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Incorporating the status quo effect into the decision making process: The case of municipal companies merger

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ABSTRACT

Decision-making for cooperation between municipal entities involves elected members serving public interest who argue in both quantitative (e.g. financial performance), and qualitative (e.g. social acceptance) grounds. Policy support should consider conflicting objectives in a context of uncertainty and imprecision as well as in presence of organizational lock-ins that tend to favor incumbent arrangements. In search of appropriate algorithm to support decision making in such cases we opted for the PROMETHEE outranking method integrating novel findings of behavioral theory. Thus its preference functions are specified so that they reflect bounded rationality that shapes risk attitudes of decision makers within the uncertain environment of public management. Moreover alternative weighting procedures have been applied for group decisions. The prospect theory multi-criteria methodology, termed PT-PROMETHEE is implemented relating proposed options to observed behavior providing useful insights especially regarding status quo options also allowing for sensitivity analysis. Thus acceptance of MCDM support by the stakeholders is enhanced leading to solid compromise institutional arrangements.

1. Introduction

In the present paper, the selection of the best form of cooperation of municipal companies is investigated in the context of decision theory and multi-criteria decision aid methods. On the one hand, a holding company comprises municipal entities dealing with the supply of heat energy, public transport and water supply systems additionally operating a waste incinerator. Another municipal company that only deals with waste management is independent of the holding company. With a view to making the waste management process more effective, the question arose as to whether a takeover of the independent waste management company by the holding company would be worthwhile or it would be preferable to stick to the current situation. The criteria influencing the adoption of alternative solutions include formal and legal aspects, taxation aspects, financial analyses, environmental concern, social aspects and the previous experiences of the companies, in other words both quantitative and qualitative measurements are present in the decision problem.

Sauter [1] developed a framework for the study of mergers in the public sector at a time when the literature on organizational mergers primarily focuses on for-profit corporations criteria for mergers. The author observes that many of the goals for the merger among private companies are similar to those in the public sector nevertheless the trade-offs are not the same. Public agencies' mergers are in general supposed to benefit the citizens whereas they only assume the costs, moreover costs and benefits that need to explicitly be accounted for fall into a much wider range than in the case of corporations due to the multi-perspective nature of the problem. Then examining alternative degrees of merger cost-benefit analysis (CBA) is performed [1] investing a lot of effort to evaluate especially the non-economic relative cost and benefits. With the development of multicriteria decision analysis in the 80's and its extensive use in management and policy problems, CBA is complemented and eventually replaced by multi-criteria analysis (see Marleau-Donnais et al. [2] for a review). Multicriteria decision analysis (MCDA) techniques are capable of broadening the strict boundaries of a financial and cost-benefit analysis including criteria whose performance

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cannot be monetized while avoiding intuitive solutions that are often applied in practice [3]. According to Haastrup et al. [4], taking several individual criteria into account in a multidimensional manner leads to more rational decision-making than the optimization of a single-dimensional objective function (such as the CBA), when selecting Municipal Sewage Waste Management options. Another merit of MCDA approaches is pointed out in the comparative analysis by Tudela et al. [5].

Although the outcome of the multi-criteria method did not match the one suggested by the cost benefit analysis, it did match the final decision by the authority. This is a very important statement that reveals the explanatory power of the MCDA capturing various dimensions of the decision problem. In modelling terms this refers to the model validation stage when the analyst checks whether the model is able to reproduce observed decisions.

The complexity, the scope and vagueness of strategic decisions such as mergers, acquisitions and joint ventures have a strong effect on firm performance. In order to be successful in highly competitive environments sophisticated methods of MCDA are required such as in the case of a multinational consumer electronics company where the weights of the factors are determined by interval type-2 Fuzzy Analytic Hierarchy Process (AHP) and then the best strategy is selected by Hesitant Fuzzy TOPSIS [6]. PROMETHEE methodology can also accommodate those concerns, in fact several recent publications focus on cases of public administration and governance as in education [7] in healthcare [8] and in energy management in municipal properties [9].

PROMETHEE method is one of the most commonly used methods of all the multi-criteria decision aids as it can accommodate both semi-aggregation (PROMETHEE I) and full aggregation (PROMETHEE II). It constructs an outranking relation via pairwise comparisons of alternatives for each separate decision-making criterion. PROMETHEE methodology produces enriched preference structures, making it suitable for handling uncertainty and the effect of heuristics through generalised criteria which delimit indifference and preference areas as well as intermediate preference states.

In the public and municipal administration context, often organizational culture prevents or delays management decisions. Thus the status quo becomes a powerful alternative depending on the depth of incumbency in the socio-technical system. Moreover decision makers value differently losses and gains with regard to the reference option. Advances in behavioural economics reflect such peculiarities. Complementing expected utility theory, prospect theory was developed by Kahneman and Tversky [10] from the cognitive psychology literature describing effective decision making behaviour. Through its focus on how people think when faced with lotteries, prospect theory has provided a descriptive model which is able to reproduce real-life choices, and has shown that people over-evaluate losses compared to gains and most often remain to business as usual. A strand of literature has recently introduced prospect theory elements into the PROMETHEE algorithm [11–13] or inspired to develop alternative method [14].This latter has triggered a large number of subsequent publications culminating in recent methodological novelty [15]. Because it reduces the preference function options to one, we opted for the adoption of the typical PROMETHEE algorithm as basis that allows for six different preference functions. Following the former track, we have modified the PROMETHEE method using: (1) the status quo as a reference point, and; (2) preference functions modified with regard to loss aversion in the making of pairwise comparisons where the first alternative is a reference point. Integrating prospect theory with PROMETHEE method introduces an empirical element to its normative nature enabling analysts to simulate behaviour and bring about prescriptive models. This allows rational governance approaches to take the inertia inherent in the decision-making rationale of stakeholders into account when seeking to implement better decision-making processes, and when formulating alternative actions, in institutional and legal settings. This is particularly important because proposing unrealistic and unsustainable alternatives and criteria discredits the methods and processes used to formulate the proposals.

The adoption of MCDA by policy makers is a relatively recent phenomenon [16], and therefore improving commonly used decision-making methods may result in better decision-making and subsequently in evidence-based policies. Conventional and prospect theory approaches are implemented in light of the case study so that to enrich the decision process, and their results are presented against each other to enhance discussion in light of different ranking of the alternatives. At present, the literature appears to contain few such attempts [11–13], and none specifically relating to the area of business cooperation and industrial symbiosis.

The first section provides an overview of the literature on the use of PROMETHEE method in management decisions. Particular attention is paid to the process of managing company change and the status quo effect, which is prominent in this context. The status quo effect is also discussed in the context of economic psychology theories. Subsequently, the PROMETHEE algorithm is presented in detail in a methodology section followed by algorithms for determining the preference structure. And then implementation of the MCDA method and its results with respect to the case study based on extensive information from the municipality of Krakow illustrates the impact of the status quo effect on a final ranking derived within the framework of the modified PROMETHEE. Finally, results are commented and discussed and conclusions are drawn.

2. Literature review

2.1. Multicriteria analysis methods

Roy [17] defines the most common types of problems dealt with multi-criteria decision aid (MCDA) as choice problems (selecting the best action), ranking problems (placing all alternative actions into a complete or partial order) and sorting problems (sorting actions into predefined ordered categories). The sub-area of the methodology dealing with discrete sets of alternatives is termed multi-attribute decision making (MADM), while the sub-area dealing with continuous sets of alternatives is termed multi-objective decision making (MODM). The former consists of two major schools: proponents of utility function methods and proponents of outranking methods [18], with Matarazzo [19] proposing a compromise mixed method developed using the framework of the pairwise criterion comparison approach (PCCA) [20]. Due to their adaptability to the relatively poor structure of most real-world decisions, outranking methods have developed rapidly during the last decade. Where cardinal information about the evaluation of alternative choices is available, decision makers can choose between full and semi-aggregation. The traditional weighted sum method and the hierarchical analytic hierarchy process method (AHP) [21,22] identify to full aggregation ranking alternatives at complete pre-order. AHP is one example of methods that aggregate different criteria to form a single optimized function within multi-attribute utility theory; the so-called American school [23]. This approach is rooted in multi-attribute utility theory (MAUT) which was introduced by Fishburn [24], Keeney [25–27], and Keeney, Raiffa and Rajala [28]. In addition to AHP, other popular methods exist such as the analytic network process (ANP) introduced by Saaty [29] and the utility additive (UTA) method introduced by Jacquet-Lagreze and Siskos [30,31]. These methods belong to the so-called European school and are based on the bilateral surpassing of relationships for all criteria, where in many cases a partial pre-order revealing incomparability of alternatives and ex aequo may be preferable and leave room for semi-aggregation methods [32]. The two most popular methods in this group are elimination and choice expressing reality (ELECTRE; [18,33]) and the preference ranking organization method for enrichment of evaluations (PROMETHEE; [34,35]).

