PROMETHEE

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INTRODUCTION

PROMETHEE (**p**reference **r**anking **o**rganization **meth**od for **e**nrichment **e**valuation) introduced in Brans, Mareschal, and Vincke (1984) and Brans, Vincke, and Mareschal (1986), is a multi-criteria decision support tool for the ranking of alternatives based on their values over different criteria. As an outranking method, it quantifies a ranking through the pairwise preference comparison (differences) between the criterion values describing the alternatives.

The main initial goal of PROMETHEE was to offer a means of multi-criteria decision support characterised by simplicity and clearness to the decision maker (Brans et al., 1986). PROMETHEE is also considered to have a transparent computational procedure (Georgopoulou, Sarafidis, & Diakoulaki, 1998). These characteristics of PROMETHEE have made it a versatile methodology in many areas of study, including in particular energy management (Pohekar & Ramachandran, 2004; Simon, Brüggemann, & Pudenz, 2004), but also more diverse areas such as decision making in stock trading (Albadvi, Chaharsooghi, & Esfahanipour, 2006) and authentication of food products (Zhang, Ni, Churchill, & Kokot, 2006).

Developments on the original PROMETHEE include: an interval version (Le Téno & Mareschal, 1998), a fuzzy version (Radojevic & Petrovic, 1997), and a stochastic version (Marinoni, 2005), as well as its utilisation to elucidate rank uncertainty (Hyde, Maier, & Colby, 2003). These developments have been undertaken to take into account the possible imprecision and distribution of the concomitant criteria values considered. The graphical bi-plot representation called GAIA (geometrical analysis for interactive aid), based on a special type of principal component analysis, was developed to identify the principal criteria that contribute to the rank order of the alternatives when using PROMETHEE (Keller, Massart, & Brans, 1991). Recently, the use of constellation plots has also enabled a visual representation of the preference contribution of the criteria (Beynon, 2008).

Concerns and consequences on the use of PROMETHEE were succinctly outlined in De Keyser and Peeters (1996), including how the importance weights of criteria should be interpreted and the effect of adding or deleting an alternative from consideration. A small example data set of alternatives is considered here to illustrate the operational rudiments of PROMETHEE. The acknowledgement of uncertainty in an identified ranking, when employing PROMETHEE, is also demonstrated, using the approach of Hyde et al. (2003) and Hyde and Maier (2006).

BACKGROUND

This section outlines the rudiments of PROMETHEE, which identifies a preference rank order of alternatives, based on their values over a number of different criteria. To express the preference structure of alternatives and to withdraw the scaling effects of the K criteria considered ($c_1, \ldots, c_K$), with PROMETHEE, generalised criterion preference functions $P_k(\cdot, \cdot)$ ($k = 1, \ldots, K$) are defined. Each is a function of the difference between criterion values of pairs of alternatives (from $a_1, \ldots, a_N$), where $P_k(a_i, a_j) \in [0, 1]$ confers the directed intensity of the preference of alternative a_i over a_j, with respect to a single criterion c_k. The often exposited qualitative interpretations to the $P_k(a_i, a_j)$ values are (see Brans et al., 1986):

$P_k(a_i, a_j) = 0 \Leftrightarrow a_i$ is not better than a_j with respect to criterion c_k
$P_k(a_i, a_j) \sim 0 \Leftrightarrow a_i$ is 'slightly' better than a_j with respect to criterion c_k
$P_k(a_i, a_j) \sim 1 \Leftrightarrow a_i$ is 'strongly' better than a_j with respect to criterion c_k
$P_k(a_i, a_j) = 1 \Leftrightarrow a_i$ is 'strictly' better than a_j with respect to criterion c_k

These qualitative interpretations highlight that at least one of the values $P_k(a_i, a_j)$ and $P_k(a_j, a_i)$ will be zero, depending on whether a_i or a_j is the more preferred between them (then $P_k(a_j, a_i)$ or $P_k(a_i, a_j)$ will be zero respectively). Expressing the $P_k(a_i, a_j)$ by:

$$P_k(a_j, a_i) = \begin{cases} \mathrm{H}(d) & a_i - a_j > 0 \\ 0 & a_i - a_j \le 0 \end{cases}$$

where $a_i - a_j > 0$ and $a_i - a_j \le 0$ refer to whether a_i or a_j is the more preferred on that criterion (taking into account the direction of preferment of the individual criterion values), and where $d = v(a_i) - v(a_j)$ is the difference between the criterion values of a_i and a_j. The extant research studies have worked on the utilisation of six types of generalised preference functions for H(d). While true, the preference function of each criterion is determined mostly through the nature of the criterion and the associated decision-maker's viewpoint (see for example Albadvi et al., 2006). Their names, labels (required parameters), and graphical representations are given in Box .1

