Multi-criteria decision-making methods for project portfolio management: a literature review

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Abstract: Project portfolio management (PPM) has become a key element of large organisations’ service delivery due to the close attention inherently paid to numerous issues in the discipline of project management. Its success is closely associated with the degree of understanding of its issues and the quality of decisions made at the portfolio level which can be addressed using multi-criteria decision-making (MCDM) methods. Although several of these MCDM methods have been introduced to support decision-making functions as part of PPM, there has been little assessment of their performances, particularly when combining some of them. This paper identifies the key challenges of PPM, proposes a new framework for classifying PPM MCDM related methods and presents a literature review of applications of MCDM methods to PPM.

Keywords: project portfolio management; PPM; multi-criteria decision making; MCDM; MCDM classification; PPM Challenges; decision problem.


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1 Introduction

Management activities, such as improving public services, implementing new policies, and introducing new management systems, are conducted through projects and portfolios, with their poor performances and, in particular, their failures to deliver targeted benefits, having a negative effect on national growth, not to mention the waste of public assets and taxpayers’ money (Chih and Zwikael, 2013). There are many decision-making techniques that can support Project portfolio management (PPM), with organisations which use structured ones to manage and implement their portfolios more successful due to their capability to reduce the gap between PPM and multi-criteria decision-making (MCDM) (Müller et al., 2008). However, in order to use appropriate decision-making methods, it is necessary to understand the challenges of PPM decision making.

Although a few studies discuss PPM challenges (e.g., Cooper et al., 2001b; Elonen and Artto, 2003) and relevant decision-making issues (e.g., Manos et al., 2010), there is no frameworks for properly linking them, in particular, using MCDM in PPM decision making.

Properly understanding PPM and its decision-making challenges also helps to correctly identify the factors required to develop a structured framework for selecting the ideal MCDM method(s) as a tool(s) in PPM decision making.

Based on the observed knowledge gaps, the primary concerns of this study are: ‘What is PPM?’; ‘what are the key challenges of PPM?’; ‘what are the failure factors of PPM?’; ‘what is a MCDM?’; ‘what kinds of MCDM methods are available?’; and ‘How can MCDM methods be classified?’. In this study, a comprehensive review of the literature is conducted to analyse the challenges of PPM decision making. Then, MCDM techniques are classified to improve knowledge of their assessment and decision-making approaches, with their strengths and weaknesses in relation to PPM decision making analysed to determine any constraints and limitations on applying them. Accordingly, a solid structure of MCDM techniques that improves knowledge of the assessment and selection techniques for projects in complex organisations are presented.

The selection of publications considered is restricted based on the following factors. The review covers the literature on decision making, and organisational and portfolio management published between 1860 and 2016, with Google scholar used to retrieve the relevant articles accessed using the following search phrases: ‘PPM’ or ‘portfolio
management’ or ‘project and program management’) and [‘MCDM’ or ‘complex decision making’] which produces more than 1,400 extracted publications.

The work in this study extends the sensitivity analysis frameworks introduced by Barron and Schmidt (1988), Insua and French (1991), Wolters and Mareschal (1995), and Ringuest (1997). The difficulties of PPM decision making can be identified in different project situations, such as the selection of projects, prioritisation and balancing of resources (e.g., cost and time) or financial management. Since selecting and prioritising of projects in PPM are our areas of interest, this research is undertaken from a management decision making rather than mathematical point of view.

2 PPM

2.1 PPM overview

Portfolio management seems to have been first employed in the 1950s to determine inventory portfolios (Markowitz, 1952). Most studies acknowledge that PPM is generally considered as an active decision-making procedure whereby a set of projects is modified (Martinsuo and Lehtonen, 2007). Project and program management are focused on ‘performing the project/program right’ while portfolio management refers to ‘carrying out the right project’ (Cooke-Davies, 2002; PMI, 2006). In this study, we focus on the following.

