

REVIEW ARTICLE

Multiple criteria decision-making techniques and their applications – a review of the literature from 2000 to 2014

Abbas Mardani^{a*}, Ahmad Jusoh^b, Khalil MD Nor^a, Zainab Khalifah^a,
Norhayati Zakwan^a and Alireza Valipour^b

^aFaculty of Management, Universiti Teknologi Malaysia (UTM), Skudai Johor, 81310, Malaysia;

^bConstruction management center, RESA group, Universiti Teknologi Malaysia (UTM), Skudai Johor, 81310, Malaysia

(Received 6 May 2015; accepted 18 July 2015)

Multiple criteria decision-making (MCDM) is considered as a complex decision-making (DM) tool involving both quantitative and qualitative factors. In recent years, several MCDM techniques and approaches have been suggested to choosing the optimal probable options. The purpose of this article is to systematically review the applications and methodologies of the MCDM techniques and approaches. This study reviewed a total of 393 articles published from 2000 to 2014 in more than 120 peer reviewed journals (extracted from Web of Science). According to experts' opinion, these articles were grouped into 15 fields. Furthermore, these articles were categorised based on authors, publication date, name of journals, methods, tools, and type of research (MCDM utilising research, MCDM developing research, and MCDM proposing research). The results of this study indicated that in 2013 scholars have published articles more than in other years. In addition, the analytic hierarchy process (AHP) method in the individual tools and hybrid MCDM in the integrated methods were ranked as the first and second methods in use. Additionally, the *European Journal of Operational Research* as the first journal with 70 publications was the significant journal in this study. Finally, energy, environment and sustainability were ranked as the first areas that have applied MCDM techniques and approaches.

Keywords: decision-making techniques and approaches; multiple criteria decision-making (MCDM); literature review

JEL classification: C4-C44

1. Introduction

Multiple criteria decision-making (MCDM) has grown as a part of operations research, concerned with designing computational and mathematical tools for supporting the subjective evaluation of performance criteria by decision-makers (Zavadskas, Turskis, & Kildienė, 2014). Several studies have been carried out to develop MCDM (Zavadskas & Turskis, 2010; Zavadskas, Turskis, Antucheviciene, & Zakarevicius, 2012). In recent years several previous studies have employed MCDM tools and applications to solve area problems such as energy, environment and sustainability (Şengül, Eren, Eslamian Shiraz, Gezder, & Şengül, 2015; Soltani, Hewage, Reza, & Sadiq, 2015; Zavadskas, Turskis, & Bagočius, 2015), supply chain management (Rajesh & Ravi, 2015), material (Zavadskas, Kaklauskas, Trinkunas, & Trinkuniene, 2004), quality management (Lupo,

*Corresponding author. Email: mabbas3@live.utm.my

2015), GIS (Latinopoulos & Kechagia, 2015), construction and project management (Monghasemi, Nikoo, Khaksar Fasaee, & Adamowski, 2015), safety and risk management (Ilangkumaran, Karthikeyan, Ramachandran, Boopathiraja, & Kirubakaran, 2015), manufacturing systems, technology and information management (Oztaysi, 2014), operation research and soft computing (Angilella & Mazzù, 2015; Bouyssou & Marchant, 2015; Zhu, Xu, Zhang, & Hong, 2015; Del Vasto-Terrientes, Valls, Słowiński, & Zielniewicz, 2015; Chen, 2015; Roszkowska & Wachowicz, 2015), strategic management (Hosseini Nasab & Milani, 2012), production management (Rabbani, Zamani, Yazdani-Chamzini, & Zavadskas, 2014) and tourism management (Akincilar & Dagdeviren, 2014).

Since the 1960s, MCDM has been an active research area and produced many theoretical and applied articles and books (Roy, 2005). MCDM methods have been designed to designate a preferred alternative, classify alternatives in a small number of categories, and/or rank alternatives in a subjective preference order. MCDM is a generic term for all methods that exist for helping people make decisions according to their preferences, in cases where there is more than one conflicting criterion (Ho, 2008). Using MCDM can be said to be a way of dealing with complex problems by breaking the problems into smaller pieces. After weighing some considerations and making judgements about smaller components, the pieces are reassembled to present an overall picture to the DMs. Most of MCDM methods deal with discrete alternatives, which are described by a set of criteria. Criteria values can be determined as a cardinal or ordinal information. Information could be determined exactly or could be fuzzy, determined in intervals. Modern MCDM methods enable decision-makers to deal with all above mentioned types of information. One of the problems encountered during the MCDM process is the choice of the aggregation procedure for solving the decision problem. However, multiple criteria decision analysts provide a variety of aggregation procedures. Recent decades have seen a dramatic increase on all main areas of MCDM: Formal models (algorithms, procedures and selection paradigms); Evaluation theories (assumptions about values or preferences and structured representations of values or preferences); Assessment methodologies (elicitation, estimation and scaling of individuals' preferences, utilities and subjective probabilities in MCDM situations) (Fishburn, 1978; Zavadskas et al., 2014). There is no unique and well-defined methodology that one could follow step-by-step from the beginning to the end of a decision aiding process. When dealing with objects that can only be described and compared using several characteristics, aggregation is a major issue: it aims at operating a synthesis of the, usually contradictory, features of the objects, in view of achieving a goal such as choosing among the objects, rank ordering them, sorting them into categories and so on (Bouyssou, Marchant, Pirlot, Tsoukias, & Vincke, 2006).

This study has the following contributions: MCDM is one of the most widely used decision methodologies in various fields such as; energy and environment, business, economy, production, and so on. MCDM techniques and approaches improve the quality of decisions by creating the development more efficient, rational and explicit. Several studies (Behzadian, Kazemzadeh, Albadvi, & Aghdasi, 2010; Ho, 2008; Vaidya & Kumar, 2006) have demonstrated the vitality of the field and reported several methods proposed in the literature. A large number of approaches and techniques have been introduced in this area of study. However, previously-conducted surveys have not kept pace. Thus, we believe that there is a need for a new systematic survey to consolidate recent research conducted on this area of study. In recent decades, the MCDM techniques and approaches have received a great deal of attention from practitioners and

researchers. This article attempts to document the exponentially grown interest in the MCDM techniques and approaches and provide a state-of-the-art review of the literature regarding the MCDM applications and methodologies. Based on a classification scheme, a reference repository has been established, including 393 articles published in more than 120 international journals from 2000. Articles are classified based on the year of publication, application areas, authors' nationality, and MCDM techniques and approaches combined with other methods. This article is evolving a categorising structure with a focus on applicable considerations, presenting an organised review in a way to provide a guide to previous studies on the MCDM tools and approaches, and recognising topics for future research. Additionally, in our study, two new perspectives are taken into consideration to review the articles, namely categorisation of the articles into 15 fields (energy, environment and sustainability, supply chain management, material, quality management, GIS, construction and project management, safety and risk management, manufacturing systems, technology management, operation research and soft computing, strategic management, knowledge management, production management, tourism management and other fields) and examination of the type of study (MCDM utilising research, MCDM developing research, MCDM proposing research).

In this article, the literature related to the descriptors of MCDM has been reviewed comprehensively using academic databases of Web of Science. Following a methodological decision analysis on the whole collected articles, a total of 393 international journal articles published from 2000 to 2014 were reviewed. This article attempts to answer the following questions: (1) which decision-making (DM) techniques have been used?; (2) Which type of study has been conducted on these MCDM techniques?; (3) Which one of the 15 fields (Energy, environment and sustainability, Supply chain management, Material, Quality management, GIS, construction and project management, safety and risk management, manufacturing systems, technology management, operation research and soft computing, strategic management, knowledge management, production management, tourism management and other fields) has further used these MCDM techniques and approaches?; (4) What kinds of MCDM techniques and approaches have been employed in these years based on 15 fields?; (5) Which journal published articles related to these MCDM techniques and approaches?; and (6) In which year, the previous authors published more papers regarding MCDM techniques and approaches based on the 15 fields?

The remainder of this article is organised as follows. Section 2 provides a brief overview of the literature review and framework. Section 3 describes the research methodology and the procedure of this study. Section 4 provides the findings of this review based on the research objectives and questions. Section 5 discusses the results based on the research questions. Finally, Section 6 presents the conclusion, limitations and recommendations for future studies.

2. Summary of the literature review

MCDM methods cover a wide range of quite distinct approaches. MCDM methods can be broadly classified into two categories: discrete MCDM or discrete Multi-attribute Decision-Making (MADM) and continuous Multi-objective Decision-Making (MODM) methods (Chauhan & Vaish, 2012; Zavadskas et al., 2014). Recently, hundreds of publications have been published to provide information about MCDM methods, their development and application in different fields. This article attempts to document the exponentially grown interest in the MCDM techniques and approaches and provide a

state-of the-art review of the literature regarding the MCDM applications and methodologies. The research is based on Web of Science database, which is a part of Thomson Reuters Web of Knowledge. The 1970s was an important decade for many seminal works. The foundations of modern MCDM were developed in 1950s and 1960s. The development of MCDM research accelerated during the 1980s and early 1990s, and seems to have continued its exponential growth (Köksalan, Wallenius, & Zionts, 2011). The book by Köksalan, Wallenius, and Zionts (2011) provides a brief history of the development of MCDM methods. It briefly describes the development of the area from ancient to modern times. Keeney, Raiffa, and Rajala (1979), formulated the basics of Decision with Multiple Objectives. Hwang and Masud (1979), provided review on development of MODM methods and applications in a relatively short period of time. Later, Tzeng and Huang (Tzeng & Huang, 2011) reviewed the MADM methods [simple additive weighting (SAW), technique for order of preference by similarity to ideal solution (TOPSIS), elimination and choice expressing reality (ELECTRE), and the linear programming technique for multidimensional analysis of preference (LINMAP)].

Saaty (1980), published a detailed study on the analytic hierarchy process (AHP). Later, Saaty (1996) published a study on the further development of the analytic network process (ANP) method. Zeleny and Cochrane (1982) published a book which deals with the problem of compromise theory. Hwang and Lin (1967), published a study for Group Decision Making Under Multi-criteria. Roy (1996) summarised the information on ELECTRE group methods. Seminal studies have been prepared by Belton and Stewart (2002) and Gal, Stewart, and Hanne (1999), Miettinen (1999). Brauers (2004) published a study on the basis of which multi-objective. optimization by ratio analysis (MOORA), and multiple objective optimization on the basis of ratio analysis plus full multiplicative form (MULTIMOORA) methods were developed. Recently, the development of hybrid and modular methods is becoming increasingly important. They are based on previously developed well-known methods, such as TOPSIS (Hwang & Yoon, 1981), SAW (MacCrimmon & Rand, 1968), AHP (Saaty, 1971, 1988), ANP (Saaty, 1996), Vise Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR; Opricovic, 1998; Opricovic & Tzeng, 2002), decision making trial and evaluation laboratory (DEMATEL; Fontela & Gabus, 1976), DEA (Charnes, 1994; Charnes, Cooper, & Rhodes, 1978), preference ranking organization method for enrichment evaluations (PROMETHEE; Mareschal, Brans, & Vincke, 1984), ELECTRE (Roy, 1968, 1971, 1978; Roy & Bertier, 1972) and their modification, by applying fuzzy and grey number theory. Relatively recently developed MCDM methods, such as generalized regression with intensities of preference (GRIP; Figueira, Greco, & Słowiński, 2009), complex proportional assessment method (COPRAS; Zavadskas & Antucheviciene, 2007; Zavadskas, Kaklauskas, & Sarka, 1994; Zavadskas, Kaklauskas, Turskis, & Tamošaitiene, 2008), additive ratio assessment (ARAS; Turskis & Zavadskas, 2010; Zavadskas & Turskis, 2010; Zavadskas et al., 2008), RUTA (Kadziński, Greco, & Słowiński, 2013) MOORA (Brauers & Zavadskas, 2006), UTADIS^{GMS} (Greco, Kadziński, & Słowiński, 2011), MULTIMOORA (Brauers & Zavadskas, 2010), step-wise weight assessment ratio analysis (SWARA; Keršulienė, Zavadskas, & Turskis, 2010) and weighted aggregated sum product assessment (WASPAS; Zavadskas, Turskis, Antucheviciene, & Zakarevicius, 2012) are rapidly developed and applied to solve real life problems.