Since the publication of the seminal paper in the eighties [30], numerous applications have been reported in the literature [36], these

being in fields such as environmental management, hydrology and water management, business and financial management, chemistry, logistics and transportation, manufacturing and assembly, energy management, socio-economics, medicine, agriculture, education, design, government and sports. With respect to the present topic, PROMETHEE method has been extensively implemented to evaluate the financial performance of private enterprises [37], cooperatives [38] and microfinance [39], the latter currently being a hot topic in developing countries and China [40]. Specific issues in the area of finance, such as portfolio selection [41] and the advancement of public-private partnerships [42], have triggered methodological improvements of the original method.

2.2. Using PROMETHEE method in business transformation processes

The literature contains a number of cases where PROMETHEE method has been used in corporate management settings. For example, it has been employed to choose a system for planning a company's resources (enterprise resource planning: ERP) and to integrate organizational units providing significant information for a company [43]. The appropriate implementation of ERP is important because it has a major impact on a company's competitiveness and efficiency [44]. In creating a framework to identify an optimal ERP system, PROMETHEE methodology is used to extend and supplement criteria weight assessment methods such as the analytic network process (ANP) [43] and stepwise weight assessment ratio analysis (SWARA) [44] by enriching alternative preference rankings.

PROMETHEE method is also used in the making of decisions relating to venture capital financing of business start-ups [45], and can be used in the process of using multiple criteria to choose finance methods at the early stage of a company's operations where political and social factors are involved. This facilitates the assessment and identification of promising information technology start-ups and in areas identified as being of high priority by governments of developing countries. With regard to venture capital, a decision-making process based on a large number of (sometimes subjective) criteria can be distorted, and here a framework created using PROMETHEE method can constitute a tool for selecting the best candidates [45].

Another example of the use of PROMETHEE method is presented by Athawale and Chakraborty [46]. This example involved the economic justification of the location of a complex of industrial facilities. Decisions concerning the location of facilities play a crucial role in production companies' long-term planning. The choice of a location has to be based on a number of criteria, and failure to meet these criteria can result in lack of access to raw materials, inadequate transport infrastructure, and, consequently, increased operating costs and negative consequences with respect to political and social factors. Moreover, the decision-making process in question involved a number of alternatives, and the selection of relevant criteria required compromises relating to the significance of various factors [46].

Many authors have stressed the potential of PROMETHEE method because it can provide solutions to decision problems characterised by a large number of frequently contrary criteria and alternatives (see Refs. [46–48]). The use of MCDA methods is valuable in the financial sector, for example, when evaluating the financial stability of commercial banks where decreasing information asymmetry is a feature of the market. Here, the results of such evaluations provide a suitable level of comprehension for depositors and at the same time allow decision makers to obtain adequate perceptions of a bank's financial stability using many criteria [49]. In this evaluation of the stability and soundness of commercial banks PROMETHEE methodology was used, including preference functions and the parameters of them chosen by decision makers [50]. Finally, multi-criteria decision aid tools have also been used to evaluate the financial performance of companies, such evaluations consisting of accounting measures and economic value measures [51].

2.3. Disturbing the status quo: the process of change

According to Drucker [52], systematic economic or social change requires a purposeful and organized search for changes and a systematic analysis of opportunities for implementing the changes. Changes to the existing order in an organization frequently cause concern among employees, leading to their resistance and stress. Change is often identified with a crisis which disturbs an organization's functioning, interpersonal relationships, communication and leadership [53]. Many definitions of change point to one significant common aspect: the introduction of change to an organization is conditioned by the organization's psychosocial characteristics and the value systems of its members. Social barriers are crucial, these resulting from resistance to change caused by psychological and awareness barriers, i.e. a lack of understanding of the need for change [54]. According to the Satir Change Model [55], in the face of change, people seek to maintain the status quo: the state of affairs which is a familiar and repeated component of everyday life. When people encounter unfamiliar things, i.e. change factors, chaos appears, this is a stage of rejection, and people act to maintain the status quo for as long as possible [56]. According to Kurt Lewin's force field theory, any change involves driving and restraining forces. Acts aimed at introducing change lead to behaviour which seeks to maintain the status quo and resist the new behavioural patterns desired. Increased pressure for change is accompanied by greater resistance to change. Activities which aim to implement a process of change should take into account the fears and concerns of the people affected so that changes can be implemented in an effective way [57].

2.4. The status quo in economic psychology

Prospect theory by Kahneman and Tversky [10] is a descriptive theory that explains the process of decision making under conditions of risk. It is widely used in management research, focusing primarily on research in strategic management and organisational behaviour or human resource management (see Holmes for a review [58]). Kahneman and Tversky [10] introduced a value function which is defined with respect to a reference point for gains and losses, and which is much steeper for losses than for gains. Tversky and Kahneman [59] proposed the following analytical form of the value function $v(x) = \begin{cases} x^{\alpha}, & x \geq 0 \\ -\lambda(-x)^{\beta}, & x < 0 \end{cases}$ with coefficients $\alpha = \beta = 0.88$ and a loss aversion

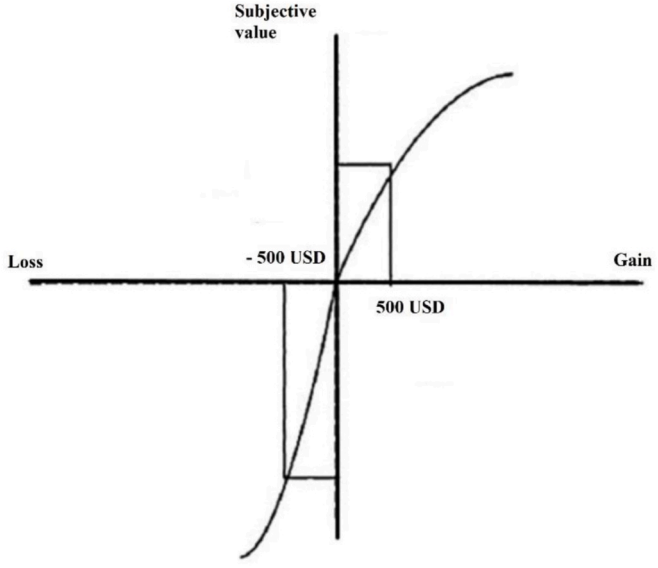

Fig. 1. The value function under prospect theory.
Source: Based on Tversky and Kahneman (1992).

coefficient of λ = 2,25. This function presented in Fig. 1

In our later analysis we will refer to the linear piecewise function $v(x) = \begin{cases} x, & x \geq 0 \\ \lambda x, & x < 0 \end{cases}$. Due to the loss aversion (measured by λ = 2,25), the magnitude of the subjective positive value of a potential loss of $500 is greater than the subjective negative value of a potential gain of $500. If a decision maker considers alternatives other than the status quo (which is their reference point), then the pain associated with potential losses is more than twice as great as the satisfaction associated with potential gains. In this way, fear of change and attachment to a current situation cause the status quo effect [60].