PPM is a dynamic decision process, whereby a business’s list of active new products (and R&D) projects are constantly up-dated and revised. In this process, new projects are evaluated, selected and prioritised; existing projects may be accelerated, killed or de-prioritised; and resources are allocated and reallocated to the active projects. The portfolio decision process is characterised by uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependence among projects, and multiple decision-makers and locations (Cooper et al., 2001a).

The systematic control of a portfolio’s outcomes has enhanced benefits for businesses (Platje et al., 1994). As PPM can handle several projects as a single program, it is more popular with practitioners (Artto et al., 2004). Many studies emphasise the significance of PPM for assessing, prioritising and choosing the right projects and programs according to organisational policies (e.g., Cooper et al., 2001a). Also, as the main critical studies of PPM concentrate on its practices of project selection and prioritisation (Artoo et al., 2004; Elonen and Artto, 2003; PMI, 2006), choosing the most appropriate project is a significant aspect of organisational management. The goals of PPM are maximising a portfolio’s value, developing its strategic arrangement and balancing its assignments (Cooper et al., 2002) which this research uses to determine whether a PPM is successful.

Various analyses have suggested that PPM and its performance results need to be assessed at the project, portfolio and organisational levels (Müller et al., 2008), with an effective PPM required to promote an organisation’s overall goals. Therefore, an organisation’s short and long-term success factors are taken into account in the work of Shenhar et al. (2001) and applies the measurements of Maylor et al. (2006) on Cooper’s three PPM goals (i.e., maximising a portfolio’s value, developing its strategic arrangement and balancing its assignments) (Cooper et al., 2002) to discover their
relationships. MCDM methods can fulfil these requirements; for example, their scoring techniques are used for large portfolios while pair-wise comparison methods are more suitable for smaller projects. However, finding the most suitable method(s) for PPM is a challenging task that requires a constructive review and comparison of MCDM methods to identify the most suitable one(s) for PPM decision making for determining which projects in a portfolio add most value to the organisational objectives.

2.2 PPM decision making challenges

While several studies describe various PPM issues, such as obtaining executive level support and commitment (Kendall and Rollins, 2003), gaining a perception of a portfolio across projects (McDonough and Spital, 2003; Wheelwright and Clark, 1992), and having proper information (Martino, 1995; Wideman, 2004) and sufficient time to perform PPM (Lawson et al., 2006; Vähäniitty, 2006), a major concern is ascertaining the key challenges of PPM.

Most organisations encounter difficulties when selecting specific projects (De Reyck et al., 2005; Meskendahl, 2010) using an adaptable decision-making practice (Bessant et al., 2011; Blichfeldt and Eskerod, 2008). While several PPM studies indicate the significance of selecting a specific group of projects, they do not properly examine the issues faced during the selection process (Bessant et al., 2011). PPM studies have not presented a comprehensive idea of exactly how processes for selection and project prioritisation are actually stated in PPM. Therefore, further investigation is required to determine exactly the types of methods employed for the examination and selection of projects (Geraldi, 2008).

The challenges of assessing and selecting options and projects are discussed below through an examination of PPM studies as well as observations based on decision-making principles.

2.2.1 Sensitivity analysis/uncertainty treatment

Organisations deal with several uncertainties, including insufficient data, inaccurate cost information, the completion period and availability of resources and benefits (Cooper et al., 2001a). A sensitivity analysis is an essential aspect of quantitative decision models (Dantzig, 1998; Insua, 1990) and an effective process because it demonstrates the advantages and disadvantages of a/the particular examination (Commission, 1992) while efficient uncertainty management is the most critical challenge in the decision-making process (Felli and Hazen, 1998; Steffens et al., 2007). A comprehensive decision assessment demands an in depth sensitivity examination (Belton and Hodgkin, 1999) which can be very challenging (Larichev, 2000). The selection process consists of numerical inputs which might not be fully accurate (French et al., 1998). Every step in the MCDM procedure consists of some kind of uncertainty, such as selecting the technique (Bouyssou, 1990) and factors, examining the factors’ values and choosing weights (Janssen et al., 1990). Consequently, a decision maker (DM) usually has to first estimate the effect of change on the relevant portfolio and then calculates the essential information with considerably higher degrees of accuracy and reliability. For these reasons, a sensitivity analysis of MCDM challenges must be conducted. Insua (1990) emphasises the need for this as difficult decisions can be extremely sensitive to certain changes in the issues; for example, assessing and selecting an entirely new system which
is being created is an extremely unknown/uncertain situation (Wheelwright and Clark, 1992).