3. Research methodology

This article reviews the literature in order to recognise the articles that have been published in popular journals and provided the most important information to practitioners and researchers who investigate issues related to the MCDM methods. To this end, an extensive search was carried out to find MCDM in titles, abstracts, keywords, and research methodologies of the article. This article attempts to document the exponentially grown interest in the MCDM methods and provide a state-of-the-art review of the literature regarding the MCDM applications and methodologies. According to a classification scheme, a reference repository, including a total of 393 published articles in more than 120 journals since 2000, has been established. The articles are classified in terms of the application areas, publication year, the journal's name and MCDM techniques and approaches. The present article has three contributions: the development of a classification scheme with a focus on practical considerations, structurally reviewing the literature to guide the research on the MCDM techniques and approaches, and the identification of issues to be studied in future. Additionally, two new perspectives are taken into consideration to review the articles, namely the categorisation of the articles into four 15 fields (energy, environmental and sustainability, supply chain management, material, quality management, GIS, construction and project management, safety and risk management, manufacturing systems, technology management, operation research and soft computing, strategic management, knowledge management, production management, tourism management and other fields) and examination of the type of study (MCDM utilising research, MCDM developing research, MCDM proposing research).

In particular, we targeted Web of Science which covers the most important journals in 15 fields. Items such as doctoral dissertations, master's theses, textbooks, conference proceeding articles, and unpublished articles were ignored in this review. For this review, the primary data were collected from 393 cited articles related to MCDM published since 2000. For choose 393 scholarly journal articles we have used most of international journals specially related to DM methods. Some of journals cited in this review were, *Expert Systems with Applications*, *Applied Soft Computing*, *Journal of Intelligent and Fuzzy Systems*, *Information Sciences*, *International Journal of Production Research*, *Technological and Economic Development of Economy*, *European Journal of Operational Research*, *International Journal of Intelligent Systems*, *International Journal of Production Economics*, *Mathematics and Computers in Simulation*, *Fuzzy Sets and Systems*, *Omega*, *Knowledge-Based Systems*, *International Journal of Information Technology & Decision Making*, *Computers in Industry* etc. The majority of articles on MCDM have been published since 2000; as a result, this year was chosen as the starting date for this study. It is noticeable that since online database access point is limited, some articles could not be downloaded; for that reason, they were overlooked in this survey. After reviewing each article, the article was summarised and highlighted. An article is taken into consideration in this review if it discusses thoroughly the application and development of MCDM.

MCDM is the most well-known branches of DM. In the DM approach, the selection is made from amongst the decision alternatives that are described by their attributes. Over time, a large number of MCDM techniques and approaches have been proposed, which are different in their theoretical background, the type of questions asked, and the type of obtained results. For a given problem, a number of methods have been particularly proposed, which cannot be applied to other problems. Several keywords and criteria should be taken into account for the selection of an MCDM method. In this

review article, to identify the scholarly articles related to DM methods in the database, we have searched using several keywords, they were: MCDM, DM, AHP, COPRAS, TOPSIS, VIKOR, ELECTRE, MULTIMOORA, DEMATEL, SWARA, ANP, MOORA, PROMETHEE, WASPAS, SAW, FDM, ARAS, Entropy, Hybrid MCDM, and so on. After a preliminary search and collecting these scholarly articles, those relating to DM techniques and approaches were selected.

4. Results

4.1. Classifications and observations

This article is based on a literature review and classification of international journal articles from 2000 to 2014. The majority of the journals are specialist journals in the MCDM area. For the purpose of this part of the article, some of journals are listed based on publishers, and some journals (e.g. Web of Science database) are integrated based on their publishers.

Research on MCDM continued and found many applications to different fields. MCDM provides strong DM in domains where selection of the best alternative is highly complex. This article reviews the main streams of considerations in MCDM theory and practice in detail, and we aimed to identify various applications and approaches and suggest approaches that can be most robustly and effectively used to identify the best alternative. This survey also addresses the problems in MCDM techniques. MCDM method has been applied to many domains to choose the best alternatives. Where many criteria have come into existence, the best one can be obtained by analysing different scopes of the criteria, weights of the criteria, and the selection of the optimum ones using any MCDM techniques.

This article investigates the developments of various methods of MCDM and its applications. In our daily life, many decisions are made based on various criteria; thus the decision can be made by assigning weights to different criteria and all the weights are obtain from expert groups. It is important to determine the structure of the problem and explicitly evaluate multi-criteria. For example, in building a nuclear power plant, certain decisions have been taken based on different criteria. There are not only very complex issues involving multi-criteria, some criteria may have an effect on some problems; however, to have an optimum solution, all alternatives must have common criteria, which clearly lead to more informed and better decisions. The AHP method is used in the analysis of the health-safety and environmental risk assessment of refineries for the location of the power plant, the risk factors such as health-safety risk, technology risk, etc. (Rezaian & Jozi, 2012). TOPSIS has been applied to the selection of the best strategic technology for the fuel cell in the automotive industry (Sadeghzadeh & Salehi, 2011).

In all these articles, different methods have been used for different applications where each method has its own characteristics in finding the best alternatives. The applications developed to solve multi-choice problems and the selected MCDM methods provide better performance in cases such as Energy, environment and sustainability, Supply chain management, Material, Quality management, GIS, construction and project management, safety and risk management, manufacturing systems, technology management, operation research and soft computing, strategic management, knowledge management, production management, tourism management and other fields. Table 1 presents the distribution of articles based on application fields.

Table 1. Distribution papers based on application areas.

Application fields	Number of paper	Percentage
Energy, environmental and sustainability	53	13.49
Supply chain management	23	5.85
Material	21	5.34
Quality management	12	3.05
GIS	14	3.56
Construction and project management	18	4.58
Safety and risk management	14	3.56
Manufacturing systems	32	8.14
Information technology management	25	6.36
Operation research and soft computing	109	27.74
Strategic management	8	2.04
Knowledge management	5	1.27
Production management	18	4.58
Tourism management	11	2.80
Other fields	30	7.63
Total	393	100

Source: Authors' calculation.

4.2. Field of category

Due to wide range of applications of MCDM in the real world, there is a strong motivation to categorise these applications across several areas and particular sub-areas. The studies that have used MCDM are categorised into three groups: MCDM utilising research, MCDM developing research, and MCDM proposing research. To identify the differences and similarities, the 393 articles were categorised into the 15 fields we have previously mentioned. In cases of articles that could fall into more than one category, based on the targeted audience defined by the article's objectives, the best possible choice was selected. This ensured the absence of any duplication in the classification scheme. In the following sections, the articles are briefly presented and each topic is further summarised using tables corresponding to their sub-areas. In each table, the articles are summarised and highlighted according to their introductions, research methods, and the results of the study. Similarly, previous studies (e.g., Behzadian, Khanmohammadi Otaghsara, Yazdani, and Ignatius (2012)) have categorised TOPSIS articles based on area of applications like manufacturing systems, supply chain issue, business and management, human resource management, energy and safety, environmental science and so on.

4.3. GIS, IT management and material science

In fields of GIS, IT management and material science various scholars have employed MCDM techniques and approaches. These fields involve several particular sub-fields including; GIS; landslide susceptibility mapping (Yalcin, Reis, Aydinoglu, & Yomralioglu, 2011), ArcGIS (Marinoni, 2004), GIS-based solar farms site (Uyan, 2013), in the field of IT management, information technology (Oztaysi, 2014), technology network (Lee, Kim, & Park, 2009), information service (Chen & Wang, 2010) and field of material science (Jahan, Mustapha, Ismail, Sapuan, & Bahraminasab, 2011; Cavallini, Giorgetti, Citti, & Nicolaie, 2013; Chatterjee, Athawale, & Chakraborty, 2009; Chatterjee, Athawale, &

Chakraborty, 2011; Shanian, Milani, Carson, & Abeyaratne, 2008; Mayyas et al., 2011). In these fields of applications, a total of 52 articles have applied MCDM techniques and approaches, GIS is 13 articles (3.27%), material science, 18 articles (4.52%) and IT 21 articles (5.28%).

4.4. Operation research, soft computing and other fields

In fields of operation research and soft computing some of previous studies have developed, proposed and presented the MCDM techniques and approaches. Most of these previous studies have attempt to solving problems in DM techniques and approaches. For example in case of developed AHP technique; (Lin, Wang, Yu, 2008; Lai, Wang, Wang, 2008; Hu & Tsai, 2006; Bortot & Marques Pereira, 2013), in the case of the TOPSIS method (Liu, Chan, & Ran, 2013; Shidpour, Shahrokhi, & Bernard, 2013; Jahanshahloo, Lotfi, & Izadikhah, 2006a; Zhang & Yu, 2012; Baky, 2014; García-Cascales & Lamata, 2012), DEMATEL technique (Li & Tzeng, 2009), ELECTRE (Figueira, Greco, Roy, & Słowiński, 2013), (Leyva-López & Fernández-González, 2003), PROMETHEE (Zhang, Fan, & Liu, 2010; Ishizaka & Nemery, 2011; Hu, 2010), ANP (Khademi, Mohaymany, Shahi, Zerguini, 2012; Lin, Chen, & Ting, 2010), and VIKOR (Sayadi, Heydari, & Shahanaghi, 2009; Ju & Wang, 2013; Liu, Mao, Zhang, & Li, 2013). Operation research and soft computing fields had the first rank in these categories, in these fields; 109 previous scholars (27.74%) have applied MCDM techniques and approaches.

4.5. Energy, environment and sustainability field

According to our review in fields of energy, environment and sustainability 55 studies (13.45%) have used MCDM techniques and approaches. Energy, environment and sustainability fields involve several specific sub-fields, some recent applications of MCDM approaches, including energy polices (Abid & Bahloul, 2011), energy resource planning (Erol & Kilkış, 2012), and renewable energy (Papadopoulos & Karagiannidis, 2008). In the environment field, environmental factors (Hasanzadeh, Danehkar, & Azizi, 2013), environmental production (Lin, Cheng, Tseng, & Tsai, 2010), environmental management system (Sambasivan & Fei, 2008), eco-environmental quality (Ying et al., 2007). In the field of sustainability: risk sustainability (Stankevičienė, Sviderskė, & Miečinskienė, 2014), government sustainability (Bilbao-Terol, Arenas-Parra, Cañal-Fernández, & Antomil-Ibias, 2014), transport sustainability (Bojković, Anić, & Pejčić-Tarle, 2010), sustainable flooring systems (Reza, Sadiq, & Hewage, 2011) and hydrogen sustainability (Ren, Manzardo, Toniolo, & Scipioni, 2013).

4.6. Supply chain, quality, production management and manufacturing systems field

Some previous scholars have applied MCDM techniques and approaches in fields on supply chain management, quality management, production management and manufacturing systems. These fields involve several specific sub-fields and sub-areas, in total 94 articles (22.74%) have used MCDM techniques and approaches, some recent publications in field of supply chain management including; supplier performance (Kang & Lee, 2010), supplier selection (Bruno, Esposito, Genovese, & Passaro, 2012; Huang, Tong, Chang, & Yeh, 2011), supplier quality (Ho, Feng, Lee, & Yen, 2012), logistic suppliers (Chen, Pai, & Hung, 2010), process of supply chain (Kirytopoulos, Leopoulos,

& Voulgaridou, 2008), sustainable supply chain management (Büyüközkan & Berkol, 2011). In the quality management field, service quality (Liou, Tsai, Lin, & Tzeng, 2011), quality indexes (Tong, Kwong, & Ip, 2003), quality parameters (Ghosh & Das, 2013), quality of learning (Kurilovas & Zilinskiene, 2013). In the field of production management, the production of thin-film (Cavallaro, 2010), production technologies (Streimikiene, Balezentis, Krisciukaitienė, & Balezentis, 2012), mass production (Chang, Hu, & Hong, 2013). In the manufacturing systems field are; the manufacturing sector (Bagočius, Zavadskas, & Turskis, 2014), manufacturing systems (Jana, Bairagi, Paul, Sarkar, & Saha, 2013), global manufacturing (Tzeng & Huang, 2012), and manufacturing strategy (Yurdakul, 2004).

4.7. Strategic, knowledge and tourism management field

In the field of knowledge management, strategic management and tourism management, some previous studies (5.86%) have published articles in different fields of MCDM techniques and approaches. Knowledge management, strategic management and tourism management involve several specific sub-fields, some recent applications of MCDM approaches in including, knowledge management (Li, Jin, & Wang, 2014; Carlucci & Schiuma, 2009; Kanapeckiene, Kaklauskas, Zavadskas, & Seniut, 2010; Chu, Shyu, Tzeng, & Khosla, 2007). In the field of strategic management (Baležentis & Baležentis, 2011; J. J. Liou, 2012; Sadeghzadeh & Salehi, 2011). In the tourism management field Liu, Tzeng, and Lee (2012), Bunruamkaew and Murayam (2011), and Hsieh, Lin, and Lin (2008), The results of Table 1 indicated that, in total 24 articles have published in these field and sub-fields.