Samuelson and Zeckhauser [61] identified a status quo effect using a questionnaire survey where subjects made choices between alternatives with and without an existing status quo position. An example of decision scenario without an existing status quo position was as follows: "You are a serious reader of the financial pages but until recently you have had few funds to invest. That is when you inherited a large sum of money from your great-uncle. You are considering different portfolios. Your choices are to invest in a moderate-risk company, a high-risk company, treasury bills, or municipal bonds." Other subjects were given the same problem wording but with a status quo option: "A significant portion of this portfolio is invested in a moderate-risk company… (The tax and broker commission consequences of any changes are insignificant.)". Subjects tended to remain with the status quo when such an alternative was offered.

Samuelson and Zeckhauser [61] pointed out that a status quo effect, that is consistent with loss aversion, can be psychologically explained by previously made commitments, a sunk cost effect or need for control, and avoidance of regret. The tendency to stick to choices that have worked in the past is a common bias, and McClelland, Liang and Barker [62] have shown that CEOs can be prone to this bias. McClelland et al. [62], provided evidence that CEOs' commitment to the status quo is of a multilevel nature and includes factors at an individual level (a CEOs' age and tenure), an organizational level (size and financial leeway), and an industry-specific level (the extent of an industry's discretion). This has been shown by content analyses of CEOs' letters to shareholders. Finally, it is important to note that reference dependency and loss aversion elements have been incorporated into PROMETHEE methodology to analyse the impact of the status quo effect for different groups of people making decisions regarding agricultural practices in Poland [12].

3. Methodology

In the present case study an integrated approach to decision-making problems is followed, this combining an ad hoc approach which facilitates the ranking and weighting of criteria by pairwise comparison [63], and which then conveys these preferences to a PROMETHEE algorithm that generates a final selection for the decision maker. Thus, decision support for the merger of the two municipal companies involved is performed by means of multi-criteria techniques. Behavioural theory is then used to simulate observed behaviour and to explore various decision processes, with the focus being on inertia with regard to the current situation (the status quo). The methodological sequence is detailed in five steps:

(1) The selection of objectives or attributes and their related indicators;
(2) The selection of criteria and determination of the relative importance (weights) of the indicators selected;
(3) Allocation of values to alternatives representing their effects on them;
(4) Processing of the values to identify global performance and rank the alternatives;
(5) Sensitivity analysis and investigation of alternative decision processes.

3.1. An overview of the PROMETHEE algorithm

Multiple criteria decision aid (MCDA) methods are used mainly for discrete problems with small sets of alternative actions, where constraints are implicitly taken into account by means of the criteria used to select alternatives. Among MCDA methods which require cardinal information from a decision maker, outranking methods [18] have seen an increasing amount of development during the last decade because they can be adapted to the poor structure of most real-world decision situations. PROMETHEE method entails the construction of an outranking relation through pairwise comparison of decision alternatives on each separate criterion [35]. By introducing several types of criteria, PROMETHEE method produces more enriched preference structures than previous similar methods such as ELECTRE, and is therefore suitable for handling the uncertainty and/or imprecision that characterises ill-structured problems. It proposes six types of generalised threshold for criteria (or unique values for choosing between indifference and preference) used to delimit indifference and preference areas, as well as intermediate preference states.

The algorithm used in PROMETHEE and presented by Mavrotas and Rozakis [64] can briefly be described as follows: Let N be the set of alternatives and M be the set of criteria. A preference function is defined through pairwise comparison of the alternatives for each criterion j as:

$$P_j(N \times N) \rightarrow 0, 1 \quad j \in M \tag{2}$$

For two alternatives a and b in N we have:

$P_j(a,b) = 0 \Rightarrow$ Indifference between a and b for the j-th criterion
$P_j(a,b) \sim 0 \Rightarrow$ Weak preference of a over b for the j-th criterion
$P_j(a,b) \sim 1 \Rightarrow$ Strong preference of a over b for the j-th criterion
$P_j(a,b) = 1 \Rightarrow$ Strict preference of a over b for the j-th criterion

The preference function is a non-decreasing function of the difference d_j between the performances of the two alternatives on j-th criterion:

$$d_j = \begin{cases} p_{aj} - p_{bj} & if \quad p_{aj} \geq p_{bj} \\ 0 & otherwise \end{cases} \tag{3}$$

$$P_j(a,b) = f(d_j) \tag{4}$$

where p_{aj} and p_{bj} are the performances of alternatives a and b on j-th criterion. It should be noted that the above relationship holds if j is a maximization criterion; if it is a minimization criterion, the signs of p_{aj} and p_{bj} must be reversed and then Equation (3) must be applied.

Six types of functional forms are available (Fig. 2), their parameters being as follows: an indifference parameter (q), a strict preference parameter (p), and a gaussian parameter (σ). The type of functional forms for each criterion and the necessary parameters values (q, p or σ) are provided by the decision maker. A multi-criteria preference index of alternative a over alternative b is defined by weighting the calculated preference functions $P_j(a,b)$ according to the importance (w_j) that the decision maker attaches to each criterion as follows:

$$\Pi(a,b) = \frac{\sum_{j=1}^{m} w_j \times P_j(a,b)}{\sum_{j=1}^{m} w_j} \tag{5}$$

where m is the number of criteria. The multi-criteria preference index $\Pi(a,b)$ represents the intensity of the preference for alternative a over alternative b as perceived by the decision maker. Repeating this procedure for every pair of alternatives gives an $n \times n$ matrix (n = number of alternatives, $n = card(N)$) containing all the multi-criteria preference indices $\Pi(j,k)$:

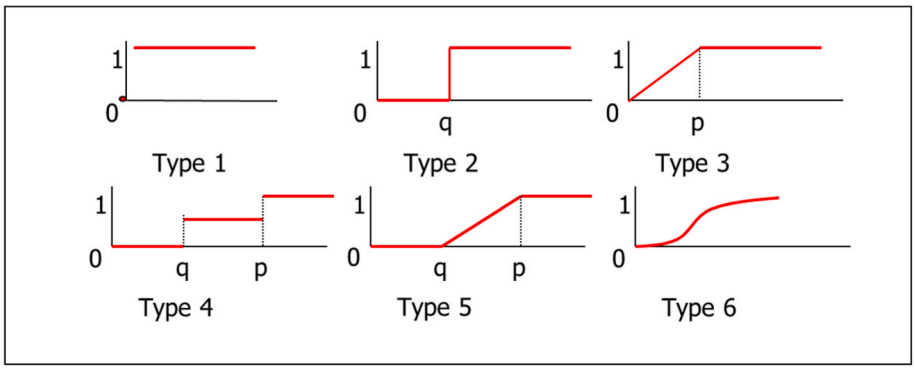

Fig. 2. Functional forms of preferences.
Source: Based on Figs. 1–6 of Brans and Vincke (1985).

$$\begin{bmatrix} - & \Pi(1,2) & \Pi(1,3) & \ldots & \Pi(1,n) \\ \Pi(2,1) & - & \Pi(2,3) & \ldots & \Pi(2,n) \\ \Pi(3,1) & \Pi(3,2) & - & \ldots & \Pi(3,n) \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \Pi(n,1) & \Pi(n,2) & \Pi(n,3) & \ldots & - \end{bmatrix} \tag{6}$$

It should be noted that the above square matrix is not symmetrical ($\Pi(a,b) \neq \Pi(b,a)$ in general). The row sum of this matrix conveys the outranking character of the corresponding alternative while the column sum gives the outranked character of the corresponding alternative. The greater the row sum (or *leaving flow*) of alternative a the better it is compared to the other alternatives. On the other hand, the greater the column sum (or *entering flow*) of alternative a the worse it is compared to the other alternatives.

The leaving and entering flows for alternative a are defined as follows:

$$\text{leaving flow:} \quad \varphi^{+} = \sum_{i=1}^{n} \Pi(a,i) \tag{7}$$

$$\text{entering flow:} \quad \varphi^{-} = \sum_{i=1}^{n} \Pi(i,a) \tag{8a}$$

By combining rankings provided on the basis of the leaving and entering flows a partial pre-order of the alternatives (PROMETHEE I) is obtained, and this accepts that some actions are incomparable. For this partial pre-order, alternative a outranks alternative b if $\varphi^{+}(a) \geq \varphi^{+}(b)$ and $\varphi^{-}(a) \leq \varphi^{-}(b)$ with at least one strict inequality, or if $\varphi^{+}(a) = \varphi^{+}(b)$ and $\varphi^{-}(a) = \varphi^{-}(b)$ then a is indifferent to b. In any other case, a is incomparable with b. Incomparability usually arises when alternative a is good on a set of criteria on which b is weak and, reciprocally, b is good on another set of criteria on which a is weak [65]. Clearly, such a situation occurs frequently in real-life decision problems.