2.2.2 Dependencies
Dealing with a portfolio of projects with uncertainty is a difficult task exacerbated by the existence of interdependencies (Collyer and Warren, 2009; Perminova et al., 2008) which is among the reasons for a PPM failure (Elonen and Arto, 2003). PPM procedures are used to determine dependencies among the projects in a portfolio so that decisions can be made knowing the potential impacts of these projects on each other (Shenhar et al., 2001). Although the interdependencies in portfolios with several projects need to be known to facilitate good judgments (Blau et al., 2004), communications among the various procedures/methods available are extremely complicated (Dawidson, 2006). Choices or unforeseen situations occurring in a single task impact on other functions (e.g., re-prioritisations of programs or evaluations of strategies). Most scientific studies of PPM manage each project as an individual process while recognising the value of considering projects’ interdependencies (Collyer and Warren, 2009; Dahlgren and Söderlund, 2010; Söderlund, 2004). To indicate the additional characteristic of PPM compared with individual project management, Cooper and Edgett (2003) employ the analogy that a project procedure addresses the ‘fingers’ while PPM focuses on the ‘fist’.

2.2.3 Decision traceability.
To deal with PPM complexities, such as uncertainty or dependencies among projects, it is essential to keep track of data and ensure that critical data is not eliminated or unnecessary data incorporated. This process has to be traceable (backwards and forwards throughout the decision cycle and from the strategic to operational levels) (Danilovic and Browning, 2007).

2.2.4 Simplicity
Although there are more than 100 different methods which can be used to calculate, examine and select decision options, most are seldom employed because: they are complicated and involve an excessive amount of input information; provide insufficient management of risk and uncertainty; are incapable of identifying interrelationships and related requirements; might simply be too difficult to understand or apply; and might not be considered from the perspective of a structured method and practice (Cooper, 2001; Cooper et al., 1997a). Although several earlier decision-making techniques tried to improve formulaic options via mathematical models and optimisation methods, generally, they are not often applied because of their complex structures (Coldrick et al., 2005). Costa (1988) states that, although there are various MCDM techniques which might be useful (in theory), they are subject to failure due to their lack of simplicity, with their complexities being the main reason for DMs preferring simple weight-rating methods. Despite the fact that there is no shortage of decision-making methods with individual positive aspects, there is certainly a lack of an overall framework for rationally arranging them in an adaptable procedure which could sustain the practice of portfolio decision making, partly because of the complexities involved in using some of them. DMs are unlikely to apply a technique/method/tool that is not both effective and simple to operate.
To attempt to overcome these issues, suitable techniques need to provide the best features of some current techniques with fewer complexities. Therefore, simple decision support tools/techniques are key elements for multiple decision making (Bender and Simonovic, 2000).

2.2.5 Quantitative and qualitative measures.

The strategic arrangement of projects in a portfolio, which is critical, requires both quantitative and qualitative techniques (Kester et al., 2009). It is also in line with analysing specifications that assist the selection of project options and decisions (Bergman and Mark, 2002). A project’s related risk level is a qualitative factor, its estimated profit a quantitative one, and its involvement in organisational strategy both qualitative and quantitative ones (Ohr and McFarthing, 2013). Although quantitative data, such as costs and time, is readily available for most projects, qualitative analysis is more often used for complex ones. In current PPM, most portfolio decisions are subjective based on assessments of various project options.