4.8. Construction, project, safety and risk management field

Results of Table 1 showed that, in fields of construction management, project management, safety and risk management 37 articles (9.05%) have applied an MCDM approach and techniques. Construction management, project management, safety and risk management involve several specific sub-fields, some recent applications of MCDM approaches include: construction management (Zavadskas, Turskis, Volvačiovos, & Kildiene, 2013; Zavadskas, Skibniewski, & Antucheviciene, 2014; Kanapeckiene et al., 2010; Brauers, Kildienė, Zavadskas, & Kaklauskas, 2013; Gudienė, Banaitis, Podvezko, & Banaitienė,

Table 2. Summary of applications of the DM techniques.

DM techniques	Frequency of application	Percentage
AHP	128	32.57
ELECTRE	34	8.65
DEMATEL	7	1.78
PROMETHEE	26	6.62
TOPSIS	45	11.4
ANP	29	7.38
Aggregation DM methods	46	11.70
Hybrid MCDM	64	16.28
VIKOR	14	3.56
Total	393	100.00

Source: Authors' calculation.

2014) in field of project management (Buchanan & Vanderpooten, 2007; Mohammadi, Sadi, Nateghi, Abdullah, & Skitmore, 2014; Zavadskas, Turskis, Tamošaitiene, & Marina, 2008), in the area of risk management (Jiang, Hu, & Jin, 2007; Wabiri & Amusa, 2010), and in fields of safety (Liu, Mao, Li, & Yao, 2007; Wang, Qin, Li, & Chen, 2009; Chen, Jin, Qiu, & Chen, 2014; Dėjus & Antuchevičienė, 2013).

4.9. Distribution based on MCDM techniques and approaches

Table 2 shows frequency of MCDM techniques and approaches. Based on the results presented in this table, a total of 393 studies have employed DM techniques and approaches. This table shows that AHP method (32.57%), and its applications have been used more than other tools and approaches. The second one is the hybrid MCDM techniques and approaches (16.28%) and DM aggregation methods (11.70%) are the third in this ranking. The frequency of other tools and approaches are presented in Table 2. All tables sorted articles alphabetically by author name.

Table 3. Distribution based on AHP.

Authors	Year	Type of study	Tools and approaches
(Yalcin, Reis, Aydinoglu, & Yomralioglu)	2011	Utilised research	Evaluated of landslide susceptibility mapping by utilised AHP and GIS
(Abba, Noor, Yusuf, Din, & Hassan)	2013	Utilised research	Used AHP for assessment of environmental impacts of solid waste disposal
(Abid & Bahloul)	2011	Utilised research	Employed AHP for determine the attractiveness factors
(Aguilar-Lasserre, Bautista, Bautista, Ponsich, & González Huerta)	2009	Utilised research	Utilised AHP for problem solving in selection of tool for the batch plant design
(Al Khalil)	2002	Utilised research	Selected the best project delivery by utilised AHP
(Al-Harbi)	2001	Utilised research	Project management evaluation by utilised AHP
(Yalcin)	2008	Utilised research	Applied AHP for three susceptibility maps
(Rezaei & Ortt)	2013	Utilised research	Applied AHP for evaluation of supplier segmentation
(Aminbakhsh, Gunduz, & Sonmez)	2013	Utilised research	Assessed of safety risk factors by used AHP
(Ataci, Shahsavany, & Mikaeil)	2013	Developed research	Determined the level of confidence of each alternative's score by used AHP
(Ayağ)	2005	Utilised research	Evaluated of conceptual design in a NPD environment by used AHP
(Azadeh, Ghaderi, & Izadbakhsh)	2008	Utilised research	Integrated of AHP for improve of the railway system
(Barker & Zabinsky)	2011	Utilised research	Employed AHP for assessment of reverse logistics
(Benítez, Delgado-Galván, Izquierdo, & Pérez-García)	2012	Developed research	Improved AHP based on pairwise comparisons with numerical judgements

(Continued)

Table 3. (Continued).

Authors	Year	Type of study	Tools and approaches
(Bentes, Carneiro, da Silva, & Kimura)	2012	Utilised research	Utilised AHP for performance assessment based on BSC framework
(Bertolini, Braglia, & Carmignani)	2006	Utilised research	Best discount selection in defining of proposal by used AHP
(Bortot & Marques Pereira)	2013	Developed research	Extended of the standard AHP aggregation scheme
(Altuzarra, Moreno-Jiménez, & Salvador)	2007	Proposed research	Proposed AHP-GDM for solving problems in DM tools
(Bernasconi, Choirat, & Seri)	2014	Developed research	Used Aggregation approaches in the AHP for classification based on algebraic properties
(Brent, Rogers, Ramabitsa-Siimane, & Rohwer)	2007	Utilised research	Sustainable development by used AHP for health care waste management systems
(Brunelli, Critch, & Fedrizzi)	2013	Developed research	Employed AHP for proportionality between some consistency indices
(Bruno, Esposito, Genovese, & Passaro)	2012	Utilised research	Evaluated of supplier based on AHP method
(Bunruamkaew & Murayam)	2011	Utilised research	Implemented AHP for evaluation of ecotourism sites
(Buyurgan & Saygin)	2008	Utilised research	Assessed advanced manufacturing systems by utilised for part routing and real-time scheduling
(Lee, Lee, Seol, & Park)	2012	Utilised research	Implemented AHP for assessment of new service concepts (NSCs)
(Chen)	2014	Utilised research	Assessment of tourism festival activities with AHP
(e Costa & Vansnick)	2008	Developed research	Used derived ranking in AHP for critical analysis of the eigenvalue method
(Lin, Wang, & Yu)	2008	Developed research	Adopted AHP for soft computing scheme and genetic Algorithms
(Chang, Wu, Lin, & Chen)	2007	Utilised research	Employed AHP for manufacturing quality in order to forecasting programmes
(Cay & Uyan)	2013	Utilised research	Evaluated of reallocation in land consolidation by used AHP
(Chan, Ip, & Lau)	2001	Utilised research	Utilised AHP for favourable equipment type
(Chinese, Nardin, & Saro)	2011	Utilised research	Space heating systems selection by utilised AHP
(Chwolka & Raith)	2001	Developed research	Extended different group preference aggregation approaches used in the AHP for solving problems DM issues
(Daim, Udbye, & Balasubramanian)	2012	Utilised research	Used AHP for selection of 3PL provider
(De Feo & De Gisi)	2010	Utilised research	Assessed of stakeholders involvement for ranking suitable MSW facility sites by utilised AHP
(Di Gironimo, Carfora, Esposito, Labate, Mozzillo, Renno, Lanzotti, & Siuko)	2013	Utilised research	Evaluation of RH system by employed AHP and TRIZ
(Dong, Hong, Xu, & Yu)	2013	Proposed research	presented an algorithm for achieve the linguistic individual in AHP

(Continued)

Table 3. (Continued).

Authors	Year	Type of study	Tools and approaches
(Effat & Hassan)	2013	Utilised research	Evaluated of economic and environmental by utilised AHP
(Entani & Sugihara)	2012	Proposed research	Proposed the models to achieve intervals of attributes based on AHP
(Erol & Kılıkış)	2012	Utilised research	Used AHP for activities of facilitate energy resource planning
(Wang, Qin, Li, & Chen)	2009	Utilised research	Used AHP for solving problem in selection of solid waste landfill site
(Gass & Rapcsák)	2004	Proposed research	Proposed new method to determine of associated weights in SVD based on AHP
(Ghosh & Das)	2013	Utilised research	Evaluation of jute fibres quality parameters by used AHP
(Gudienė, Banaitis, Podvezko, & Banaitienė)	2014	Utilised research	Identified and assessed of construction projects CSFs by used AHP
(Kou & Lin)	2014	Developed research	Proposed CM method based on the similarity measure in AHP
(Kang & Lee)	2010	Utilised research	Evaluation of supplier performance by utilised AHP
(Hajeeh & Al-Othman)	2005	Utilised research	Employed AHP for selection of technology for seawater desalination
(Handfield, Walton, Sroufe, & Melnyk)	2002	Utilised research	Employed AHP to help understand of the managers in trade-offs of environmental
(Hongwei, Zhanpeng, Shaoqi, & Ruihua)	2004	Utilised research	Assessed of the anaerobic biodegradability by used AHP
(Huang, Tong, Chang, & Yeh)	2011	Utilised research	Supplier selection by employed AHP
(Huo, Lan, & Wang)	2011	Developed research	Improved AHP by used a new parametric prioritisation method
(Ic, Yurdakul, & Eraslan)	2012	Utilised research	Implemented AHP for machine-selection
(Ivlev, Kneppo, & Bartak)	2014	Utilised research	Medical equipment selection by used AHP
(Jiang, Hu, & Jin)	2007	Utilised research	Used AHP for assessment of economic risk in real estate project
(Jovanovic, Krivokapic, & Vujovic)	2013	Utilised research	Applied AHP for assessment of environmental impacts
(K. Xu, Kong, Li, Zhang, & Wu)	2011	Utilised research	Implemented of AHP for evaluation of geological factors
(Kallas & Gil)	2012	Utilised research	Applied AHP for derive the WTP for complex goods
(Kallas, Lambarraa, & Gil)	2011	Utilised research	Used AHP for compared individual preferences for attributes and levels of an agro-food product
(Kayastha, Dhital, & De Smedt)	2013	Utilised research	Assessed landslide susceptibility map by employed AHP
(Kildienė, Zavadskas, & Tamošaitienė)	2014	Utilised research	Used AHP for evaluation of advanced technology deployment

(Continued)

Table 3. (Continued).

Authors	Year	Type of study	Tools and approaches
(Konidari & Mavrakis)	2007	Utilised research	Utilised AHP for defining coefficients weights for criteria and sub-criteria in stockholders groups
(Kurilovas & Zilinskiene)	2013	Proposed research	Presented MCEQLS AHP for the expert evaluation of quality of learning scenarios
(Lai, Wang, & Wang)	2008	Utilised research	Applied AHP for evaluation of budgets in construction project
(Lai, Wong, & Cheung)	2002	Utilised research	Used AHP for selection of software
(Liao & Kao)	2010	Utilised research	Solving supplier selection problems by integrated AHP, Taguchi loss function and goal programming
(Chen & Wang)	2010	Utilised research	Applied for evaluation of six business models
(Lin, Lee, & Ho)	2011	Utilised research	Developed economic by used AHP
(Mahdi & Alreshaid)	2005	Utilised research	Selection of the proper delivery by used AHP
(Millet & Saaty)	2000	Proposed research	Proposed procedures for choose of synthesis mode
(Yavuz, Iphar, & Once)	2008	Utilised research	Employed AHP for selection the best support design for the main transport road
(Beynon)	2005	Developed research	Investigated of the non-specificity and local ignorance measures by utilised AHP
(Beynon)	2002a	Developed research	Developed DS/AHP with respect to the measurement for understands of uncertainty
(Beynon)	2002b	Developed research	Used AHP for analysis of distributions
(Manca & Brambilla)	2011	Utilised research	Used AHP for activity assessment
(Maniya & Bhatt)	2011	Proposed research	Proposed AHP/M-GRA model for the selection of AGV alternative
(Marinoni)	2004	Utilised research	Developed of an ArcGIS VBA macro by applied AHP
(Mau-Crimmins, de Steiguer, & Dennis)	2005	Utilised research	Used AHP for assessment of national forest planning situation
(Mayyas, Shen, Mayyas, abdelhamid, Shan, Qattawi, Omar)	2011	Utilised research	Selected of material by implemented of AHP
(Mishra, Khasnabis, & Swain)	2013	Utilised research	Employed of AHP for feasibility of strategies
(Moeinaddini, Khorasani, Danehkar, Darvishsefat, & zienalyan)	2010	Utilised research	Used AHP spatial auto-correlation of the land suitability map layer
(Mohajeri & Amin)	2010	Utilised research	Employed AHP for optimum site off railway station

(Continued)

Table 3. (Continued).