To obtain a complete pre-order of the examined alternatives (PROMETHEE II), net flows are calculated as the difference between the leaving and entering flows:

$$\textit{net flow}: \varphi(a) = \varphi^{+}(a) - \varphi^{-}(a) \tag{8b}$$

In this case alternative a outranks b if $\varphi(a) > \varphi(b)$, and a is indifferent to b if $\varphi(a) = \varphi(b)$. Consequently, PROMETHEE II produces a complete ranking of the examined alternatives in decreasing order of preference.

3.2. Integrating prospect theory into PROMETHEE method

Attempts have been made to integrate prospect theory into PROMETHEE method, reference points and loss aversion for an alternative's attributes have been incorporated into the preference functions used in pairwise comparisons in PROMETHEE methodology. Fan et al. [66] introduced both a new preference function mirroring the analytical formula of prospect theory's value function [59] and a V-shaped preference function with an indifference threshold (Type 5 in PROMETHEE). Also, Lerche and Geldermann [11] modified all six types of PROMETHEE preference function by adjusting the slope for negative differences in attribute values.

As both the preference functions and the value function of prospect theory are defined with respect to differences, preference functions seem to be advantageous in that they can incorporate loss aversion reasonably well. In prospect theory, loss aversion is represented by a steeper slope for losses in the value function. Degree of loss aversion is determined by the coefficient $\lambda = 2.25$, which was estimated by Tversky and Kahneman [59] in their experimental decision-making study. Instead of an S-shaped value function, for simplicity, the piecewise-linear value function of prospect theory

$$v(x) = \begin{cases} x, & x \geq 0 \\ \lambda x, & x < 0 \end{cases} \tag{9}$$

is transferred into the PROMETHEE method when we consider the Type III (V-shaped) preference function:

$$f(x) = \begin{cases} 0, & x < 0 \\ \dfrac{x}{p}, & 0 \leq x \leq p \\ 1, & x > p \end{cases} \tag{10}$$

The loss aversion coefficient is incorporated by using λx instead of argument x used in the classical preference function. This leads to a new preference function in the domain of losses:

$$f_{Loss}(x) = \begin{cases} 0, & x < 0 \\ \dfrac{x}{p/\lambda}, & 0 \leq x \leq p \Big/ \lambda \\ 1, & x > p/\lambda \end{cases} \tag{11}$$

Loss aversion causes a decision maker to be more sensitive to changes, i.e. if their preference threshold is initially equal to p, then due to the steeper function in the domain of losses their preference threshold is reached earlier at p/λ (this follows from the equation $\frac{\lambda x}{p} = 1$). According to Brans et al. [34], the same procedure can also be used for the other five preference functions: the thresholds for p, q and σ are adjusted by dividing them by λ and arguments in the preference functions are replaced with λx.

Based on the reference alternative defined in prospect theory, loss aversion can be integrated into the PROMETHEE method [12]. As shown by Fan et al. [66] and Kahneman and Tversky [10], loss or gain properties of outcomes do not have a symmetric impact on desirability/undesirability with respect to reference points, and this effect should be considered when determining preferences using the PROMETHEE methodology. Using the commonly used PROMETHEE procedure, we consider preferences between alternatives by specifying a

preference function, which takes a value between 0 and 1, and by defining a direction for the optimization of a given criterion. The idea of loss is not incorporated in the commonly used PROMETHEE procedure (for negative arguments, the preference function given by formula (3) is equal to zero). But we believe that loss aversion should be introduced by using a modified preference function f_{LOSS} in pairwise comparisons in cases where the first alternative is a reference point. This reflects the fact that reluctance to change from a reference state is observed in many groups of decision makers. If the reference point is the status quo, then reluctance to change is referred to as the status quo effect. While selecting other reference points proposed in the literature can have advantages and disadvantages, the status quo is relatively easy to determine and comprehensible to decision makers, although it can lead to the neglect of certain expectations or requirements relating to an overall goal. When expectations are considered as a reference point any alternative compared with these expectations will be considered to be a loss and may only meet minimal requirements.

When reference dependency and loss aversion elements are incorporated into PROMETHEE method they can be used to analyse status quo effects in multi-criteria decisions [11]. We propose the following modifications to PROMETHEE methodology: (1) the status quo is considered as a reference point, and; (2) modifications regarding loss aversion preference functions are only used in pairwise comparisons where the first alternative is a reference point. The proposed modifications are referred to as PT-PROMETHEE and they are able to reveal the status quo effect in multi-criteria decisions.

3.3. Weighting determination using AHP

In Multi-criteria Analysis preference explicit representation and integration is a crucial part in the decision process [67]. In principle only non-dominated alternatives should be included in the decision problem and the selection or ranking largely depends on the preferences of the decision maker(s) on the relevant criteria. PROMETHEE suggests no particular guidelines or formal procedure for the determination of weights. For this reason various weighting elicitation or estimation methods are proposed in the literature especially when the number of criteria overwhelms arbitrary value selection (say greater than 3). The Analytical Hierarchy Process (AHP) is readily used especially because it has the distinct advantage of decomposing the decision problem in subsystems and in particular builds hierarchies of criteria characterized by simplicity and providing ex ante consistency treatment [68]. Thus it is not uncommon that AHP supports PROMETHEE in this respect (i.e. [69,70]), some authors proposed enhanced integration of those methods [71]. The AHP method was proposed by Saaty [72] and it is performed as follows:

Structuring the problem into a hierarchical structure: Firstly the decision problem is structured as a model hierarchy at different levels revealing the relationship between the objectives, criteria, sub-criteria if applied, and alternatives. Schematically the hierarchy can be resumed in three levels: the decision overall objective, the criteria and the alternatives in the lower level.

Determining the weights of the criteria: A pairwise comparison matrix with the performance of each criterion against each other based on the decision makers' judgment. $P_c(a_i, a_j)$ measures the intensity of preference of the element i over the element j with regard to criterion c in the scale from 1 to 9 to identify the degree of intensity, that are presented in Table 1.

Constructing the comparison matrix, we must respect the following rules: If $a_{ij} = a$, then $a_{ji} = \frac{1}{a}$. If criterion i has equal importance to the criterion j, then $a_{ij} = a_{ji} = 1$, so $a_{ii} = 1$ for all i. If the comparisons demonstrate perfect consistency, then $\forall\, i,j,k\ a_{ik} = a_{ij} \cdot a_{jk}$ In practice this is not obvious since DM comprehensive ability is increasingly bounded with the matrix size. The consistency check is done by following these steps:

Table 1
Evaluation scale for pairwise comparisons.

Verbal evaluation	Value
The two factors are of equal importance.	1
i element is slightly more important than j	3
i element is clearly important than j	5
i is much more important than j	7
i is extremely more important comparing with j	9
intermediate values	2, 4, 6, 8

1. A^*W^T is calculated where W denotes the calculation relating to the criteria weights.
2. We calculate the largest eigenvector (λ_{max}) : $\frac{1}{n}\sum_{i=1}^{n}\frac{i^{th}\ \text{entry to AW}}{i^{th}\text{entry to W}}$ (1), where n denotes the dimension of the pairwise comparisons table.
3. We calculate the consistency index (CI): $CI = \frac{(\lambda_{max})-n}{n-1}$ (2)
4. We divide the consistency index with an arbitrary consistency index (RI) from a frequency table provided by Saaty's random simulations. RI denotes the random index which is the average of CI for a large random sample comparison tables. The smaller the index (towards zero), the greater the consistency is denoting consistent enough comparisons to give valid results. If the consistency ratio (CR = CI/RI) is lower than 0.10 then the consistency is satisfactory, but if CR > 0.10, then there are inconsistencies which must be corrected, otherwise the method AHP will not provide reliable results.