2.2.6 Number of projects

The number of programs/projects planned for a given portfolio can be quite significant (Cooper et al., 1997a) and confusion regarding portfolio decisions arises as the number of projects to be taken into consideration increases (Levine, 2005). Cooper and Edgett (2003) justify the significance of excellent decision making and the need to acquire top quality information for that purpose. Selecting and delivering a number of projects beyond an organisations’ capacity are among the main reasons for projects’ failures to achieve organisational objectives (Almendra and Christiaans, 2009; Yelin, 2005). As the possibility of reaching sound organisational decisions can be diminished if many programs/projects must be considered, verification processes must be conducted before the commencement of portfolio selection to justify the inclusion of specific programs/projects in this process.

2.2.7 Trade-offs/conflict

MCDM enhances a DM’s ability to examine trade-offs between options and assess their influences on different stakeholders (Mysiak et al., 2005). There are several, usually inconsistent, targets linked to the selection of programs/projects for inclusion in a portfolio; for instance, are financial targets more important than political ones, and if so, to exactly what degree? In a MCDM’s closing stage, the ideal option is that which offers an appropriate cross-section of trade-offs among variables (Simonovic et al., 1997).

2.2.8 Group decision making

As DMs usually work in groups, which make formal and informal choices at different levels (Gutiérrez et al., 2008), their decision-making processes are a great deal more complicated than that of an individual or, arguably, even inefficient (Proctor, 2001). The members of a decision group may vary from an organisation’s senior executives with similar targets to its mid-level managers with entirely opposite ones (Davey and Olson, 1998). A key factor behind the complexities of group decision making is the lack of a strategy in which all DMs are able to present their opinions (Georgopoulou et al., 1997),
but there are few methods which can adequately overcome this difficulty (Leyva-Lopez and Fernandez-Gonzalez, 2003). It is necessary that DMs ensure that their perspectives are considered in a decision-making process (Miettinen and Salminen, 1999). Souder (1975) seeks to achieve consensus on portfolios by discovering mixtures of integrated comparisons, group discussions and participant connections in decision making.

2.2.9 Hierarchical structure (mutual links between projects and strategic levels)

A PPM procedure starts from, and reports to, the strategic level and manages a link between that and the operational level (Poskela et al., 2005). As previously stated, PPM decision-making methods can be very complicated, difficult to use and normally require large amounts of input information (Cooper et al., 2001b). To minimise these types of issues, a portfolio is structured hierarchically, with each phase beginning from a top-down (i.e., strategic level) or bottom-up (i.e., project/operational level) perspective. Moreover, PPM is generally set up at several levels within an organisation, including departmental, divisional, branch or unit ones, while some techniques, e.g., top-down and bottom-up ones, can line operations up at only an organisation’s strategic level (Cooper and Edgett, 2008). The capability of PPM to use top-down strategic objectives with bottom-up strategic processes are examined in various investigations (e.g., Crawford, 2001), with many studies (e.g., Meskendahl, 2010) suggesting the need for a mutual connection between the operational and strategic levels of an organisation. Killen et al. (2008) believe that the association of new system achievements with portfolio performance is a key factor for organisational growth.

2.2.10 Other criteria

Other challenges and requirements in accordance with operational assumptions (e.g., workforce management, financial availability, honesty, and politics and policy variations) are not considered in this assessment because they rely more on managing capabilities than on the techniques themselves. Nevertheless, this does not imply that these factors are less important during a PPM MCDM assessment process but that they are more in line with the operational stage following the selection of the preferred MCDM method(s).

A summary of the key PPM challenges in this study are presented in Table 1.