Authors	Year	Type of study	Tools and approaches
(Nigim, Suryanarayanan, Gorur, & Farmer)	2003	Utilised research	Determined special protection schemes (SPS) failures in a power system by AHP
(Nikou & Mezei)	2013	Utilised research	Employed AHP for mobile services in order to driving the adoption
(Oddershede, Arias, & Cancino)	2007	Developed research	Rural development for improved AHP
(Ojha, Das, Mondal, & Maiti)	2010	Utilised research	Solved problem in solid transportation by utilised AHP
(Ong, Koh, & Nee)	2001	Utilised research	Employed AHP for derive a single environmental score
(Orencio & Fujii)	2013	Utilised research	Employed AHP for reduce the vulnerability of coastal
(Othman, Repke, & Wozny)	2010	Utilised research	Implemented of AHP for rank of sustainable chemical process design
(Hsu & Chen)	2008	Utilised research	Criteria selection from pertinent literature by employed AHP
(Padma & Balasubramanie)	2009	Developed research	Developed AHP for build a KBDSS that assist to overcome problem
(Perez-Vega, Peter, Salmeron-Ochoa, Nieva-de la Hidalga, & Sharratt)	2011	Utilised research	Employed AHP for pharmaceutical process development
(Podvezko & Sivilevičius)	2013	Utilised research	Used of AHP for methodology of the logical control in filling of the questionnaire
(Ramanathan)	2007	Utilised research	Used AHP for subjective and objective information
(Ramesh & Kodali)	2012	Utilised research	Assessment of lean manufacturer performance by utilised AHP
(Ren, Manzardo, Toniolo, & Scipioni)	2013	Utilised research	Employed AHP for classify and ranking of hydrogen sustainability in supply chains
(Reza, Sadiq, & Hewage)	2011	Utilised research	Assessment of sustainability flooring systems by employed AHP
(Roig-Tierno, Baviera-Puig, Buitrago-Vera, & Mas-Verdu)	2013	Utilised research	Retail site location selection by utilised AHP
(Rousos & Lee)	2012	Utilised research	Utilised AHP for evaluation of shipping investment
(Chen)	2009	Utilised research	Employed of AHP for intellectual capital of e-learning for competitive advantages
(Sabharwall, Kim, & Patterson)	2012	Utilised research	Applied AHP for evaluation of generation in nuclear reactors
(Sadeghi & Ameli)	2012	Utilised research	Applied AHP for sectoral allocation of energy subsidy
(Safari, Ataei, Khalokakaie, & Karamozian)	2010	Utilised research	Utilised AHP for selection of plant location
(Sahin, Mohamed, Warnken, & Rahman)	2013	Utilised research	Applied AHP for improve Gold Coast's resilience for climate change

(Continued)

Table 3. (Continued).

Authors	Year	Type of study	Tools and approaches
(Sambasivan & Fei)	2008	Utilised research	Used AHP for ranking of environmental management system CSFs
(Şener, Şener, Nas, & Karagüzel)	2010	Utilised research	Employed AHP and GIS for selection of landfill site
(Shen, Muduli, & Barve)	2013	Utilised research	Utilised AHP for competitive ranking of GSCM implementation
(Tang)	2011	Utilised research	Used AHP to evaluating and planning for ESL programmes
(Tian, Bai, Sun, & Zhao)	2013	Utilised research	Evaluated process of sustainability for coastal beach by used AHP
(Triantaphyllou)	2001	Developed research	Developed AHP for problems solving in DM techniques
(Uyan)	2013	Utilised research	Election of suitable sites for solar farms by utilised AHP
(Venkata Rao)	2004	Utilised research	Selections of strip-layout procedure for metal die stamping work by used AHP
(Vinodh, Shivraman, & Viswesh)	2011	Utilised research	Evaluated of lean manufacturing systems by used AHP
(Wang, Yu, Yang, Lin, Lee, & Cheng)	2013	Utilised research	Selection of BV contractors in construction projects by applied AHP
(Wabiri & Amusa)	2010	Utilised research	Used AHP for energy policies and geopolitics for oil producers
(Wong & Li)	2008	Developed research	Assigned and ranked the important weightings for the perceived criteria by applied AHP
(Zhu & Dale)	2001	Utilised research	Used AHP for problem solving on the World Wide Web
(Chen, Yu, & Khan)	2010	Utilised research	Analysis MCDM criteria weight sensitivity based on GIS-based AHP-SA
(Chen, Yu, & Khan)	2010	Utilised research	Evaluation of environment-friendly impact based on transport measures by used AHP
(Hu & Tsai)	2006	Developed research	Applied AHP for back propagation multi-layer perceptron
(Liu, Mao, Li, & Yao)	2007	Utilised research	Assessed of safety systems by used AHP
(Wang & Chin)	2009	Proposed research	Proposed new DEA for priority determination in the AHP
(Dong, Xu, Li, & Dai)	2008	Developed research	Presented two performance measurements for evaluation of prioritisation methods and numerical scales based on AHP
(Zhang, Deng, Wei, & Deng)	2012	Utilised research	Employed AHP for evaluation of E-Commerce security
(Ying, Zeng, Chen, Tang, Wang, & Huang)	2007	Utilised research	Used AHP for evaluation of synthetically eco-environmental quality
(Zhang, Sun, & Qin)	2012	Utilised research	Assessment of sustainable development by applied AHP
(Zangeneh, Jadid, & Rahimi-Kian)	2009	Utilised research	Ranking and evaluation of DG technologies by used AHP

Source: Authors' calculation.

Table 4. Distribution based on PROMETHEE.

Authors	Year	Type of study	Tools and approaches
(Abedi, Ali Torabi, Norouzi, Hamzeh, & Elyasi)	2012	Utilised research	Applied PROMETHEE II for produce the desired MPM
(Abedi, Gholami, & Norouzi)	2013	Utilised research	Employed PROMETHEE II for assessment of applied to geological layers, airborne geophysical data, and remote sensing images
(Albadvi)	2004	Utilised research	Strategic selection for application flagships by employed PROMETHEE
(Albadvi, Chaharsooghi, & Esfahanipour)	2007	Utilised research	Stock trading assessment by applied PROMETHEE
(Araz, Mizrak Ozfirat, & Ozkarahan)	2007	Utilised research	Applied PROMETHEE for selection of suitable outsourcers for the strategic partners
(Chen, Pai, & Hung)	2010	Utilised research	Ranking of logistic suppliers by used PROMETHEE
(Chou, Lin, Lin, Chou, & Huang)	2004	Utilised research	Employed PROMETHEE for selection of depression outlet location
(Corrente, Figueira, & Greco)	2014	Developed research	Applied the SMAA for solving problems in DM based on the PROMETHEE
(de Almeida & Vetschera)	2012	Developed research	Corrected portfolio problems by using PROMETHEE V
(Dhouib & Elloumi)	2011	Developed research	Proposed integrated methods for multi-criteria analysis by used PROMETHEE
(Ghafghazi, Sowlati, Sokhansanj, & Melin)	2010	Utilised research	Used PROMETHEE for ranking of energy options
(Ishizaka & Nemery)	2011	Utilised research	Selection the statistical distribution by used PROMETHEE
(Beynon & Wells)	2008	Utilised research	Used PROMETHEE for lean improvement in the chemical emissions
(Kadziński, Greco, & Słowiński)	2012b	Proposed research	Proposed PROMETHEE ^{GKS} based on Robust ordinal regression
(Oberschmidt, Geldermann, Ludwig, & Schmehl)	2010	Utilised research	Assessed of technology's life cycle by employed PROMETHEE
(Queiruga, Walther, González-Benito, & Spengler)	2008	Utilised research	Site location assessment for WEEE recycling plants by applied PROMETHEE
(Rousis, Moustakas, Malamis, Papadopoulos, & Loizidou)	2008	Utilised research	Evaluated of WEEE management system by used PROMETHEE
(Parreiras & Vasconcelos)	2007	Developed research	Improved PROMETHEE II for solving problems of multiobjective optimisation
(Tsoutsos, Drandaki, Frantzeskaki, Iosifidis, & Kiosses)	2009	Utilised research	Applied for PROMETHEE I and PROMETHEE II energy planning issues
(Vetschera & De Almeida)	2012	Utilised research	Employed PROMETHEE for solving problem in selection of portfolio
(Vinodh & Jeya Girubha)	2012	Utilised research	Selected the best sustainable concept by employed PROMETHEE
(Waeyenbergh, Vannieuwenhuyse, & Pintelon)	2004	Utilised research	Used PROMETHEE for solve problem in predictive maintenance programme

(Continued)

Table 4. (Continued).

Authors	Year	Type of study	Tools and approaches
(Hu & Chen)	2011	Developed research	Developed PROMETHEE for multi-criteria classification problems
(Hu)	2010	Developed research	Developed a new PROMETHEE II-based SLP using concepts from the PROMETHEE II
(Zhang, Fan, & Liu)	2010	Developed research	Developed PROMETHEE to obtain the ranking result of alternatives

Source: Authors' calculation.

Table 5. Distribution based on ELECTRE.

Authors	Year	Type of study	Tools and approaches
(Shanian, Milani, Carson, & Abeyaratne)	2008	Utilised research	Selection of material by used ELECTRE III
(Beccali, Cellura, & Mistretta)	2003	Utilised research	Implemented of ELECTRE for technology assessment of renewable energy
(Bisdorff)	2002	Proposed research	Proposed ELECTRE-like method for clustering judges
(Bojković, Anić, & Pejić-Tarle)	2010	Utilised research	Evaluated of transport-sustainability by utilised ELECTRE
(Bouyssou & Marchant)	2007	Developed research	Developed ELECTRE TRI for sorting models problems
(Bouyssou & Pirlot)	2009	Proposed research	Used conjoint measurement for achieve axiomatic characterisation of preference relations such as ELECTRE
(Brito, de Almeida, & Mota)	2010	Proposed research	Proposed a multi-criteria model for risk assessment in natural gas pipelines based on ELECTRE and Utility Theory
(Buchanan & Vanderpooten)	(2007)	Utilised research	Project selection by employed ELECTRE III
(Cavallaro)	(2010)	Utilised research	Assessed of processes in the production of thin-film photovoltaic
(Dias & Mousseau)	2006	Proposed research	Presented a partial inference process to compute the value of the veto-related parameters based on ELECTRE
(Dias, Mousseau, Figueira, & Climaco)	2002	Proposed research	Developed ELECTRE TRI based on interactive aggregation-disaggregation approach to achieve robust conclusions
(Doumpos, Marinakis, Marinaki, & Zopounidis)	2009	Developed research	Proposed evolutionary approach in the ELECTRE environment
(Figueira, Greco, & Roy)	2009	Developed research	Extended of the concordance index for ELECTRE methods
(Figueira & Roy)	2002	Developed research	Developed ELECTRE based on revised Simos

(Continued)

Table 5. (Continued).

Authors	Year	Type of study	Tools and approaches
(Georgopoulou, Sarafidis, Mirasgedis, Zaimi, & Lalas)	2003	Utilised research	Applied ELECTRE III for greenhouse gases emissions reduction
(Greco, Kadziński, Mousseau, & Słowiński)	2011	Proposed research	Proposed new ELECTRE ^{GKMS} for robust ordinal regression
(Giannoulis & Ishizaka)	2010	Utilised research	Used ELECTRE III for British universities ranking
(Iniestra & Gutiérrez)	2009	Utilised research	Applied ELECTRE III for evaluation of transportation projects
(Ishizaka & Nemery)	2014	Utilised research	Developed ELECTRE-SORT for strategies of maintenance
(Leyva-López & Fernández-González)	2003	Developed research	Extended the ELECTRE III for solving problems to assist group of decision-makers
(Li & Sun)	2009	Proposed research	Proposed new model based on ELECTRE-CBR-I and ELECTRE-CBR-II
(Lourenço & Costa)	2004	Proposed research	Proposed interactive 'branch-and-bound like' for progressively build the nondominated set and combined with ELECTRE TRI
(Martin, Ruperd, & Legret)	2007	Utilised research	Applied ELECTRE III for evaluation of the best management practice
(Taillandier & Taillandier)	2012	Utilised research	Developed ELECTRE III for solving MCDM problems with imprecise data
(Mousseau & Dias)	2004	Developed research	Adapted slight of the relation of valued outranking used in the ELECTRE TRI and ELECTRE III
(Mousseau, Figueira, & Naux)	2001	Developed research	Developed ELECTRE TRI based on interactive aggregation-disaggregation
(Huck)	2010	Proposed research	Evaluated of Pairs trading based on Neural Networks and ELECTRE III
(Norese)	2006	Utilised research	Employed ELECTRE III for waste-treatment plants localisation
(Papadopoulos & Karagiannidis)	2008	Utilised research	Decentralised energy systems by used ELECTRE III
(Roy & Słowiński)	2008	Developed research	Proposed computing the credibility of outranking in multi criteria aggregation process such as ELECTRE
(Sánchez-Lozano, Henggeler Antunes, Garcia-Cascales, & Dias)	2014	Utilised research	Applied ELECTRE-TRI and GIS for selection of photovoltaic solar farms site
(Figueira, Greco, Roy, Słowiński)	2013	Developed research	Presented and discuss the features of ELECTRE
(Ulubeyli & Kazaz)	2009	Utilised research	Employed ELECTRE III for solve problem in selection of concrete pumps
(Tervonen, Figueira, Lahdelma, Dias, & Salminen)	2009	Proposed research	Proposed SMAA-TRI method based on ELECTRE TRI in sorting problems

Source: Authors' calculation.