In case of acceptable consistency we proceed to the calculation stage of the weights, W= (w_1, w_2, w_3, …,w_n), from the pairwise comparison matrix, with the following steps:

1. We divide each element of the column i with the sum of the column. As the result, we have a new table, the normalized table, where the sum of each column is equal to 1.
2. We calculate the average of values entered in column i of the normalized table.

Following the seminal paper by Forman and Peniwati [73] in case of more than one participants to the decision process main options include: (1) aggregating the individual judgments for each set of pairwise comparisons into an 'aggregate hierarchy'; (2) synthesizing each of the individual's hierarchies and aggregating the resulting priorities, referred as aggregating individual judgments (AIJ) and aggregating individual priorities (AIP) respectively.

When individuals are willing to identify their own preferences (values, objectives)

for the good of the organization, they act in concert and pool their judgments in such a way that

the group becomes a new 'individual' and behaves like one. There is a synergistic aggregation of individual judgments (AIJ). Individual identities are lost with every stage of aggregation and a synthesis of the hierarchy produces the group's priorities. The group could also decide to exclude an individual's judgments to secure consistency. When individuals are each acting in their own right, with different value systems, we are concerned about each individual's resulting alternative priorities (AIP). The Pareto (unanimity, agreement) principle essentially says that given two alternatives A and B, if each member of a group of individuals prefers A to B, then the group must prefer A to B. The principle has been formulated and applied in the social sciences in the AIP context described above. An aggregation of each individual's resulting priorities can be computed using either a geometric mean. The elements of aggregated comparison matrix $\widehat{A}_g$ may be described by the following formula: $(a_{i,j})_g = \sqrt[N]{\prod_{n=1}^{N}(a_{i,j})_{Ind\_n}}$, where $(a_{i,j})_{Ind\_n}$ is the judgment of the individual n [73]. Group decision making is given attention since the early years of the AHP development [74] with

numerous applications including suggestions of indices and procedures to detect variation in opinions in the group [75].

3.4. Method combining PROMETHEE and DEA

Caravaggio et al. [76] proposed a new technique of weighting in aggregation technique PROMETHEE based on the Data Envelopment Analysis (DEA) by Charnes et al. [77]. In the DEA approach, which is a non-parametric technique, weights are set on comparing feasible input-output combinations based only on the available data. Net flows are determined for each alternative a from the set of all alternatives N and each criterion k from the set M as follows:

$$\varphi_k(a) = \frac{1}{n-1}\sum_{b\in N}[P_k(a,b) - P_k(b,a)]$$

where P_k is a preference function from PROMETHEE model. In the classical PROMETHEE method the weights are fixed and independent of preference, but there is a risk that they are fixed subjectively by experts. In a modification of the PROMETHEE method using DEA, the weights are fixed for each alternative in such a way that they maximise the global score $\varphi(a)$ as a weighted average of the scores for all sets of criteria $\varphi_k(a)$. The weights for each alternative $a\varepsilon N$ are determined by optimizing the linear programming problem:

$$\varphi(a) = \max_{w_i}\sum_{k\in M}\varphi_k(a)w_k,$$

$$\sum_{k\in M} w_k = 1,\ \forall\, k \in M\ w_k \geq 0.$$

The resulting weights are the most favorable for the given alternative a and they optimize the net flow $\varphi(a)$ from PROMETHEE method. If for the preference functions P_k we used modification based on the value function from prospect theory, than the weights are optimizing the net flow $\varphi(a)$ from PT- PROMETHEE method. The optimization of the above formula reflects the "optimistic" approach by matching the highest weights with the most favorable criterion. Caravaggio et al. [76] also proposed optimization by looking at the most "pessimistic" scenarios, replacing the maximum operator by the minimum. In this paper we present results for the optimistic approach.

The combination of DEA and PROMETHEE gives weights that favor a given alternative by selecting the criterion against which the alternative is best evaluated. As a result of the optimization, the vector of weights, has a value of 1 for the most favorable criterion and 0 for the others. This approach can take into account the preferences of the status quo alternative through the selection of the criterion and not the modification of preferences in the loss area.

4. Implementation of the modifications in a MCDA and its results

4.1. Case study: selection of objectives and alternative actions (step 1)

Krakowski Holding Komunalny (KHK) is a holding company comprised of municipal entities dealing with the supply of heating systems, public transport, and water supply systems in the City of Krakow. KHK was established in 1996 and it is the first, and as of now the only, capital group in Poland with the status of a tax capital group. All companies included in KHK become one corporate taxpayer entity. Entities do not settle taxes separately, but their revenues and costs are summed up and the tax is determined for the entire group, that can optimize tax liabilities. Miejskie Przedsiębiorstwo Oczyszczania (MPO) is the municipal company established in 1993. MPO deals with city cleaning and waste management. KHK is the owner of the Thermal Waste Transformation Plant, which is the last link in the city's waste management system that has been implemented for many years. The resulting installation, in addition to the thermal transformation of the residual fraction of mixed municipal waste, is also to produce electricity and heat from municipal waste. Since their establishment, KHK and MPO have been single-person companies of the Municipality of City of Krakow, while MPO operates outside the capital group formed by KHK. City of Krakow entrusted KHK a project consisting in the preparation, construction, and operation of the Thermal Waste Transformation Plant in Krakow on November 5, 2008. The project was completed on November 30, 2016. Then the question arose, who should manage the Thermal Waste Transformation Plant, KHK which built the plant and manages energy production or MPO for which plant is the final point of the waste management process?

Four possible models for the acquisition of MPO were considered: three forms of takeover – the sale of MPO (W1), selling the organized part of MPO (W2), and contributing MPO shares to KHK (W4) – and one form of a merger: incorporation (W3). The analysis also considered another possibility: W0 – maintaining the status quo. The sale of the company or its organized part would involve the purchase of MPO assets by KHK, resulting in an increase of the assets on KHK's accounting books. In this scenario MPO would operate as an entity outside the capital group, and the waste-related "company" would be incorporated into KHK's structure, this not resulting in a change of ownership. Contributing shares would result in KHK becoming a new owner, with MPO retaining its legal status and all of its assets. The process of incorporation would entail the merging of KHK and MPO, the removal of MPO from the register of companies, and a change in ownership structure: the hitherto owner of MPO would acquire a new issue of KHK shares (the shares would be owned by Gmina Miejska Kraków/the borough of Krakow).

In the document entitled "Here I want to live. Kraków 2030″, which was adopted in 2017, the development strategy of the city of Kraków was defined. In it we find, among others, a provision stating that the municipal authorities will want to manage municipal waste efficiently so that up to 50% of waste (paper, metal, plastics, glass) is reused. This strategic objective has been included in KHK's Closed Circuit Economy (CCE) Strategy of December 2020. In this strategy, KHK will strive to completely recycle waste or convert it into energy or heat. KHK already obtains a green energy certificate for 50% of the energy it produces. Also, the Board of the Małopolska Voivodeship, in the Voivodeship Development Strategy "Małopolska 2030″ adopted in 2019, indicates among the main directions of the region's development policy the areas of renewable energy and energy efficiency as well as rational waste management. At the same time, it should be emphasized that, at present, the tasks in the area of renewable energy and energy efficiency are carried out by KHK, while waste recycling is the task of MPO. MPO plans to invest in the process of recycling soft plastics, which are currently landfilled. Implementation of the idea of a Closed Circuit Economy, in which no waste will be produced at all, requires either increased cooperation between KHK and MPO (variant W0) or implementation of variant W4 or W3.

The following empirical part of the article presents a ranking of the above MPO acquisition models including the status quo effect (W0). The models involving incorporation (W3) and the contribution of MPO shares to KHK (W4) would be the most satisfying solutions because of the benefits that would result from cooperation between the two companies and the simultaneous elimination of risks involved in financing transactions which would occur with the sale of MPO (W1) and the sale of the organized part of MPO (W2).