<table>
<thead>
<tr>
<th>Challenging factors</th>
<th>Description</th>
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<tbody>
<tr>
<td>Sensitivity analysis/uncertainty treatment</td>
<td>A decision assessment involves different inputs which may not be entirely specific (e.g., insufficient data, inaccurate cost information, an undetermined completion period, and little knowledge of the resources and benefits).</td>
</tr>
<tr>
<td>Dependencies</td>
<td>For effective decision making, the interdependencies in portfolios with several projects need to be known. Every program depends on the others and may be linked by many different dependencies. Often, as projects in portfolios are very interdependent in nature, all of them must be considered in every step of a decision-making process.</td>
</tr>
<tr>
<td>Decision traceability</td>
<td>To deal with PPM complexities (e.g., uncertainty and dependencies), it is essential to keep track of data and ensure that critical data is not eliminated and/or unnecessary data incorporated.</td>
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Table 1 Summary of key PPM challenges (continued)

<table>
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<tr>
<th>Challenging factors</th>
<th>Description</th>
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<tr>
<td>Simplicity</td>
<td>While most decision-making methods are very difficult to understand and/or apply, DMs are unlikely to use one that is not effective and simple. Also, as there is an overall lack of a framework for arranging these methods, choosing simple ones is one of the key elements for multiple decision making.</td>
</tr>
<tr>
<td>Quantitative and qualitative techniques</td>
<td>The strategic arrangement of projects in a portfolio, which is extremely critical, requires both quantitative and qualitative techniques.</td>
</tr>
<tr>
<td>Number of projects</td>
<td>As the number of possible projects in a portfolio can be enormous, the method used to solve decision challenges cannot be restricted to dealing with a certain number of items or options which is the case in some techniques.</td>
</tr>
<tr>
<td>Trade-offs/conflict</td>
<td>There are several, usually inconsistent, targets linked to the selection of programs, with prioritising them a challenging task. As non-compensatory methods fail to permit trade-offs between elements, only compensatory ones are selected for detailed analysis in this study.</td>
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<tr>
<td>Group decision making</td>
<td>Large and difficult decisions, especially at executive senior management levels, often require several DMs operating in groups.</td>
</tr>
<tr>
<td>Mutual link between projects and strategic levels (hierarchical structure)</td>
<td>PPM is generally set up at several levels, with its decision-making methods very complicated and usually requiring large amounts of input information. To minimise these types of issues, a portfolio needs to be structured in a hierarchical way so that each phase can begin from a top-down (strategic level) or bottom-up (project/operational level) perspective and examine the maturity of all levels in a PPM process (e.g., project, program and portfolio management/strategic ones).</td>
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3 Classifications of PPM decision-making techniques

An appropriate harmonic combination of projects must be selected to increase the benefit of a portfolio and its organisational strategy (PMI, 2006). Given that each project performs a unique function and presents an individual input to PPM, organisations have to determine, choose, prioritise and allocate options to different kinds of projects (Geraldi, 2008).

Techniques for eliminating and resolving multi-criteria issues are continually being developed while the number of MCDM related articles is gradually increasing (Wallenius et al., 2008). As there is no single MCDM method or tool that can support strategic PPM decision making, different ones are used to suit different PPM situations (Killen et al., 2008; Verbano and Nosella, 2010).

Despite the fact that earlier investigations examined and evaluated decision making, the work of Neumann and Morgenstern (1947) and Savage (1954) can be regarded as the beginning of multi-criteria studies.

3.1 Proposed classifications framework

On the basis of an extensive literature review of various decision-making methods (e.g., Hwang and Yoon, 1981; Hobbs, 1986; Hwang and Yoon, 1981; MacCrimmon, 1973a;
MCDM methods for minimising the challenges and complexities involved in dealing with large amounts of data during decision-making operations appear to have been used for the first time in the financial industry in the 1960s (Figueira et al., 2005), with a significant number of MCDM assessments based on a more recent investigation by MacCrimmon (1973b). MCDM also incorporates several methods that enable estimations of various requirements to assist DMs to select, rank and evaluate various options (Belton and Stewart, 2004). Although several researchers explain these issues in a basic manner by outlining their individual components and patterns, only a few (e.g., Goicoechea et al., 1982; Milan, 1982) clarify the steps in their algorithms.