Table 6. Distribution based on TOPSIS.

Authors	Year	Type of study	Tools and approaches
(Baky & Abo-Sinna)	2013	Proposed research	Presented TOPSIS for solving problems in bi-level MODM tools
(Baky)	2014	Developed research	Improved TOPSIS for solving problem in MLN-MODM methods
(Bilbao-Terol, Arenas-Parra, Cañal-Fernández, & Antomil-Ibias)	2014	Utilised research	Government sustainability assessment by employed TOPSIS
(Cheng)	2008	Proposed research	Presented the effective approach by adopt TOPSIS for solving MCDM problems
(Dadelo, Turskis, Zavadskas, & Dadeliene)	2014	Utilised research	Sport team formation ranking and evaluation by used TOPSIS
(Du, Gao, Hu, Mahadevan, & Deng)	2014	Utilised research	Applied TOPSIS for identifying nodes in complex networks
(Dymova, Sevastjanov, & Tikhonenko)	2013	Developed research	Extended on TOPSIS based on direct interval
(García-Cascales & Lamata)	2012	Proposed research	Proposed modifications in the algorithm of Hwang and Yoon TOPSIS method
(Li, Adeli, Sun, & Han)	2011	Utilised research	Applied TOPSIS for prediction of binary business failure
(Zhang & Yu)	2012	Developed research	Extended TOPSIS for ranking of all the alternatives
(İç)	2012	Proposed research	Applied TOPSIS for solving problems in selection of CIM
(İç)	2014	Utilised research	Employed TOPSIS for assessment of company ranking
(Jadidi, Hong, & Firouzi)	2009	Developed research	Applied TOPSIS for solve problem of the MOMILP
(Jadidi, Sai Hong, Firouzi, & Yusuff)	2009	Proposed research	Proposed a new TOPSIS in grey theory to deal with the suppliers' selection problem
(Jahanshahloo, Lotfi, & Izadikhah)	2006a	Developed research	Extended the TOPSIS for DM problems with interval data
(Jahanshahloo, Hosseinzadeh Lotfi, & Davoodi)	2009	Proposed research	Presented a new TOPSIS for ranking of DMUs
(Jahanshahloo, Khodabakhshi, Hosseinzadeh Lotfi, & Moazami Goudarzi)	2011	Developed research	Presented a new super-efficient for rank of decision-making units based on TOPSIS
(Kao)	2010	Developed research	Improved TOPSIS for solving problem in MCDA methods
(Karimi-Nasab & Seyedhoseini)	2013	Utilised research	Applied TOPSIS for ranking of performance indexes in the job shop environment
(Kou, Peng, & Lu)	2014	Utilised research	Bank loan assessment by used TOPSIS
(Kwong & Tam)	2002	Utilised research	Applied TOPSIS for obtain of design solution of low power transformers
(Li, Jin, & Wang)	2014	Utilised research	Selection of knowledge management system by employed TOPSIS and QFD
(Lin & Yeh)	2012	Proposed research	Integrated NSGA-II and TOPSIS for evaluation of network reliability

(Continued)

Table 6. (Continued).

Authors	Year	Type of study	Tools and approaches
(Martin, Spano, Küster, Collu, & Kolios)	2013	Developed research	Developed two methods for extend the TOPSIS capability
(Liu)	2009	Proposed research	Proposed TOPSIS for solving problem in MADM methods
(Park, Park, Kwun, & Tan)	2011	Developed research	Extend TOPSIS to solve problem in MAGDM problems
(Pazand, Hezarkhani, & Ataei)	2012	Utilised research	Employed TOPSIS and GIS for evaluation of providing prospectively maps
(Pinter & Pšunder)	2013	Utilised research	Proposed new TOPSIS-M for evaluation of construction project
(Rahman, Odeyinka, Perera, & Bi)	2012	Utilised research	Applied TOPSIS for best roofing materials selection in the market of UK housing
(Sadeghzadeh & Salehi)	2011	Utilised research	Developed fuel cell based on strategic technologies by used TOPSIS
(Shidpour et al., 2013)	2013	Utilised research	Applied TOPSIS for finding best the design of configuration product
(Shih)	2008	Developed research	Developed TOPSIS for examines the necessity of incremental analysis
(Shih, Shyur, & Lee)	2007	Developed research	Improved TOPSIS by provide new options including; normalisation, mean operators and distance measures
(Tong, Kwong, & Ip)	2003	Utilised research	Used TOPSIS for derive quality indexes in electronic packages
(Tong, Wang, Chen, & Chen)	2004	Utilised research	Employed TOPSIS for determine of performance index in multiple responses
(Tsaur)	2011	Proposed research	Presented a new TOPSIS for ranking the alternatives and normalising the collected data
(Li, Lai, & Kao)	2011	Utilised research	Applied TOPSIS for assessment of building requirement systems
(Ülengin, Kabak, Önsel, Ülengin, & Aktaş)	2010	Utilised research	Used TOPSIS for selection if the best transportation policy
(Yeh & Willis)	2001	Utilised research	Used TOPSIS for solving problem in process of winner determination
(Yue & Jia)	2013	Developed research	Determined the weights of DMs by improved TOPSIS
(Yurdakul & Ic)	2009	Utilised research	Applied TOPSIS for selection of machine tools
(Zhu, Wu, Wang, & Liang)	2012	Utilised research	Evaluated of quality credit by used TOPSIS
(Zhu, Li, Wu, Wang, & Liang)	2013	Utilised research	Applied TOPSIS for consumer credit classification
(Liu, Chan, & Ran)	2013	Developed research	Determined weights of the decision makers by extended TOPSIS method

Source: Authors' calculation.

Table 7. Distribution based on ANP.

Authors	Year	Type of study	Tools and approaches
(Agarwal, Shankar, & Tiwari)	2006	Utilised research	Applied ANP for evaluation of supply chain based on agile, lean, and agile systems
(Aragonés-Beltrán, Aznar, Ferrís-Oñate, & García-Melón)	2008	Utilised research	Used ANP for evaluation of asset valuation
(Chang, Hu, & Hong)	2013	Utilised research	Employed ANP for evaluation and ranking of agility factors
(Dou, Zhu, & Sarkis)	2014	Developed research	Developed grey ANP-based model for evaluation of green supplier development
(Wu, Lin, & Lee)	2010	Utilised research	Employed ANP for selection of competitive marketing strategy
(Lin, Chen, & Ting)	2010	Utilised research	Evaluated purchasing systems by using ANP and LP
(Erdoğan, Aras, & Koç)	2006	Utilised research	Employed ANP for fuels alternative in residential heating
(Erensal, Gürbüz, & Esra Albayrak)	2010	Utilised research	Competence mapping evaluation by used ANP
(Hasanzadeh, Danehkar, & Azizi)	2013	Utilised research	Employed ANP for ranking of environmental factors for selection of oil jetties sit
(Hsieh, Lin, & Lin)	2008	Utilised research	Evaluated of service quality framework by used ANP
(Ivanović, Grujičić, Macura, Jović, & Bojović)	2013	Utilised research	Used ANP for selection of road transport project
(Lee)	2010	Utilised research	Evaluated the competitive types for development of an airport by using ANP
(Khademi, Mohaymany, Shahi, Zerguini)	2012	Utilised research	Presented an algorithm for structure design based on ANP
(Khan & Faisal)	2008	Utilised research	Utilised ANP for desirability of disposal alternatives
(Kirytopoulos, Leopoulos, & Voulgaridou)	2008	Utilised research	Applied ANP for process of supply chain selection in parpharmaceutical industry
(May, Shang, Tjader, & Vargas)	2013	Developed research	Developed ANP based on stability and sensitivity of models
(Mohammadi, Sadi, Nateghi, Abdullah, & Skitmore)	2014	Utilised research	Employed ANP for selection of project manager
(Nixon, Dey, Ghosh, & Davies)	2013	Utilised research	Applied HANP for evaluation of technologies alternatives for generating electricity
(Parthasarathy & Sharma)	2014	Utilised research	Employed ANP for selection of feasible customisation in the implementation of ERP system
(Kirytopoulos, Voulgaridou, Platis, & Leopoulos)	2011	Utilised research	Applied ANP as a power matrix method for getting the limit matrix
(Kuo & Lin)	2012	Utilised research	Supplier selection by implemented of ANP
(Chen & Shyu)	2006	Utilised research	Selected weapon systems by utilising ANP
(Shiue & Lin)	2012	Utilised research	Employed ANP for evaluation of optimal strategies
(Theißen & Spinler)	2014	Utilised research	Applied ANP for the CO2 management in collaborative contexts

(Continued)

Table 7. (Continued).

Authors	Year	Type of study	Tools and approaches
(Tjader, Shang, & Vargas)	2010	Utilised research	Applied ANP for selection of the best governing policy business activities in the offshore outsourcing
(Verdecho, Alfaro-Saiz, Rodriguez-Rodriguez, & Ortiz-Bas)	2012	Utilised research	Utilised ANP for the assessment of the renewable energy sector
(Wey & Wu)	2007	Utilised research	Applied ANP for selection and assessment of a TI project
(Chang, Wey, & Tseng)	2009	Utilised research	Evaluated different revitalisation strategies by using ANP
(Lin, Chiu, & Tsai)	2008	Utilised research	Employed ANP for wafer fabrication assessment

Source: Authors' calculation.

Table 8. Distribution based on VIKOR.

Authors	Year	Type of study	Tools and approaches
(Bahraminasab & Jahan)	2011	Utilised research	Employed VIKOR for ranking materials of TKR
(Chang & Hsu)	2009	Utilised research	Applied VIKOR for ranking of land-use restraint strategies
(Cavallini, Giorgetti, Citti, & Nicolaie)	2013	Utilised research	Mixed VIKOR and QFD for material selection
(Liu, Liu, & Wu)	2013	Utilised research	Selected of materials by implemented of VIKOR method
(Liu, Liu, & Wu)	2013	Utilised research	Used VIKOR for selection of material problem under incomplete information and uncertain environment
(Liu, You, Fan, & Chen)	2014	Utilised research	Applied VIKOR for selection of site in waste management
(Liou, Tsai, Lin, & Tzeng)	2011	Utilised research	Evaluated service quality model by applied VIKOR method
(Jahan & Edwards)	2013	Utilised research	Solved materials selection problems by applied VIKOR
(Jahan, Khodabakhshi, Hosseinzadeh Lotfi, & Moazami Goudarzi)	2011	Utilised research	Applied VIKOR for optimum material selection
(Ju & Wang)	2013	Developed research	Developed VIKOR for solve MCDM problems
(Hsu)	2014	Utilised research	Applied VIKOR and Entropy for performance evaluation
(San Cristóbal)	2011	Utilised research	Applied VIKOR for Renewable Energy project selection
(Sayadi, Heydari, & Shahanaghi)	2009	Developed research	Developed VIKOR for MCOC for multi-criteria optimisation of complex systems
(Vučićak, Kupusović, Midžić-Kurtagić, & Čerić)	2013	Utilised research	Applied VIKOR for assessment of sustainable hydropower process

Source: Authors' calculation.

Table 9. Distribution based on DM aggregation methods.