It should be noted that this case study was subjected to expert commentary by Andrzejewski et al. [63] and was presented in an article by Kubińska et al. [78], but both of these publications only considered use of the AHP method in determining the final ranking of alternatives W0 – W4.

4.2. Determining the main criteria (step 2)

The overall objective of the case study described was to provide evidence to help choose the best model of cooperation between the two municipal entities. All alternatives were evaluated on six main criteria reflecting different aspects of the companies' activities (the experience of the entities in important areas, and waste management issues) and the risks associated with the different models of cooperation (formal and legal aspects, financial analysis, and taxation aspects), and how the changes would affect the residents of Krakow (social aspects).

The first criterion, i.e. **formal and legal aspects (f1),** involved subcriteria such as the risk of having to reimburse EU subsidies, the risk of liabilities arising to MPO employees as a result of their employer changing, the loss of MPO's legal status, problems arising from the consolidation of municipal services, and payments associated with takeover costs. The criterion relating to the **experience of the entities in important areas (f2)** measured experience in the areas of managing working capital and the coordination of investment projects. With regard to the **waste management (f3)** criterion, compliance with waste policy obligations and issues surrounding the recovering of energy from waste were evaluated for each alternative: this criterion involved environmental protection requirements and public awareness of correct waste management procedures. The **financial analysis (f4)** criterion assessed the alternatives in terms of profitability, liquidity, debt and operational efficiency indicators. **Social aspects (f5)** were determined using the results of a questionnaire-based survey among the residents of Krakow. The questionnaire aimed to test residents' opinions about financial efficiency, the quality of services provided, system trustworthiness and environmental impacts.[1] Finally, with respect to the sixth criterion, **taxation aspects (f6),** alternatives were examined with respect to preferences regarding corporate income tax (CIT), value added tax (VAT) and tax on civil law transactions (PCC).

The weights of the main criteria were determined by pairwise comparisons following both rationales namely aggregating individual judgments (AIJ) and aggregating individual priorities (AIP). For the first case we supposed that discussion takes place between experts that act as stakeholders within the municipality not representing personal strong opinions or different vested interests. Thus pairwise comparisons are discussed among the experts and the preference value is assigned following a commonly admitted rule. In this case study we deployed an ad hoc procedure where the experts were asked to choose which of two criteria was the more important, providing answers on a dichotomous scale.

The experts' judgements are presented in Table 2, where 1 indicates that a majority believed that the criterion in the row was more important than the criterion in the column. The final column in Table 1 contains criteria weights, and shows that the most important criterion was considered to be formal and legal aspects with a weight of 28.57%, followed by taxation aspects with a weight of 23.81%, financial analysis with a weight of 19.05%, waste management with a weight of 14.29%, social aspects with a weight of 9.52%, and the experience of the entities in important areas with a weight of 4.76%.

Secondly we considered a situation of distinct individual priorities identifying to the AIP. In the case study we asked the five experts to express their opinion filling separately their own pairwise comparison matrix of the six selected criteria. In this case the AIP group decision making process was applied, since the individual opinions differ between respondents. Then we come with five different weight sets calculated by means of the AHP algorithm that produce a synthesis table using the geometric mean that provides the group weighted set (Table 3). We assume that each participant is of equal importance in the decision process. The calculated inconsistency index for each individual as well as the aggregate one is less than 0.1 [79]. Aggregate results are shown in the tables below (the five pairwise comparison tables are in the xls file in sheet "matrix" in supplementary material).

[1] The survey asked respondents to evaluate simplified versions of variants, i.e. scenarios in which waste management tasks would be partially implemented by MPO and partially by KHK (variant W0) or implemented by KHK (variants W1–W4). The models in which MPO would become part of KHK were rated as better (variants W1–W4).

Table 2
A matrix showing the results of experts' pairwise comparisons of criteria.

	f1	f2	f3	f4	f5	f6	Sum	Weight (AIJ)
f1 Formal and legal aspects	1	1	1	1	1	1	6	28.57
f2 Experience of the entities …	0	1	0	0	0	0	1	4.76
f3 Waste management	0	1	1	0	1	0	3	14.29
f4 Financial analysis	0	1	1	1	1	0	4	19.05
f5 Social aspects	0	1	0	0	1	0	2	9.52
f6 Taxation aspects	0	1	1	1	1	1	5	23.81
SUM							21	100.00

Note. A value of 1 indicates that the criterion in the row is more important than the corresponding criterion in the column (otherwise a value is 0). Consequently, values in the lower triangle are the opposite of those in the upper triangle, i.e. if there is a 1 in a given cell, then in the cell with the line and column numbers reversed the value is 0, and vice versa. All the cells on the diagonal contain 1. Summing the values in the rows of the matrix and then scaling them (dividing them by the sum of sums) determines the weights for the criteria.

4.3. Evaluation of the different alternatives using the main criteria (step 3)

Apart from the status quo (the independent operation of MPO and KHK; W0), three forms of takeover were considered – the sale of MPO (W1), the sale of the organized part of MPO (W2), and contributing MPO shares to KHK (W4) – as well as one form of merger: incorporation (W3). An evaluation of alternatives was carried out by experts while preparing a report for one of the municipal companies in December 2016 [63]. Alternative W0, i.e. the independent operation of MPO and KHK (the status quo), attained the highest value on the first main criterion: formal and legal aspects (f1) as shown in Table 4. Changes to the status quo resulted in risks to formal and legal aspects of the companies' activities, for example, the risk of having to return European Union subsidies, and the risk of liabilities occurring to MPO employees as a result of their employer changing. In the case of the second main criterion: the experience of the entities in important areas, the best alternatives were W1 (the sale of MPO), and W3 (a merger of the companies through acquisition). These two alternatives were the most effective from the perspective of managing working capital, coordination of investment projects and policies relating to quality. Alternative W4 (contribution of MPO shares to KHK) attained the highest score under the waste management criterion (f3). The W1 variant (the sale of MPO) was the most satisfactory with respect to the financial analysis (f4) criterion. Assessments relating to the social aspects criterion (f5) were based on the results of a questionnaire survey in which opinions concerning financial efficiency, quality of services provided, system trustworthiness and environmental impact were examined among Krakow's residents.

Table 3
Aggregate AHP pairwise comparison table (geometric mean of 5 experts).

	f1	f2	f3	f4	f5	f6	Weight (AHP)
f1	1.00	2.43	1.93	2.41	1.83	1.52	26.41
f2	0.41	1.00	0.46	0.34	0.48	0.36	7.12
f3	0.52	2.17	1.00	0.38	1.74	0.53	12.93
f4	0.42	2.91	2.64	1.00	2.86	0.46	19.71
f5	0.55	2.10	0.57	0.35	1.00	0.43	10.49
f6	0.66	2.77	1.89	2.17	2.32	1.00	23.35
							100.00

Table 4
Performance matrix and parameters for PROMETHEEE II and PT-PROMETHEE II.

Criteria	f1	f2	f3	f4	f5	f6
Alternative W0	14	5	10	0	12	9
Alternative W1	9	9	9	4	16	5
Alternative W2	10	6	8	1	16	8
Alternative W3	11	9	10	3	16	8
Alternative W4	13	8	11	3	16	6
Criteria weights AIJ (%)	28.57	4.76	14.29	23.81	9.52	19.05
Criteria weights AIP (%)	26.41	7.12	12.93	19.71	10.49	23.35
Direction	max	max	max	Max	max	max
Type	2	3	5	4	1	6
q (or σ)	4		1	1		3
p		5	5	2		
PT: q or σ for $\lambda = 2{,}25$	1.778		0.444	0.444		*
PT: p for $\lambda = 2{,}25$		2.222	2.222	0.889		
PT: q or σ for $\lambda = 4.25$	0.941		0.235	0.235		
PT: p for $\lambda = 4{,}25$		1.176	1.176	0.471		

Criteria: f1 – formal and legal aspects, f2 – experience, f3 – ecological aspects/ waste management, f4 – financial analysis, f5 – social aspects, f6 – taxation aspects.