Some researchers discuss processes for classifying and selecting a suitable MCDM technique based on its input specifications (e.g., Hwang and Yoon, 1981; Hobbs, 1986; Hwang and Yoon, 1981; Ozernoy, 1992). Also, Jelassi and Ozernoy (1989) recommend using a professional framework to select MCDM techniques, with Jacquet-Lagreze and
Siskos (2001) suggesting measurable, ordinal, probabilistic and fuzzy requirements. Bouyssou (1990), Georgopoulou et al. (1997) and Al-Kloub et al. (1997) all agree on the requirements for selecting MCDM methods, that is, they need to be simple and easy to understand, operational, complete, non-redundant and essential. Furthermore, Kheireldin and Fahmy (2001) categorise MCDM methods as cardinal, frequency, scale modelling and mixed information. MCDM methods are also grouped according to their allocated weights (Harboe, 1992). Hajkowicz (2000) proposes classifying MCDM methods as ‘continuous’ and ‘discrete’ techniques but excludes outranking ones.

This study classifies MCDM into multi-objective decision-making (MODM) (or continuous) and multi-attribute decision-making (MADM) (or discrete) techniques. The former can be used for an unlimited (infinite) number of options implicitly identified by their difficulties whereas the latter consider a limited (finite) number of options and criteria (Hajkowicz et al., 2000) which enables them to be sub-divided into ranking techniques (Nijkamp et al., 2013). Therefore, MODM techniques handle design/search problems and seek an optimal quantity which may change considerably in a decision challenge whereas MADM ones are effective for selection/evaluation problems (Hwang and Lin, 2012).

3.2.1 MADM/discrete methods

According to Yoon and Hwang (1995), MADM techniques share the following features: they screen, prioritise, select and rank a limited (finite) number of options; have various elements per issue and a variety of units of measurement among the elements; usually require data regarding the relative advantages of each element; generally, are available based on ordinal or cardinal data; and their difficulties can be stated in a matrix structure.

Research conducted during the past three decades shows an increasing number of new and combined MADM techniques with different classifications (e.g., Nijkamp et al., 2013), most of which belong to the categories of multi-attribute utility (utility-based); Outranking; and mixed (compromise) methods. Greco et al. (2004) classify these methods in the three categories of utility features, outranking relationships and models of decision principles. While Kangas et al. (2001), and Guitouni and Martel (1998) categorise them as:

1 the value and utility theory (known as ‘American school’ techniques)
2 outranking (a.k.a. ‘European school’ techniques)
3 interactive approaches.

Based on the theories behind them, this study groups MADM methods as follows.

3.2.1.1 Utility-based techniques (UBT) (a.k.a. multi-attribute utility techniques, compensatory methods or performance aggregation-based methods)

Neumann and Morgenstern (1947) and Savage (1954) were the first to present effective observations of how multi-criteria decisions are made. However, their experiments do not clearly assist DMs in making decisions involving complex multi-criteria tasks. In order to overcome these challenges, Keeney and Raiffa (1993) present UBTs that basically aim to allocate a utility amount to every alternative, for example the analytic hierarchy process (AHP) or analytic network process (ANP). What might make their recommendations
useful is that their model considers uncertainty and provides options for the alternatives to communicate with each another. Using a UBT, DMs can obtain accurate responses and solutions to a variety of choices (Belton and Stewart, 2002). UBTs are also referred to as compensatory methods because of their inadequate performances for some criteria (Linkov et al., 2006). A UBT does not consider choices to be mutually independent and tends to be more user-friendly and straightforward than other MCDM methods. However, its use of additive utility features is only applicable when the criteria are independent.