Authors	Year	Type of study	Tools and approaches
(Baležentis & Baležentis)	2011	Utilised research	Lithuanian transport efficiency assessment by using MULTIMOORA and DEA
(Alimardani, Hashemkhani Zolfani, Aghdaie, & Tamošaitienė)	2013	Utilised research	Used SWARA for evaluation of energy system sustainability for supplier selection
(Bagočius, Zavadskas, & Turskis)	2013	Utilised research	Mixed WASPAS and entropy for deep-water port selection
(Bagočius, Zavadskas, & Turskis)	2014	Utilised research	Wind turbine selection by employing WASPAS
(Balezentis & Balezentis)	2011	Utilised research	Evaluation of strategic management model by employing MULTIMOORA
(Banaitiene, Banaitis, Kaklauskas, & Zavadskas)	2008	Utilised research	Applied COPRAS for evaluation of building's life cycle
(Chakraborty & Zavadskas)	2014	Utilised research	Applied WASPAS, MOORA and MULTIMOORA for robustness verification
(Dadelo, Turskis, Zavadskas, & Dadeliene)	2012	Utilised research	Personnel selection and evaluation by applying ARAS
(Dėjus & Antuchevičienė)	2013	Utilised research	Applied WASPAS and SWARA for regions evaluation for solar projects
(Džiugaitė-Tumėnienė & Lapinskienė)	2014	Utilised research	Analysis of performance by applying WASPAS for journals of Civil engineering
(Šiožinytė & Antuchevičienė)	2013	Utilised research	Used WASPAS COPRAS; AHP and TOPSIS for problem solving of tradition continuity and daylighting
(Zavadskas, Turskis, & Vilutiene)	2010	Utilised research	Used ARAS for foundation instalment selection
(Zavadskas & Vilutiene)	2006	Utilised research	Selection and evaluation of performance in maintenance contractor's by used COPRAS
(Hashemkhani Zolfani Esfahani, Bitarafan, Zavadskas, & Arefi)	2013	Utilised research	Applied SWARA and WASPAS for selection of shopping mall location
(Zavadskas, Kaklauskas, & Vilutiene)	2009	Utilised research	Dwelling maintenance contractors' evaluation by using COPRAS
(Zavadskas, Kaklauskas, Banaitis, & Kvederyte)	2004	Utilised research	Implemented of COPRAS for rational credit development and choosing the best efficient housing investment instruments and lenders
(Zavadskas, Kaklauskas, Turskis, & Tamošaitiene)	2008	Utilised research	Implemented COPRAS and COPRAS-G for selection of effective dwelling house walls
(Zavadskas, Kaklauskas, Turskis, Tamosaitiene, & Kalibatas)	2011	Utilised research	Used COPRAS-G for assessment of indoor environment
(Zavadskas, Turskis, Volvačiovas, & Kildiene)	2013	Utilised research	Technology selection by applied MULTIMOORA, SWARA-TOPSIS, SAWARA-VIKOR, SAWARA-ELECTURE III in construction sector

(Continued)

Table 9. (Continued).

Authors	Year	Type of study	Tools and approaches
(Zavadskas, Turskis, Tamošaitiene, & Marina)	2008	Utilised research	Used COPRAS-G for selection of constructions' projects managers
(Liu, Fan, Li, & Chen)	2014	Utilised research	Developed FMEA model by implemented of Extended MULTIMOORA
(Liu, You, Lu, & Shan)	2014	Utilised research	Selection and evaluation of technology in health-care waste treatment by using interval 2-tuple linguistic MULTIMOORA
(Aghdaie, Hashemkhani Zolfani, & Zavadskas)	2014	Utilised research	Used SWARA-VIKOR for selection of personnel
(Hashemkhani Zolfani & Bahrami)	2014	Utilised research	Ranking high tech industries by employed SWARA-COPRAS
(Jana, Bairagi, Paul, Sarkar, & Saha)	2013	Utilised research	Scheduling priority in manufacturing system by used MOORA
(Kaklauskas, Zavadskas, Raslanas, Ginevicius, Komka, & Malinauskas)	2006	Utilised research	Employed COPRAS for low- e windows selection in public buildings
(Kaklauskas, Zavadskas, Naimavicienė, Krutinis, Plakys, & Venskus)	2010	Utilised research	Applied COPRAS for intelligent built environment to improve inhabitant's quality of life and to satisfy inhabitants
(Kalibatas, Zavadskas, & Kalibatienė)	2012	Utilised research	Applied MAAIA and MOORA for selection of apartment with optimal indoor
(Kanapeckiene, Kaklauskas, Zavadskas, & Seniut)	2010	Utilised research	Used COPRAS for new original Knowledge Based Decision Support System in Construction Projects Management
(Karande & Chakraborty)	2012	Utilised research	Selection of ERP system by using fuzzy MOORA
(Keršulienė, Zavadskas, & Turskis)	2010	Utilised research	SWARA and WASPAS for regions evaluation for solar projects
(Kracka & Zavadskas)	2013	Utilised research	Selection of MOORA and MULTIMOORA for panel building
(Kracka, Brauers, & Zavadskas)	2010	Utilised research	Applied MOORA and MULTIMOORA for heating losses ranking in building
Keršulienė and Turskis	2011	Utilised research	Used ARAS-F and SWARA for selection of architect
(Ruzgys, Volvačiovas, Ignatavičius, & Turskis)	2014	Utilised research	SWARA, COPRAS, SAW and TOPSIS for strategy of public buildings retrofit
(Stankevičienė, Sviderskė, & Miečinskienė)	2014	Utilised research	Assessment of country risk sustainability by using MULTIMOORA and MOORA
(Baležentis, Baležentis, & Brauers)	2011	Utilised research	Well-being optimisation by applying MULTIMOORA
(Vafaeipour, Hashemkhani Zolfani, Morshed Varzandeh, Derakhti, & Keshavarz Eshkalag)	2014	Utilised research	Wind turbine selection by employed WASPAS

(Continued)

Table 9. (Continued).

Authors	Year	Type of study	Tools and approaches
(Brauwers & Zavadskas)	2006	Utilised research	Proposed MOORA for transition of economy
(Brauwers & Ginevičius)	2009	Utilised research	Applied MOORA for robustness in different regions of Lithuania
(Brauwers)	2013	Utilised research	Used MOORA for selection of the best location of seaport
((Brauwers, Kildienė, Zavadskas, & Kaklauskas)	2013	Utilised research	Assessment of construction sector based on macroeconomic view by using MULTIMOORA
(Brauwers, Kracka, & Zavadskas)	2012	Utilised research	Building elements selection by using MULTIMOORA and MOORA
(Brauwers, Zavadskas, Peldschus, & Turskis)	2008	Utilised research	Applied MOORA for evaluation of road design
(Brauwers, Zavadskas, Turskis, & Vilutiene)	2008	Utilised research	Applied MOORA for best performing contractor
(Hashemkhani Zolfani & Saparauskas)	2013	Utilised research	Used SWARA for evaluation of energy system sustainability

Source: Authors' calculation.

Table 10. Distribution papers based on DEMATEL.

Authors	Year	Type of study	Tools and approaches
(Bai & Sarkis)	2013	Utilised research	Assessment of business process management by utilising DEMATEL
(Hsu, Kuo, Chen, & Hu)	2013	Utilised research	Selected of supplier by using DEMATEL for evaluation of carbon management
(Hu, Lee, Yen, & Tsai)	2009	Utilised research	Analysed performance in computer industry by using DEMATEL
(Ho, Feng, Lee, & Yen)	2012	Utilised research	Assessed performance of supplier quality by implementing DEMATEL
(Horng, Liu, Chou, & Tsai)	2013	Utilised research	Applied DEMATEL for assessment of criteria for design of restaurant space
(Lee & Lin)	2013	Utilised research	Used DEMATEL for the cognition maps of financial experts
(Li, Hu, Zhang, Deng, & Mahadevan)	2014	Utilised research	Ranking of CSFs of emergency management by using DEMATEL

Source: Authors' calculation.

4.10. Distribution based on MCDM techniques and approaches

Tables 3–11 show implementation of each MCDM technique and approach. Based on the results presented in these tables, a total of 393 studies have employed classical DM techniques and approaches, these Tables show that AHP with 128 articles has been used more than other tools and approaches. The second one is the other and integrated

Table 11. Distribution papers based on hybrid MCDM.

Authors	Year	Type of study	Tools and approaches
(Abdi & Labib)	2011	Utilised research	Applied ANP and AHP for RMS performance evaluation
(Cortés-Aldana, García-Melón, Fernández-de-Lucio, Aragonés-Beltrán, & Poveda-Bautista)	2009	Utilised research	Used AHP and ANP for evaluation of universities technology transfer
(Altuntas, Dereli, & Yılmaz)	2012	Utilised approach	Applied AHP and ANP for evaluation of SERVQUAL model in hospitals
(Ayağ & Özdemir)	2007	Utilised research	Applied AHP and ANP for evaluation of customers and company based on the needs and expectations
(Bouyssou & Marchant)	2007	Developed research	Mixed ELECTRE TOPSIS, VIKOR and PROMETHEE for stability intervals and trade-offs analysis
(Büyüközkan & Öztürkcan)	2010	Utilised research	Combined DEMATEL, ANP for selection of Six Sigma project
(Liu, Tzeng, & Lee)	2012	Utilised research	Utilised DEMATEL, VIKOR and ANP for improvement of tourism policy
(Çalışkan)	2013	Utilised research	Used EXPROM2 VIKOR and TOPSIS and methods for selection of the best coating material
(Çalışkan, Kurşuncu, Kurbanoglu, & Güven)	2013	Utilised research	PROMETHEE II, VIKOR and TOPSIS for the tool selection in hard milling
(Chatterjee & Chakraborty)	2012	Utilised research	Utilised PROMETHEE II and COPRAS-G for solving problem in selection of solving a gear material
(Chatterjee, Athawale, & Chakraborty)	2009	Utilised research	Employed VIKOR and ELECTRE for selection of suitable material in engineering application
(Chatterjee, Athawale, & Chakraborty)	2011	Utilised research	Combined COPRAS and EVAMIX for selection of suitable material in engineering application
(Chen, Lien, & Tzeng)	2010	Utilised research	Applied ANP and DEMATEL for assessment of environment watershed plans
(Chen, Jin, Qiu, & Chen)	2014	Utilised research	Used AHP and Entropy for safety assessment
(Chen & Wu)	2010	Utilised research	Used AHP and ANP for evaluation of automobile manufacturer
(Chen & Tzeng)	2011	Utilised research	Integrated DEMATEL, VIKOR and ANP for evaluation of aspired intelligent
(Chin, Xu, Yang, & Ping-Kit Lam)	2008	Utilised research	Mix AHP and ER for screening of product project.
(Chu, Shyu, Tzeng, & Khosla)	2007	Utilised research	Utilised VIKOR, TOPSIS and SAW for assessment of Knowledge management
(Corrente, Greco, & Słowiński)	2013	Developed research	Extended PROMETHEE and ELECTRE for the hierarchy of criteria

(Continued)

Table 11. (Continued).

Authors	Year	Type of study	Tools and approaches
(Corrente, Greco, & Słowiński)	2012	Developed research	Proposed MCHP for handles of hierarchy criteria in MCDA
(Dembczyński, Greco, & Słowiński)	2009	Developed research	Extended DRSA for solving problems in multiple criteria classification
(Ergu, Kou, Peng, & Shi)	2011	Developed research	Combined ANP and AHP for identify the inconsistent elements in the pairwise comparison matrix
(Greco, Matarazzo, & Słowiński)	2013	Proposed research	Proposed DRSA for solving multi-objective optimisation problems
(Goh, Kok, Yeo, Lee, & Mohd. Zin)	2013	Utilised research	Used AHP and TOPSIS for assessment of large pulp mill electrical system
(Halдар, Ray, Banerjee, & Ghosh)	2012	Utilised research	Employed TOPSIS and AHP for selection and evaluation of suppliers
(Huang, Chang, Li, & Lin)	2013	Developed research	Used MAUT and SAW for GDM problems
(J. J. Liou)	2012	Utilised research	Mixed DEMATEL and ANP for selection of airlines suitable partners for strategic alliances
(Jalao, Wu, & Shunk)	2014	Developed research	Proposed PCM for applied in AHP and ANP
(Jeng & Bailey)	2012	Utilised research	Integrated DEMATEL and ANP for evaluation of customer retention framework and promotional strategies
(Kadziński, Greco, & Słowiński)	2012b	Proposed research	Proposed ELECTRE ^{GKMS} and PROMETHEE ^{GKS} based on robust ordinal regression
(Kasanen, Wallenius, Wallenius, & Zionts)	2000	Utilised research	Employed MCDM/MAUT for evaluating the managerial decision process
(Kasirian & Yusuff)	2013	Utilised research	Utilised TOPSIS and AHP for supplier selection
(Khorshidi & Hassani)	2013	Utilised research	Applied AHP and TOPSIS for selection of PSI materials
(Kuo, Yang, Cho, & Tseng)	2008	Utilised research	Applied TOPSIS and AHP for selection of suitable dispatching rule for workstation
(Lee & Tu)	2011	Utilised research	Combined DEMATEL, ANP and VIKOR for evaluation of company value
(Leung & Cao)	2001	Developed research	Used ANP, Sinarchy and AHP for problems solving in MADM problems
(Lin, Wang, Chen, & Chang)	2008	Utilised research	Identified customer requirements and design characteristics by used AHP and TOPSIS
(Macharis, Springael, De Brucker, & Verbeke)	2004	Developed research	PROMETHE and AHP for synergies of operational design

(Continued)

Table 11. (Continued).

