple stakeholders—has concluded that simple models can at best approximate satisfactorily the more complex models. We show how these conclusions can be reconciled. Additionally, we discuss the theory available for explaining the relative performance of simple and more complex models. Finally, we present an aid to help determine if a simple model should be used, or not, for a particular type of decision problem.

1. Introduction: quantitative models for decision analysis and support

Few decision analysts today would blindly use quantitative models. And just as few would outright reject them. Models make clear that decisions consist of entities such as options, attributes of options, values of attributes, utilities of values, that tradeoffs may need to be made, that some options are dominated by others, and so on. Models may be used to derive initial solutions, which can then be accepted as they are or improved further, or be used to inspire other models and solutions.

Whereas some decision problems are so “wicked” [74], or “complex” and “chaotic” [33], that quantitative models cannot help, there are important decision problems to which models do apply: For example, personal choices can be supported by multi-attribute utility functions [53], credit scoring can be tackled by regression [86], and product demand can be forecasted by time series models [64].

An important practical difficulty is that decision makers often resist the models offered by decision theorists. It is not hard to see why: The models tend to be too complex psychologically, in the sense that they require the elicitation and combination of quantities such as probabilities, utilities, and weights. Even if software does most of the work, decision makers have reasons to feel overwhelmed or fail to understand the premises, concepts, and computations of the models.

Simplification holds a strong appeal for decision analysis and support. Trust in the decision process and opportunities for reflection and insight are critical elements of good decision analysis and support, and these elements are typically easier to achieve when decision makers understand the tools they are using. This favors the use of simple rather than complex models. But, of course, cau-

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tion is necessary: One can go too far and oversimplify. The potential benefits of simplicity, such as increased transparency, trust, reflection and insight, should be weighed against its potential costs, notably possible decreases in performance.

In considering the role of quantitative models—simple or not—for decision analysis and support, it is important to recognise the diversity of problem settings to which these models may be applied. The following categories are near the ends of a spectrum of these settings.

(1) Frequently repeated decisions, typically operational, involving one or a few decision makers. Examples include predicting consumer choice behaviour and credit scoring.
(2) More or less one-off decisions, typically strategic, involving group decision making and multiple stakeholders. Examples include deciding the amount of corporate investment in a new production facility and its location.

The first of the above two categories is allied to statistical models for prediction or forecasting of the future. This is self-evident in problems of consumer choice behaviour, but it is also relevant in a mode of analysis and support, as in credit scoring. Although a credit scoring model may initially be viewed as an aid to decisions regarding whether or not to grant credit, it may also be seen as predicting what a well informed and experienced expert would decide. It is possible to compare recommendations of the model with a set of expert evaluations, which establish a kind of ground truth.

In the second of the two categories, however, there is no clear means of establishing a ground truth in order to test and validate a quantitative model. Experience with problems of the first category may provide some basis for adopting particular models in the second category, but caution is needed as there are no repeated trials to compensate for one decision being wrong.

Even though we recognise that many decision problems will not fall at either extreme, here we examine the potential of simple decision models in exactly these two categories. Additionally, we make a distinction between problems of repeated operational decisions, involving (*i*) inference; that is, determination of the category of an option—as when classifying a customer as active or not—or some other characteristic of an option, and (*ii*) forecasting; that is, predicting the worth or value of a decision option—such as a company's stock—in the future, as this reflects a divide often encountered in the literature. Thus, we consider three research strands: *inference, forecasting*, and *strategic* decision making.

The authors of this article are decision modelers who have, for the most part, worked on a single one of the strands. We essentially used the same formal methods and often tested the same simple models, such as equal weighting of attributes or sequential processing of attributes [44]. But we have not arrived at the same conclusions. And, the conclusions of the third strand were different as well. As we scanned the academic literature, we realized that this is a general issue and there is not much communication among the inference, forecasting, and strategic decision making strands. Analogously, our consulting experiences suggest that practitioners have diverse impressions.

We acknowledge that the formal research from which we draw here does not so much speak to how models fare on dimensions such as transparency and insight, and thus cannot provide a full answer to which models should be used in practice [27]. In a sense, this work contributes more to normative rather than to prescriptive knowledge about decision models [10,81]. We believe, however, that such research is key for deciding whether or not to use simple models in practice. If simple models perform equally well or better than more complex models, then it seems that they should be employed (assuming, as it might seem reasonable to do, that they fare better on dimensions such as transparency and insight).

Our article has three main goals. The first is to review in one place the main empirical findings of mathematical and simulation research on the relative performance of simple and complex decision models, and to synthesize those findings. Our synthesis reveals that the conclusions of the various strands can be reconciled. The second goal is to reflect on the theory available for specifying *a-priori* if simple or complex models should be preferred for a particular decision problem. Our third goal is to translate the available theory to an aid to help determine if simple models should be used, or not, for a particular decision problem.

The remainder of the article is structured as follows. Sections 2 and 3 review material on the performance of simple decision models for inference and forecasting, and strategic decision making respectively. In order to speak to a broad audience, the treatment is not mathematical, but we have strived to remain precise. We provide just a limited amount of technical detail. Notably, we refrain from providing a technical definition of simplicity—which is indeed a thorny issue [22]—and confine ourselves to just labelling nested versions of models as simpler than the original models. Section 4 summarizes common elements and reconciles apparently contradictory findings from the research strands. Section 5 discusses the theory available for explaining the relative performance of simple and more complex models. Based on this theory, Section 6 presents an aid that can be used to help determine if a simple model should be used, or not, for a particular type of decision problem.

2. Simple models for repeated operational decisions

2.1. Inference

As indicated previously, repeated operational decisions are closely linked to statistical prediction. A typical empirical study of simple inference models is the following.

In a project sponsored by the Bank of England, Aikman et al. [5] considered the problem of predicting which of the 118 global banks that had at least 100 billion USD in assets at the end of 2006, went bankrupt during the financial crisis and which did not. After the fact, it is known that 43 banks failed and 75 banks survived the crisis (for definitions of bank failure, see [58]). For each bank, the authors gathered data on a number of economic indicators, such as leverage ratio (i.e., the proportion of a bank's capital that is not based on debt), the amount of wholesale funding (e.g., government or public funding), and so on. In decision analysis jargon, these indicators would be called attributes, and they would be called predictors in statistics, features in artificial intelligence, and cues in psychology.

The research problem is how to mathematically combine the available attributes in order to predict bank failure reasonably well. A standard macro-economic solution is to use logistic regression [58]. In order to keep the model tractable, the four most statistically informative attributes were used. The authors compared the performance of logistic regression with that of a family of simpler models, *fast and frugal decision trees*. An example of a fast and frugal decision tree, developed based on economic intuition by some of the authors, is depicted in Fig. 1: Instead of always trading off all four attributes to categorize a bank, this simple tree goes through attributes one at a time, asks a binary question on each attribute's value, where for each question there is a possible answer that allows a decision to be made so that the process terminates. More generally, such models are also *lexicographic.* Because the tree is intended as a decision support tool for financial regulators, it does not assign a bank to a "fail" or "survive" category, but rather suggests whether a bank is at a risk for failing

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