3.2.1.2 Outranking methods (a.k.a. partially compensatory or preference aggregation-based methods)

Outranking methods assess sets of preferences to determine whether option ‘A’ is at least as effective as option ‘B’ (Roy, 1991), that is, they rely on the philosophy that, as one option can attain a level of control over other available ones (Kangas et al., 2001), all the options need to be ranked (Rogers and Bruen, 1998). Two methods in this category are: elimination and choice expressing reality (ELECTRE); and preference ranking organisation method for enrichment evaluation (PROMETHEE). As outranking methods do not assume that only one best option is available; for instance, they do not consider the relative levels of importance of under and over performances, they are also referred to as partially compensatory methods. Usually, they are used when the factor metrics are difficult to aggregate or there are broad ranges of different units and unique dimensions for each factor (Seager and Theis, 2004). The major issue regarding the use of an outranking method is the different definitions of what represents outranking and how its threshold variables are arranged and later adopted by a DM.

3.2.1.3 Compromise methods

The compromise model (Milan, 1982; Yu, 1973) can assist DMs to arrive at a final decision for a problem with mixed factors and offer the best possible practical option by sharing ideas. Sometimes, the selection process draws on political factors whereby a DM can define the essential elements of compromise options (Yu, 1973). Compromise methods, such as the technique for order performance by similarity to ideal solution (TOPSIS), are driven by an aggregating feature that provides bonding to the ideal (Chatterjee et al., 2009) and a foundation for discussions concerning a DM’s choice based on the factors’ weights (Sayadi et al., 2009).

3.2.2 MODM/continuous methods

It is quite normal to simultaneously deal with various targets without having a clear direction as to which refer to performances and which to issues. These difficulties of ‘many multiple decision criteria’, ‘depending on limitations’ and ‘several targets’ are generally known as MODM problems. It is most likely that Kuhn and Tucker (1951) were the first to identify these issues which are also called ‘vector-maximum’ ones. The challenges of MODM (in a mathematical programming framework) are broken into different groups. The first does not require obtaining any data from DMs throughout the process of selecting an alternative as its techniques depend on pre-assumptions about the DMs’ choices (Milan, 1982; Zeleny, 2012). The second involves collecting cardinal or ordinal selected data prior to the solving process. A few of these approaches collect only
cardinal priorities while others, such as goal programming (GP), use a combination of the capabilities of both cardinal and ordinal data. The third delivers a number of alternative options from which DMs are able to select the ideal one, for example, data envelopment analysis (DEA) which offers options and results consistently connected to a DM’s opinion (Wu and Blackhurst, 2009).

MODM methods are much better at describing reality and verifying a large number of options than MADM ones (Cohon, 2013).

More detailed information on MODM and MADM methods and applications can be found in Hwang and Masud (1979) and Hwang and Yoon (1981).

4 Conclusions

PPM has become an essential part of an organisation’s capability to successfully direct its projects (Cooper et al., 1997b). It is a decision-making practice that examines and selects options, prioritises them and directs them between activities (Cooper et al., 2001b). However, few studies have addressed using MCDM in PPM decision making.

PPM aims to present a logical structure by which to determine the projects that need to be performed by a corporation (Tidd et al., 1997; Jonas, 2010; Killen and Hunt, 2010), with those associated with organisational policies required to be compared. Therefore, it is essential to identify the most suitable projects in PPM for selection and prioritisation procedures (Archibald, 2004; Englund and Graham, 1999; Wheelwright, 1992). Different projects may possess unique functions, with their types indicating various difficulties for final decisions and choosing PPM practices (Blomquist and Müller, 2006). Nevertheless, PPM studies have not yet properly highlighted the difficulties that DMs and organisations might encounter when integrating various methods (Geraldi, 2008) for identifying different options and projects (Bessant et al., 2011).

In this study, the PPM challenges are described and the problems associated with them are discussed in detail. Moreover, PPM MCDM techniques are broadly reviewed in light of other studies (e.g., Cooper et al., 2001b; Danilovic and Sandkull, 2005; Dawidson, 2006; Dye and Pennypacker, 1999; Verbano and Nosella, 2010).