Simplified alternatives were presented to respondents, i.e. a scenario in which MPO and KHK would continue to work independently (variant W0) or together (variants W1–W4). The models in which MPO would be part of KHK (variants W1–W4) were considered to be better by Kracovians. Alternative W0 proved to be the best option in terms of taxation aspects (f6). For alternative W0, there was no risk of additional corporate income tax (CIT), value added tax (VAT) and civil law transactions tax (PCC), while for every other solution (W1–W4) the risks of paying additional taxes were conditional or unconditional. The final performance matrix for the main criteria is shown in Table 4. Exact assessments for each of the alternatives on the subcriteria within each main criterion are presented in the report of Andrzejewski et al. [63]. Subcriteria were summated to produce overall values for each criterion, taking into account the positive or negative impact of subcriteria (where minimization of subcriteria was required, they were multiplied by −1 and then summated with other values).

In addition to a performance matrix, Table 4 also presents information relating to preference functions, with parameters assigned to criteria using the PROMETHEEE method detailed in the next section. The table also includes parameter modifications reflecting the loss aversion coefficient in the PT-PROMETHEE methodology.

4.4. Implementation of multi-criteria analysis (step 4) with sensitivity analysis (step 5)

Both the PROMETHEE II and PT-PROMETHEE (results based on modifications incorporating prospect theory rationale into PROMETHEE II) were implemented using the assumptions about preference functions inherent in the threshold parameters presented in Table 2. We applied multi-criteria decision analysis methods to three scenarios in our case study. Scenario A included all the analysed models of cooperation between KHK and MPO: independent operation of MPO and KHK (W0); the three forms of takeover, i.e. the sale of MPO (W1), the sale of the organized part of MPO (W2), and the contribution of MPO shares to KHK (W4); and a merger by incorporation (W3). Scenarios B and C were based on a reduced number of alternatives and tested the impact that the status quo can have on rankings provided to decision makers. Scenario B included the independent operation of MPO and KHK (W0) and two forms of takeover: the sale of MPO (W1) and the sale of the organized part of MPO (W2). Scenario C included the status quo (W0), a merger by incorporation (W3), and a takeover via contribution of MPO shares to KHK (W4). Table 5 shows results for leaving flow, entering flow and net flow, and the results of PROMETHEE and PT-PROMETHEE rankings with W0 as the status quo.

Using the traditional PROMETHEE II methodology, for Scenario A the alternatives were ranked in the following descending order: W3, W4, W1, W2, W0 (the status quo). Thus, this first result using PROMETHEE II showed that each of the alternatives was considered to be better than the status quo and that an organisational change in the operations of MPO and KHK was necessary. However, when the realistic assumption that people exhibit loss aversion was included in an analysis using the PT-PROMETHEE methodology, the status quo alternative moved up two places up in the order of ranking: W4, W3, W0, W1, W2.

As the weight sets estimated through AJP and AIP approaches are practically similar (Tables 1 and 2) and therefore they result in identical rankings, we implemented PROMETHEE with an individual expert's weight set quite different from the others and the aggregate result. Unlike the majority of the experts that considered f1 as the most important dimension, the E2 attributed equal importance to criteria f2, f3, f5, and f6 with much less consideration to f1 and f4. Ranking of alternatives is the same with the one resulted using the aggregate weight set, however the ranking does not changes when PT-PROMETHEE model is used, thus such preferences outweigh the status quo effect. In the context of PT-PROMETHEE sensitivity can be examined regarding the value of lambda. For increasing values, thresholds for different value functions diminished so that the status quo alternative's is strengthened, that is illustrated in the graph in Fig. 3 (λ values in the horizontal axis; phi values in the vertical axis). As expected for low values of lambda

Table 5
Calculated values of leaving flow, entering flow and net flow (Φ+, Φ- and Φ), and rankings of alternatives using PROMETHEE and PT-PROMETHEE.

	PROMETHEE				PT-PROMETHEE with W0 as the status quo			
A. A model with all alternatives								
Alternatives	Φ+	Φ-	Φ	Rank	Φ+	Φ-	Φ	Rank
W0	0.529	1.329	−0.799	5	1.365	1.329	0.036	3
W1	0.648	0.594	0.054	3	0.648	0.691	−0.043	4
W2	0.337	0.706	−0.369	4	0.337	1.093	−0.756	5
W3	0.677	0.010	0.667	1	0.677	0.308	0.369	2
W4	0.617	0.170	0.448	2	0.617	0.224	0.394	1
B. A model with the status quo (W0) and alternatives W1 & W2								
Alternatives	Φ+	Φ-	Φ	Rank	Φ+	Φ-	Φ	Rank
W0	0.444	0.595	−0.151	3	0.928	0.595	0.333	1
W1	0.638	0.473	0.165	1	0.638	0.570	0.068	2
W2	0.299	0.313	−0.014	2	0.299	0.700	−0.401	3
C. A model with the status quo (W0) and alternatives W3 & W4								
Alternatives	Φ+	Φ-	Φ	Rank	Φ+	Φ-	Φ	Rank
W0	0.085	0.733	−0.648	3	0.437	0.733	−0.297	3
W3	0.419	0.010	0.409	1	0.419	0.308	0.111	2
W4	0.362	0.122	0.239	2	0.362	0.176	0.186	1

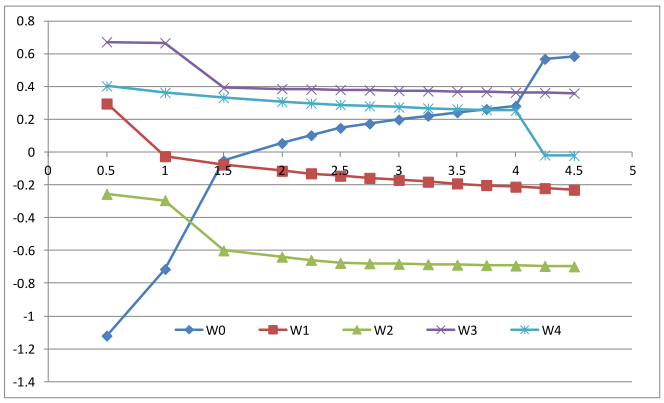

Fig. 3. Ranking of alternatives by PT-PROMETHEE for increasing lambda.

(horizontal axis) W0 alternative is ranked the last with W3 and W4 first and second respectively. From λ attaining 1.5 the W0 alternative outperforms W1 and W2 and beyond 4 it becomes the best choice. In Table 4, threshold values for $\lambda = 4.25$ are shown in the last two lines.

The PT-PROMETHEE methodology showed that if only the new alternatives W1 and W2 (the two forms of takeover in Scenario B) were to be considered by the city of Krakow (the owner of MPO and KHK), then taking the status quo effect into account would lead to significant changes in the rankings of the alternatives: in this scenario the status quo rose by two places and attained first place among the three alternatives involved. Finally, findings for Scenario C showed that taking loss aversion into account did not influence the position of the status quo compared to the two relatively good alternatives (W3 and W4 occupied the first two positions in the rankings for Scenario A). Interestingly, in Scenario C, W0 occupied third position in the rankings when using both the PROMETHEE and PT-PROMETHEE methodologies, but the first and second position orderings of W3 and W4 were reversed by taking the status quo effect into account: the final PROMETHEE ranking was W3, W4, W0, while the final PT-PROMETHEE ranking was W4, W3, W0. This was caused by the fact that, in the PT-PROMETHEE methodology, for the status quo only leaving flow φ^+ is modified, while in the case of alternatives other than the status quo only entering flow φ^- is modified.

A pairwise comparison of the formal and legal aspects (f1) main criterion with a preference function of type 2 and a threshold of 4 caused the biggest difference in the outcomes produced by PROMETHEE and PT-PROMETHEE. Here, alternatives W0 and W3 scored 14 and 11 respectively, the difference (3) not exceeding the threshold of 4 for PROMETHEE but exceeding the threshold of 1.778 for PT-PROMETHEE. Also, the entering flow for W3 was larger, and W3 was weaker in the final ranking.

The results of the method, which is a combination of PROMETHEE and DEA, are shown in Table 6. Panel A shows the net flow values for each alternative (W0 –W4) and for each criterion (f1-f6) based on the preference functions from PROMETHEE model, which are the basis for further calculations.