Authors	Year	Type of study	Tools and approaches
(Makan, Malamis, Assobhei, Loizidou, & Mountadar)	2012	Utilised research	Applied PROMETHEE and AHP for selection of suitable site for a new landfill
(Mousavi, Tavakkoli-Moghaddam, Heydar, & Ebrahimnejad)	2013	Utilised research	PROMETHEE, Delphi and AHP for selection of plant location
(Nakagawa, Nasu, Saito, & Yamaguchi)	2010	Developed research	Proposed research based on AHP and ANP for evaluation of policy alternative
(Opricovic & Tzeng)	2004	Developed research	TOPSIS and VIKOR for aggregating function and normalisation problems
(Oztaysi)	2014	Utilised research	Used TOPSIS and AHP for selection of information technology
(Partovi & Corredoira)	2002	Utilised research	Employed AHP and ANP for evaluation of QFD
(Peng)	2012	Utilised research	Combined TOPSIS, PROMETHEE II, VIKOR, ELECTRE III, GRA, and WSM for evaluation of the earthquake vulnerability
(Peng, Wang, & Wang)	2012	Utilised research	ELECTRE I, DEA, PROMETHEE II and TOPSIS for evaluation and ranking a selection of classification algorithms
(Percin)	2009	Utilised research	Used AHP and ANP For selection of 3PL providers' criteria
(Raju, Duckstein, & Arondel)	2000	Utilised research	Used ELECTRE III, PROMETHEE II, EXPROM II, ELECTRE VI and CP for assessment of economic factors
(Hu, Lu, & Tzeng)	2014	Utilised research	Employed DEMATEL, DANP and VIKOR for improvements of smart phone
(Sarkis & Sundarraj)	2002	Utilised research	Combined AHP and ANP for Hub location evaluation and selection
(Shyjith, Ilangkumaran, & Kumanan)	2008	Utilised research	Mixed AHP and TOPSIS for maintenance policy selection
(Shyur)	2006	Utilised research	Evaluated overall performance by employing ANP and TOPSIS
(Singh & Kumar)	2013	Utilised research	Utilised AHP and TOPSIS for assessment of technologies in effective utilisation of advanced manufacturing
(Streimikiene, Balezentis, Krisciukaitienė, & Balezentis)	2012	Utilised research	Employed TOPSIS and MULTIMOORA for selection of sustainable energy sources
(Yang, Chen, & Hung)	2007	Utilised research	Used TOPSIS and AHP solve problem in dynamic operator allocation
(Tao, Chen, Liu, & Wang)	2012	Proposed research	Integrated DEA, AHP and TOPSIS for solving problems in MCDM
(Tsai, Lin, Lee, Chang, & Hsu)	2013	Utilised research	Used DEMATEL and ANP for evaluation of green building project

(Continued)

Table 11. (Continued).

Authors	Year	Type of study	Tools and approaches
(Tzeng & Huang)	2012	Utilised research	Applied VIKOR, DEMATEL and GRA for selection of global manufacturing and logistics strategy
(Wu)	2008	Utilised research	Integrated DEMATEL and ANP for evaluation of knowledge management system
(Wu, Lin, & Tsai)	2010	Utilised research	Applied AHP and GRA for evaluation of business performance wealth management banks
(Wang & Triantaphyllou)	2008	Developed research	Applied ELECTRE II and ELECTRE III for solving MCDM problems
(Xu)	2001	Developed research	Employed SAW, TOPSIS and PROMETHEE for ranking superiority and inferiority
(Yurdakul)	2004	Utilised research	Used AHP and ANP for assessing machine tool alternatives to the manufacturing strategy

Source: Authors' calculation.

articles of hybrid MCDM tools and approaches and DM aggregation methods are the third in this ranking.

4.11. Distribution based on name of journal

Table 12 provides the distribution based on name of the journal which has been used in this survey. The article related to the MCDM techniques and approaches which are distributed through 120 journals and cover an extensive range of Web of Science database. From these 120 journals, the ranked first was the *European Journal of Operational*

Table 12. Distribution papers based on name of journal.

No.	Name of journal	Number of paper	No.	Name of journal	Number of paper
1	<i>European Journal of Operational Research</i>	70	61	<i>Journal of Engineering Design</i>	1
2	<i>Expert Systems with Applications</i>	20	62	<i>Journal of Intelligent Manufacturing</i>	1
3	<i>Applied Mathematical Modelling</i>	13	63	<i>International Journal of Production Economics</i>	1
4	<i>Materials & Design</i>	13	64	<i>Ecological Economics</i>	1
5	<i>Journal of civil engineering and management</i>	12	65	<i>Fuzzy sets and systems</i>	1
6	<i>Technological and Economic Development of Economy</i>	9	66	<i>Control and Cybernetics</i>	1
7	<i>Applied Mathematics and Computation</i>	9	67	<i>Journal of Purchasing and Supply Management</i>	1

(Continued)

Table 12. (Continued).

No.	Name of journal	Number of paper	No.	Name of journal	Number of paper
8	<i>Renewable Energy</i>	9	68	<i>International Transactions in Operational Research</i>	1
9	<i>International Journal of Production Research</i>	8	69	<i>Informatica</i>	1
10	<i>Transport</i>	8	70	<i>Asia Pacific Journal of Tourism Research</i>	1
11	<i>Knowledge-Based Systems</i>	8	71	<i>Journal of Decision Systems</i>	1
12	<i>Omega</i>	7	72	<i>Computers & Mathematics with Applications</i>	1
13	<i>Waste Management</i>	7	73	<i>Journal of Hydrology</i>	1
14	<i>Computers & Geosciences</i>	6	74	<i>Journal of economic computation and economic cybernetics studies and research</i>	1
15	<i>Journal of Materials Processing Technology</i>	6	75	<i>Fusion Engineering and Design</i>	1
16	<i>Computers & Industrial Engineering</i>	6	76	<i>Engineering Structures and Technologies</i>	1
17	<i>Journal of Business Research</i>	5	77	<i>The Egyptian Journal of Remote Sensing and Space Science</i>	1
18	<i>Energy Policy</i>	5	78	<i>Journal of Natural Fibers</i>	1
19	<i>Applied Soft Computing</i>	5	79	<i>Decision Support Systems</i>	1
20	<i>Computers & Operations Research</i>	4	80	<i>International Journal of Electrical Power & Energy Systems</i>	1
21	<i>International Journal of Project Management</i>	4	81	<i>Ocean & Coastal Management</i>	1
22	<i>Engineering Economics</i>	4	82	<i>Ecotoxicology and Environmental Safety</i>	1
23	<i>Journal of Business Economics and Management</i>	4	83	<i>International Journal of Hospitality Management</i>	1
24	<i>International Journal of Strategic Property Management</i>	4	84	<i>Asia Pacific Journal of Marketing and Logistics</i>	1
25	<i>Renewable and Sustainable Energy Reviews</i>	4	85	<i>Transportation Research Part E: Logistics and Transportation Review</i>	1
26	<i>International Journal of Management Science and Engineering Management</i>	4	86	<i>Neurocomputing</i>	1
27	<i>Transport Policy</i>	4	87	<i>Robotics and Computer-Integrated Manufacturing</i>	1
28	<i>Automation in Construction</i>	4	88	<i>Management Decision</i>	1
29	<i>Journal of Multi-Criteria Decision Analysis</i>	3	89	<i>Systems Engineering - Theory & Practice</i>	1
30	<i>Annals of Operations Research</i>	3	90	<i>Decision Science Letters</i>	1
31	<i>Journal of Environmental Management</i>	3	91	<i>Journal of the Chinese Institute of Industrial Engineers</i>	1
32	<i>Desalination</i>	3	92	<i>Applied Intelligence</i>	1
33	<i>Benchmarking: An International Journal</i>	3	93	<i>Journal of Air Transport Management</i>	1

(Continued)

Table 12. (Continued).

No.	Name of journal	Number of paper	No.	Name of journal	Number of paper
34	<i>Economic Modelling</i>	2	94	<i>Journal of China University of Mining and Technology</i>	1
35	<i>International Journal of Mining Science and Technology</i>	2	95	<i>journal of production engineering</i>	1
36	<i>Journal of Manufacturing Systems</i>	2	96	<i>Ships and Offshore Structures</i>	1
37	<i>Land Use Policy</i>	2	97	<i>Forest Policy and Economics</i>	1
38	<i>Journal of Information and Optimization Sciences</i>	2	98	<i>Arabian Journal for Science and Engineering</i>	1
39	<i>Environmental Modelling & Software</i>	2	99	<i>Electric Power Systems Research</i>	1
40	<i>Energy</i>	2	100	<i>Telecommunications Policy</i>	1
41	<i>Journal of Manufacturing Technology Management</i>	2	101	<i>International Journal of Energy Sector Management</i>	1
42	<i>Energy Conversion and Management</i>	2	102	<i>International Journal of Disaster Risk Reduction</i>	1
43	<i>Applied Energy</i>	2	103	<i>Computer Aided Chemical Engineering</i>	1
44	<i>Tourism Management,</i>	2	104	<i>Process Safety and Environmental Protection</i>	1
45	<i>Journal of Cleaner Production</i>	2	105	<i>Water Resources Management</i>	1
46	<i>Information sciences</i>	2	106	<i>Supply Chain Management: An International Journal</i>	1
47	<i>Kybernetes</i>	2	107	<i>Construction and Building Materials</i>	1
48	<i>Energy and Buildings</i>	2	108	<i>Applied Geography</i>	1
49	<i>Food Quality and Preference</i>	2	109	<i>Nuclear Engineering and Design</i>	1
50	<i>Engineering Applications of Artificial Intelligence</i>	2	110	<i>Mining Science and Technology</i>	1
51	<i>Mathematics and Computers in Simulation</i>	2	111	<i>Structural Survey</i>	1
52	<i>Maritime Policy & Management</i>	2	112	<i>Resources Policy</i>	1
53	<i>Computers in Industry</i>	2	113	<i>Evaluation and Program Planning</i>	1
54	<i>International journal of hydrogen energy</i>	2	114	<i>Journal of Environmental Planning and Management</i>	1
55	<i>Journal of Quality in Maintenance Engineering</i>	2	115	<i>Journal of Quality Assurance in Hospitality & Tourism</i>	1
56	<i>CATENA</i>	2	116	<i>Tunnelling and Underground Space Technology</i>	1
57	<i>Archives of Civil and Mechanical Engineering</i>	2	117	<i>Asia Pacific Management Review</i>	1
58	<i>Resources, Conservation and Recycling</i>	1	118	<i>Computer Modelling and New Technologies</i>	1
59	<i>Total Quality Management & Business Excellence</i>	1	119	<i>Studies in Informatics and Control</i>	1
60	<i>Journal of Safety Research</i>	1	120	<i>Journal of Computational Science</i>	1

Source: Authors' calculation.

Research with 70 articles. According to this result we can indicated that this journal has the most significant role in MCDM issues. The *Journal of Expert Systems with Applications* and *Applied Mathematical Modelling* had the second and third rank with 20 and 13 articles respectively, although the *Journal of Materials & Design* with 13 articles also had third rank. In other journal ranking; the *Journal of Civil Engineering and Management* had the fourth rank with 12 articles, moreover; the *Journal of Applied Mathematics and Computation*, *Journal of Technological and Economic Development of Economy* and *Journal of Renewable Energy* had the fifth rank with nine articles. The total number of publications of other published journals is shown in Table 12.

4.12. Distribution based on publication year

Figure 1 presents important evidence based on the frequency of distribution by the year of publication. The results indicate that from 2000 to 2014, the information about the use of DM techniques and approaches have grown increasingly. According to the findings of this section, the use of these techniques and approaches in 2000 was three articles and this number increased to 10 articles in 2001. Surprisingly, from 2006 to 2007, the numbers of studies dramatically increased. Although the use of MCDM techniques and approaches has increased in each year, the numbers of those articles in 2005 have decreased compared to 2004. Another interesting result in this is about 2013, in which previous studies have applied techniques more than other years. This year has the highest number of publications (75). Accordingly, it can be indicated that researchers in different fields and categories use the MCDM techniques and approaches nowadays in their research, and it can be predicted that in coming years, these numbers will increase. Results of the publication years is shown in Figure 1.