There is a considerable degree of uncertainty related to the scoring of projects based on particular measures while decision assessments have different inputs which may not be entirely specific (French et al., 1998). According to Zimmermann (2000), a shortage of data might be the most common reason for uncertainty. Different studies that recommend procedures for modelling uncertainty are primarily concerned with examining criteria weights (CWs) (Wolters and Mareschal, 1995). This is certainly insufficient since many other areas of multi-criteria elements (i.e., CW and assessment techniques) can have an impact on the review and rating of options.

It would be an advantage for applications to put their techniques into practice, execute and control their data, and present their outcomes from both specific and multi-perspective viewpoints. This study identifies that practical functionality acts as a significant factor in the selection of a suitable technique (Miettinen, 2001). Another key element identified as important for selecting a technique for portfolio management decision making is the number of panel members responsible. A portfolio decision is normally arrived at by a committee which combines both the goal and weighted factors concerning organisational requirements defined by a program decision committee.
There are two main issues linked to MCDM which are hard to resolve. Firstly, some targets are qualitative (e.g., they have political targets) and, secondly, the targets usually conflict with each other. Hwang and Yoon (1981) propose two techniques (i.e., compensatory and non-compensatory) for solving such problems and identify that compensatory methods (e.g., scoring ones) allow trade-offs, that is, a minor decrease in one element is appropriate when it is supported by improvements in others. On the other hand, non-compensatory methods tend not to allow trade-offs, that is, a negative value in one element cannot be mitigated by positive values in any other. Therefore, as every element/aspect must be considered individually, evaluations are produced on an attribute-by-attribute basis. Although non-compensatory methods can remove dominant solutions/options, as they can suggest several alternatives which may not be effective for making decisions, they are excluded from this study.

As a result of this investigation, the key challenges of PPM include a sensitivity analysis of its interdependencies, traceability, simplicity, supporting quantitative and qualitative data, project quantity, trade-offs, group decision making and the mutual links between portfolio levels.

The major difficulty of this practice is classifying different MCDM techniques. An examination of the literature available on MCDM during the past three decades demonstrates that the complexity and diversity levels of this area of study have increased significantly, resulted in more new and mixed techniques and led to many classifications being proposed (e.g., Figueira et al., 2005). However, this study discovers that those classifications are generally not independent of the authors’ intentions in undertaking their examinations. Another issue is that some classifications are confusing or even conflicting, with identical inaccuracies related to several methods identified; for example, AHP is regarded as a qualitative method by some researchers (e.g., Alphonce, 1997) and a quantitative one by others (e.g., Moffett and Sarkar, 2006).

This study identifies that MCDM methods are the most suitable for dealing with PPM issues and classifies them in two groups, MODM and MADM techniques. Then, MADM ones are grouped in the three sets of: UBTs; outranking; and compromise methods. It seems that MADM techniques, in particular UBTs, are more suitable for PPM than MODM ones due to their simplicity and capability to handle uncertainty. However, their major drawback is probably that, in many difficult circumstances, they require many specifications to indicate an appropriate condition for decision making which makes them complicated and problematic (Ma, 2006).

Several researchers identify project prioritisation as a key factor in PPM (Elonen and Artto, 2003; Fricke and Shenbar, 2000). To date, there has been no comprehensive study focusing on managing the entire process from strategic planning using PPM to organisational achievements; for example, there is no ideal approach for adopting PPM, identifying the appropriate method for organising activities or techniques for use with organisational factors (Dawidson, 2006). Businesses prefer methodologies that fit their own cultures and enable them to examine the program aspects they think are the most critical (Cooper, 2012; Hall and Nauda, 1990). Also, the most suitable methodologies for developing a portfolio for one program might not be the best for another. Therefore, finding the most suitable PPM MCDM technique(s) is a challenging task which requires further investigation.
References


Multi-criteria decision-making methods for project portfolio management