The augmentation of the numerical preference values throughout the operation of PROMETHEE is described through the notion of flows. A *criterion flow* $\phi_k(a_i)$ value for an alternative a_i from a criterion c_k can be defined by:

$$\phi_k(a_i) = \sum_{a_j \in A} \{P_k(a_i, a_j) - P_k(a_j, a_i)\}$$

$$\left(= \sum_{a_j \in A} P_k(a_i, a_j) - \sum_{a_j \in A} P_k(a_j, a_i) = \phi_k^+(a_i) - \phi_k^-(a_i)\right),$$

where A is the set of N alternatives considered ($a_1, \ldots, a_N$), it follows $-(N-1) \le \phi_k(a_i) \le N-1$ and

$$\sum_{a_i \in A} \phi_k(a_i) = 0$$

(the bounds are due to not normalising by $(N-1)$ which may be done). In words, a criterion flow represents the preference of an alternative over the other $(N-1)$ alternatives, with respect to a single criterion. The bracketed expressions show how the criterion flow values can be partitioned in some way (see later in this section). A subsequent *net flow* $\phi(a_i)$ value is defined by:

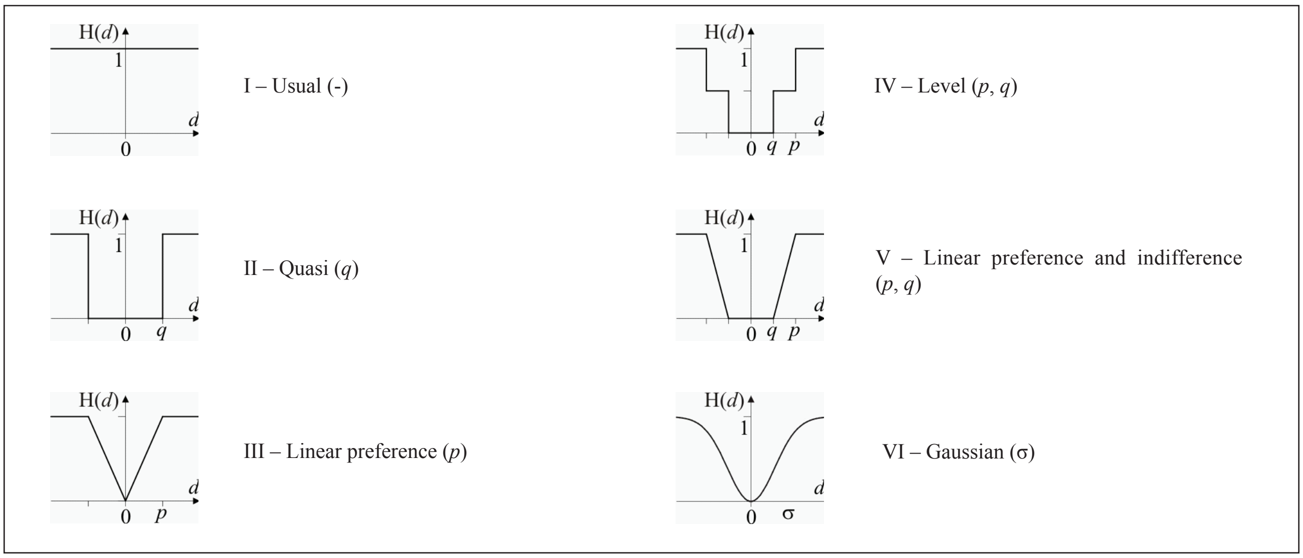
$$\phi(a_i) = \sum_{k=1}^{K} w_k \phi_k(a_i)$$

$$\left(= \sum_{k=1}^{K} w_k \phi_k^+(a_i) - \sum_{k=1}^{K} w_k \phi_k^-(a_i) = \phi^+(a_i) - \phi^-(a_i)\right),$$

where w_k, $k = 1, \ldots, K$, denotes the relative importance of the criterion c_k (the criteria importance weights). The magnitudes of the net flow values exposit the relevant rank order of the N alternatives. The higher an alternative's net flow value, the higher its rank position.

The term net flow is one of a number of terms used in PROMETHEE, including total flow (Olson, 2001), and can similarly be partitioned into separate $\phi^+(a_i)$ and $\phi^-(a_i)$ values (as shown in the sequel of this section). This partitioning has also been described in a number

Box 1. From Brans et al., 1986



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