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Target oriented multiattribute group decision making approach and application in hydroelectric project evaluation

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Abstract

We consider a group decision problem which decision maker is target oriented and value of alternatives' attributes is random variable. According to different type of targets, we propose a corresponding aggregating approach of group preference based on maximizing target expected utility. First, we translate the uncertainty of attributes' value and decision makers' targets into target oriented expected utility. Second, we obtain the preference of each decision maker by the utility function. Then, a linear approach is used to aggregate experts' preference into a group target expected utility. After that, rank of alternatives is determined by their utility. Finally, an example shows the feasibility and effectiveness of the proposed approach.

Keywords: Target based decision making; multiattribute decision making under risk; group decision; utility functions

1. Introduction

Multiattribute decision making under risk is an important type of multiattribute decision making under uncertainty. It has caused more and more research interests recently due to its great application prospect in economic and management practices such as new products research and development, investment project evaluation, environment risk forecast and so on (Stewart (2005), Yao and Yue (2005)). The main features of this type of decision making problems are as follows. First, alternatives' attributes or decision makers' preferences are random variables. Second, decision makers are unsure about what will happen in the future exactly. They can only figure out all situations that may happen and quantize the stochastic by probability distribution function (Yao and Yue (2005)). So far, researches about group decision making under risk are mainly based on two theories, i.e. expected utility theory and experts' judgments aggregation theory (Clemen and Winkler (1999)).

Since Kahneman (1979) proposed prospect theory, the rise of behavioral decision theory has questioned expected utility theory. Decision making take behavioral factors into consideration has attracted some scholars' attention (He and Zhang (2011), Hu et al. (2011)).. Against the limitation of expected utility theory, LiCalzi et al. (2000) proposed target oriented decision making approach based on their theoretical derivation and experimental research. This approach not only meets the main axioms of utility theory, but also has a good interpretation of prospect theory and cumulative prospect theory. It provides a new insight to risk decision making problem. The current researches about target oriented decision making mainly focus on single decision maker facing determinate targets and the equivalence of decision making approach based on target oriented theory and expected utility theory (Bordley and LiCalzi (2000), Bordley and Kirkwood (2004), Tsetlin and Winkler (2006)). Some literatures are written about the application of target-based decision making approach in specific projects (Sener (2012), Huynh et al. (2010)).

2. Target oriented multiattribute decision

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Let X_d be a stochastic outcome of action d and P_d be the probability density function of that outcome. Expected utility theory indicates alternatives can be ranked by their utility function as equation (1),

$$v(d) = EU(X_d) = \sum U(x)P_d(x) \quad (1)$$

where $U(x)$ is the von NM utility function. While, the utility function of target oriented decision making is as follows,

$$v(d) = P(X_d \succeq T) = \sum P(x \succeq T)P_d(x) \quad (2)$$

where, $P(X_d \succeq T)$ is the degree that X_d satisfies the target T. Suppose T and x_d are independent then $P(X_d) = \sum P(x \succeq T)P_d(x)$, where $P(x \succeq T)$ is the possibility that random variable x satisfies the target and $P_d(x)$ is probability density function of action d. If $U(x) \equiv P(x \succeq T)$, we say that decision making approach based on target oriented theory and those based on expected utility theory are equivalence. However, it can be saw from equation (2) that target oriented decision making approach is a more intuitive way than those based on expected utility theory as it only ask decision makers for their targets and the possibility of achieving it.

2.1. Basic Conception (Bordley and Kirkwood (2005))

Suppose a group decision making problem has n attributes, m experts and s alternatives. x_{ia}^{kj} denotes the value of attribute i of alternative a given by expects j.

Definition 1 Suppose an alternative has n attributes denoted by $\mathbf{X} = (X_1, X_2, ..., X_n)$. Decision makers have their own target for each attributes which is deterministic or stochastic. For an alternative $\mathbf{x} = (x_1, x_2, ..., x_n)$, if decision makers' preferences are affected by the degree of satisfaction to their targets, then we say that they are target oriented decision makers. Especially, they are totally target oriented if their utilities are only determined by satisfaction degree.

Target oriented decision makers' preferences on attributes x_i are presented by utility function $u(x_{it}; x_{ia})$, where x_{it} denotes the target of decision maker on x_i. $u(x_{it}; x_{ia})$ can be either simple (such as when $x_{ia} \geq x_{it}$, $u(x_{it}; x_{ia})$ equals to 1, and zero otherwise) or complicate, which is depend on the complexity of decision problem and risk preference of decision makers.

Definition 2 If decision makers consider probability thatan attribute i is greater than its target merely depend on x_i rather than other attributes or targets, we say that the decision makers have independent target.

Definition 3 If the utility of a decision maker with independent target is either 1 when target is achieved or 0 when target is not achieved, then we say that the decision makers have reliable target structure.

Definition 4 Let $\mathbf{x_a} = (x_{1a}, x_{2a}, \ldots, x_{na})$ be the attribute set of the decision problem, $u(x_t, x_a)$ denotes the decision makers' utility function with target $\mathbf{x_t} = (x_{1t}, x_{2t}, \ldots, x_{nt})$, and the probability for $x_a \geq x_t$ is denoted as $f_{t,a}(x_t; x_a \mid a)$. Then expected utility of an alternative with multiattribute is as follows:

$$E(u \mid a) = \int_{-\infty}^{\infty} ... \int_{-\infty}^{\infty} u(x_t; x_a) f_{t,a}(x_t; x_a \mid a) dx_t dx_a \quad (3)$$

Suppose utility for each attribute is independent and additive, weighted sum of all attributes' target oriented utility is denoted by $u(x_t, x_a)$ as follows,

$$u(x_t, x_a) = \sum_{i=1}^{n} \omega_i u_i(x_{it}, x_{ia}) \quad (4)$$

where ω_i stands for the weight of attribute i. Suppose x_{ia} and x_{it} are independent then $f_{t,a}(x_t; x_a \mid a) = f_{ia}(x_{ia} \mid a) \cdot f_{it}(x_{it})$. Expected utility based on target in equation (3) can be rewritten as follows:

$$E(u \mid a) = \sum_{i=1}^{n} \omega_i \int_{x_{ia}=-\infty}^{\infty} f_{ia}(x_{ia} \mid a) \cdot \int_{x_{it}=-\infty}^{\infty} u(x_{it}, x_{ia}) f_{it}(x_{it}) dx_{it} dx_{ia} \quad (5)$$

2.2. Target type and corresponding utility function