According to the DEA method, the weights are chosen so that they maximise the product of net flows and weights for certain alternative. The results are vectors with 1 in the position corresponding to the criterion with the highest net flow for given alternative (Panel B of Table 6). The resulted weights point the criterion against which a given alternative is best evaluated in the PROMETHEE method. The vector of weights, with one value equal to 1 given to certain criterion, causes that only this criterion influences the ranking of the alternatives in final net flow the PROMETHEE method (Panel C of Table 6). The application of DEA to alternative W0, very strongly reinforces the status quo effect in the ranking, alternative W0 receives the highest rank based on the criterium taxation aspects (f6). Taking into account the results for all alternatives, the most favorable alternative is W1 followed by W3, the others, i.e. WO, W2 and W3, have only one indication each.

5. Discussion

In this exercise we observed that, by taking into account loss aversion and including a reference alternative, the PT-PROMETHEE methodology following Lerche and Geldermann's [11] proposed variant of the conventional PROMETHEE strengthens the position of a status quo as an alternative in policy rankings: in the case involving Krakovian municipal companies that was analysed a policy of maintaining the status quo (the independent operation of MPO and KHK) was strengthened in final rankings. Specifically, initial results based on using the PROMETHEE II methodology showed that each of the alternatives considered was better

Table 6
Results of a method combining PROMETHEE and DEA.

Panel A. Net flows $\varphi_k(a)$ for each alternative and each criterion

	f1 Formal and legal aspects	f2 Experience of the entities	f3 Waste management	f4 Financial analysis	f5 Social aspects	f6 Taxation aspects
W0	0,25	−0,60	0,06	−0,88	−1,00	0,27
W1	−0,25	0,40	−0,06	0,50	0,25	−0,36
W2	0,00	−0,35	−0,25	−0,38	0,25	0,13
W3	0,00	0,40	0,06	0,38	0,25	0,13
W4	0,00	0,15	0,19	0,38	0,25	−0,18

Panel B. Weight vectors for alternatives

	f1	f2	**f3**	f4	f5	f6
W0	0	0	0	0	0	1
W1	0	0	0	1	0	0
W2	0	0	0	0	1	0
W3	0	1	0	0	0	0
W4	0	0	0	1	0	0

Panel C. 5 rankings in columns based on the weight vectors for alternatives

	W0	W1	W2	W3	W4	No. of 1st positions in 5 rankings
Criterium	f6	f4	f5	f2	f4	
W0	1	5	5	5	5	1
W1	5	1	1	1	1	4
W2	2	4	1	4	4	1
W3	2	2	1	1	2	2
W4	4	2	1	3	2	1

Note: In the case of applying the preference function with the modification from the prospect theory, the only difference in the results occurs in the case of alternative W0, where criterion f1 is the most important based on PT-PROMTHEE. The rankings for PT-PROMETHEE remain the same like in the case of PROMETHEE.

than the status quo. However, by taking loss aversion into account, the PT-PROMETHEE methodology moved the status quo alternative up in the pecking order. The present case involving municipal companies highlighted phenomena that may occur when only a smaller number of alternatives are considered. When combining two or three alternatives, the status quo may become the preferred solution by ascending from a bottom ranking to a top ranking. Also, in the case of strong alternatives, including the status quo can affect rankings, reversing the positions of strong alternatives. The choice of the set of alternatives can significantly affect the evaluation of their attractiveness when loss aversion and the status quo are taken into account. As our results show, the PT-PROMETHEE methodology can be used to explain the actual behaviour of decision makers, and it also provides insights into risk-related mechanisms when small numbers of alternatives are ranked. This element reveals the positive nature of the MCDA reducing the probability of proposing compromise alternatives that will never be realised, thus it enhances its validity and usefulness as well as the applicability of the 'best' alternative [80].The proposed methodology is extremely relevant and necessary for the implementation of development policies and strategies formulated by local urban and regional authorities. The solutions proposed in this paper have proven that local authorities will look for an optimal structure of KHK or will strive to work out novel rules of cooperation in order to achieve the goal of creating a Closed Circuit Economy recommended by the European Union. The importance of applying the proposed PT - PROMETHEE method is emphasized by the fact that the status quo variant can be more favorable alternative by policymakers and the inhabitants. The role of status quo in the Cracow's inhabitants perception of the companies' strategy can be examined in the future research. This kind of study would then be conducted with a survey among Cracow's inhabitants whose individual responses will refer to the local policy and then be analysed with the use of individuals and societal loss functions within multidimensional spatial model [81].

The present study has identified some limitations of the methodologies considered and issues that arise in implementing them. For example, studies should be designed so that they enable more systematic implementation of group decision making. This implies that it is necessary to consider alternative ways of eliciting and aggregating weights, and to perform sensitivity analysis to test the robustness of compromise solutions which are proposed. Moreover, where problems are of a multidimensional nature and conflicting interests are present among decision makers, there is a need to enforce the interactive element of the methodologies in such a way that stakeholders can consider trade-offs among alternatives with respect to various aspects of decision problems. This would enhance dialogue among decision makers and foster consensus, which is an important element of effective governance and of paramount importance at lower levels of executive power if management decisions are to be decentralized and taken at the municipal level.

6. Conclusions

Multicriteria decision making proves to be an appropriate approach to deal with the multiple dimensions of the merger issue in the public sector at large facilitating dialogue and interaction among decision makers. On top of conventional MCDM methods the PT-PROMETHEE accommodates advances in behavioural decision offering the opportunity for the decision maker to express loss aversion and to consider reference dependency thus incorporating positive aspects of decision modelling. These pivotal elements of prospect theory namely, a distinct alternative reference point (the status quo) and loss aversion with respect to this reference point, allow for compromise solutions that correspond to the intuitive choice of the stakeholders. The integration of prospect theory into PROMETHEE illustrated in the case of possible merger of two municipal companies in Krakow may have several implications. The case presents different scenarios of choosing the best model of cooperation between two Krakow's municipal entities, e.g. with fewer alternatives or with weights determined besides experts opinions to reflect the focus of decision makers on particular alternative by seeking weights that maximise the value that option in combining DEA with PROMETHEE. Those elements can be seen in the shed of nudge theory by Thaler and Sunstein [82], that shows the ways how to influence the behavior to favor the desired outcome. Status quo bias, loss aversion and framing are considered by Thaler and Sunstein as the fundamental automatic cognitive processes that are triggered in decision-making of groups or individuals. A nudge is used in choice architecture to push people to choose desired results or to accept more likely certain proposed alternative. Benartzi et al. [83] wrote that nudging is a practical and effective approach to policy implementation, but they emphasized the need for further research to develop more computational approaches to determine the relative effectiveness of nudging. We believe that PT-PROMETHEE, including the status quo effect and loss aversion, is in line with research developing numerical methods to show the impact of heuristics on decisions. The advantage of using PT-PROMETHEE is on the one hand, the inclusion of common cognitive processes in the analysis and the evaluation of alternatives, which allows to create a realistic ranking of the considered solutions in the case. This enhances the acceptance of the MCDM and its adoption as support framework by local authorities increasing the leeway of the analysts to require detailed data enforcing interactiveness in all stages of the decision process. Last but not least, the likely scenario that the algorithm outcome would propose incumbent arrangements around the status quo would alert decision makers to suggest policy instruments drastic enough to support lock-out options in order to achieve desired objectives. This idea already applied in different context by means of simulation techniques [11], can be implemented by fine-tuning parameters of the MC model that alter the performance in the decision criteria under consideration upgrading the analyst from facilitating to catalyzing the decision.

CRediT

Elżbieta Kubińska: Term, Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Writing - Review & Editing.

Magdalena Adamczyk-Kowalczuk: Term, Conceptualization, Writing - Original Draft, Writing - Review & Editing, Project Administration.

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Declaration of competing interest

We declare that no potential conflict of interest is reported with regard to the SEPS 101391 manuscript submitted and accepted for publication to Socio-Economic Planning Sciences.

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Appendix A. Supplementary data

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