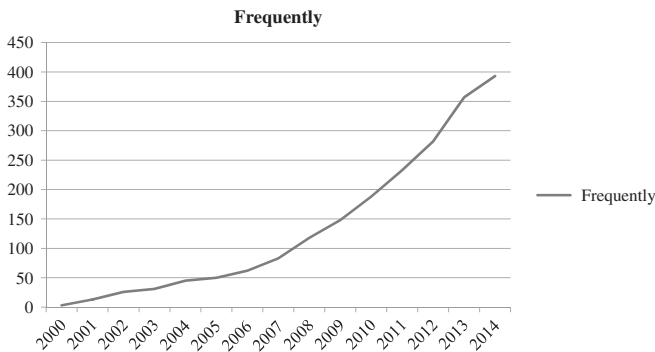


Figure 1. Distribution papers based on the total number of publications.
Source: Authors' calculation

5. Discussion

This study attempted to review articles published over 15 years (2000–2014) about MCDM techniques and approaches in 120 international peer-reviewed journals, which are accessible via the database system Web of Science. The first aim of this article was to systematically review the studies conducted based on MCDM techniques and approaches.

To this end a total of 393 published articles about MCDM were systematically and carefully chosen and summarised based on title, abstract, introduction, research method, and conclusion. Then, according to the predefined objective of this study, those articles related to MCDM techniques and approaches were selected. In this review, the obtained results were analysed based on six research questions; these questions were: (1) which DM techniques have been used?; (2) Which type of study has been conducted on these MCDM techniques?; (3) Which one of the 15 fields has further used these MCDM techniques?; (4) What kinds of MCDM tools have been employed in these years based on 15 fields?; (5) Which journals published articles related to these MCDM methods and approaches?; and (6) In which one of the years have authors published further articles related to MCDM methods and approaches based in the 15 fields? To answer the first question, we considered the results presented in Table 2 that showed the number and percentage of those MCDM techniques and approaches. This table revealed that the AHP technique with 128 studies was ranked as the first among other techniques and approaches; additionally, hybrid MCDM techniques and approaches were ranked second with 58 articles. The second question was which type of study has been conducted on these MCDM techniques? To answer the second question, we read the methodology section of each article very carefully and classified the studies in three types. Based on our reading, some studies have used MCDM techniques and approaches for solve DM problems. Based on our experience and discussions held with some experts on DM issues about this type of studies, we decided to call this type of study MCDM utilising research. Some scholars have attempted to develop DM techniques and approaches based on their objectives; therefore, the MCDM developing research is considered as the second type of study. Furthermore; our review indicated that some researchers have proposed new approach based on DM techniques and approaches, which we named MCDM proposing research type. The answers to questions three and four were presented section Table 1 and Table 2. These tables indicated that from 393 articles, operation research and soft computing area had the first rank with 109 studies (27.74%), most of the articles in this area attempted to develop and improve DM techniques and approaches for solving problems in MCDM issues. From 15 application areas, the second rank was energy, environmental and sustainability fields with 53 articles (13.49%). We believed that in recent years, most of scholars in fields of energy, environment and sustainability have applied MCDM and MCDM techniques and approaches and techniques for solving problems in these areas. In addition; based on results in Table 2, we found that previous studies have used the AHP technique more than other techniques and approaches in these 15 applications areas, also, hybrid MCDM techniques and approaches was ranked second with 64 articles (16.28%). Moreover, TOPSIS and aggregation DM methods had the third and fourth rank with 45 (11.66%) and 46 (11.92%) articles respectively. Furthermore, based on the findings in Table 2, ANP (7.38%), PROMETHEE (6.62%), ELECTRE (8.65%), DEMATEL (1.78%) and VIKOR (3.56%) had next subsequent ranks.

Question five was: (5) which journal published articles related to these MCDM methods and approaches? Table 12 showed the results of this question, as we can see in this table, from 120 journals; ranked first was the *European Journal of Operational Research* with 70 articles. According to this result, we can indicate that the *Journal of Expert Systems and Applications and Applied Mathematical Modelling* had the second and third rank with 20 and 13 articles respectively, although the *Journal of Materials & Design* with 13 articles was ranked third. In other journal ranking the *Journal of Civil Engineering and Management* was ranked fourth with 12 articles. Moreover the *Journal of Applied Mathematics and Computation*, the *Journal of Technological and Economic*

Development of Economy and the *Journal of Renewable Energy* was ranked fifth with nine publications. The total number of publications of other published journals shows in Table 12. Question six was: (6) in which year have authors published further articles relating to MCDM methods and approaches based in the 15 fields? Figure 1 presents important evidence based on the frequency of distribution by the year of publication. The results indicate that from 2000 to 2014, the information about the use of DM techniques and approaches have grown. According to the findings of this section, the use of these techniques and approaches in 2000 was three articles and this number increased to 10 articles in 2001.

6. Conclusion

In DM applications and theories, different modelling techniques have been offered, a number of suitable approaches have been provided for modelling decision aiding and help is provided for the development of alternatives as they consider the complexity of the process. Choosing a problem solution approach and a model is dependent upon the actors that are involved in the process of DM, desired goals, available information, time, and so on. The most important advantage of the multiple criteria methods is their capability of addressing the problems that are marked by different conflicting interests. Using these techniques, actors are capable of solving the problems that it is not possible to solve by the use of common optimisation models. MCDM techniques and approaches are being employed increasingly for the evaluation of alternatives and comparative analysis. Moreover, a number of significant concepts are discussed, which have not been addressed in previous studies. We provide a systematic review of MCDM which classifies articles in 15 difference areas including; energy, environment and sustainability, supply chain management, material, quality management, GIS, construction and project management, safety and risk management, manufacturing systems, technology management, operation research and soft computing, strategic management, knowledge management, production management, tourism management and other fields. Several significant articles about MCDM issues are introduced in this article.

We have reviewed the literature for the classification and interpretation of the emerging issues that make use of the MCDM methodology. In the present review, a total of 393 scholarly articles were collected from 120 journals, published since 2000, and they were categorised into 15 areas. The articles were classified based on the journal's name, publication year, application areas, and several MCDM techniques and approaches including; AHP, TOPSIS, ELECTRE, hybrid MCDM, ANP, PROMETHEE, DEMATEL DM aggregation methods (ARAS, WASPAS, SWARA, MOORA, MULTIMOORA and COPRAS) and VIKOR. This article contributes to the development of a classification scheme focusing on practical considerations, structurally reviewing the literature to create a guide for further studies on MCDM techniques and approaches, and the identification of issues for future studies. Additionally, in our study, two new perspectives are taken into consideration when reviewing the articles, namely categorisation of the articles in 15 areas and examination of the type of study (MCDM utilising research, MCDM developing research and MCDM proposing research).

Generally, the MCDM methodology has been used successfully in various applications and industrial sectors with different subjects and terms, although interdisciplinary and social decision problems should be further emphasised. Future study on the MCDM anatomy can be developed. In this study, a number of techniques have been studied as individual techniques and they are integrated or combined with other techniques;

however, some conventional MCDM techniques and approaches have not been studied. Another recommendation for future research is the investigation on the distinct differences and similarities among MCDM techniques and approaches. The insights that are provided in this article help channel research efforts and fulfil practitioners' and researchers' requirements for an easy reference to MCDM publications and studies.

This study has some major limitations that can be considered as recommendations for future studies. First, this review is focused on the use of DM techniques. Articles published in late 2014, if any, are not included in the present article due to the limited reporting time. A future review can be expanded further in scope. In addition, our article focuses on 15 fields. In this regard, future studies can use this article for classify based on different sub-fields and sub-areas. Another limitation is that the data were collected from journals, not including articles conference articles, textbooks, doctoral and master dissertations, PhD thesis and unpublished articles in the MCDM issues. Therefore, in future studies, data can be collected from these scholarly journals and the obtained results can be compared with our results. The next limitation is that the all of articles were found in English language journals, scholarly journals in the other languages were not involved in our review article. It may mean that this article is incomplete; however, we believe that we comprehensively review and include most of the articles presented by 120 high-ranking journals. As a result, our review article can provide a better understanding of MCDM techniques and approaches for future academic scholars. We hope this study will be employed by academics and managers as a basis for further research and will help practitioners make more appropriate decisions using these techniques, and guide scholars to enhance these methodologies. This article selected and summarised carefully those articles that were available from publishers in Web of Science, although, a number of relevant outlets may have remained outside the scope of this study. Therefore, future studies can review those articles which we did not discuss in this review article.

Recently, the development of hybrid and modular methods is becoming increasingly important. They are based on previously developed well-known methods, such as TOPSIS, SAW, DEA, AHP, ANP, VIKOR, DEMATEL, DEA, PROMETHEE, ELECTRE and their modification, by applying fuzzy and grey number theory. Relatively recently developed MCDM methods, such as COPRAS, ARAS-F, MOORA, MULTIMOORA, SWARA and WASPAS are rapidly developed and applied to solve real life problems. In order to help researchers and practitioners interested in hybrid MCDM techniques and approaches, it is necessary to publish reviews on these issues in future. This article presents synopses of numerous publications, which describe the use of MCDM methods in journals and some of the relatively recently developed methods. However, this review does not cover recent methods which have not yet been reviewed in books.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

- Abba, A. H., Noor, Z. Z., Yusuf, R. O., Din, M. F. M. D., & Hassan, M. A. A. (2013). Assessing environmental impacts of municipal solid waste of Johor by analytical hierarchy process. *Resources, Conservation and Recycling*, 73, 188–196.
- Abdi, M. R. & Labib, A. W. (2011). Performance evaluation of reconfigurable manufacturing systems via holonic architecture and the analytic network process. *International Journal of Production Research*, 49, 1319–1335.

- Abedi, M., Ali Torabi, S., Norouzi, G.-H., Hamzeh, M., & Elyasi, G.-R. (2012). PROMETHEE II: A knowledge-driven method for copper exploration. *Computers & Geosciences*, *46*, 255–263.
- Abedi, M., Gholami, A., & Norouzi, G.-H. (2013). A stable downward continuation of airborne magnetic data: A case study for mineral prospectivity mapping in Central Iran. *Computers & Geosciences*, *52*, 269–280.
- Abid, F., & Bahloul, S. (2011). Selected MENA countries' attractiveness to G7 investors. *Economic Modelling*, *28*, 2197–2207.
- Agarwal, A., Shankar, R., & Tiwari, M. K. (2006). Modeling the metrics of lean, agile and leagile supply chain: An ANP-based approach. *European Journal of Operational Research*, *173*, 211–225. doi:10.1016/j.ejor.2004.12.005
- Aguilar-Lasserre, A. A., Bautista Bautista, M. A., Ponsich, A., & González Huerta, M. A. (2009). An AHP-based decision-making tool for the solution of multiproduct batch plant design problem under imprecise demand. *Computers & Operations Research*, *36*, 711–736.
- Aghdaie, M. H., Zolfani, S. H., & Zavadskas, E. K. (2014). Synergies of data mining and multiple attribute decision making. *Procedia-Social and Behavioral Sciences*, *110*, 767–776.
- Akincilar, A., & Dagdeviren, M. (2014). A hybrid multi-criteria decision making model to evaluate hotel websites. *International Journal of Hospitality Management*, *36*, 263–271.
- Al Khalil, M. I. (2002). Selecting the appropriate project delivery method using AHP. *International Journal of Project Management*, *20*, 469–474.
- Albadvi, A. (2004). Formulating national information technology strategies: A preference ranking model using PROMETHEE method. *European Journal of Operational Research*, *153*, 290–296.
- Albadvi, A., Chaharsooghi, S. K., & Esfahanipour, A. (2007). Decision making in stock trading: An application of PROMETHEE. *European Journal of Operational Research*, *177*, 673–683.
- Al-Harbi, K. M. (2001). Application of the AHP in project management. *International Journal of Project Management*, *19*, 19–27.
- Alimardani, M., Hashemkhani Zolfani, S., Aghdaie, M. H., & Tamošaitienė, J. (2013). A novel hybrid SWARA and VIKOR methodology for supplier selection in an agile environment. *Technological and Economic Development of Economy*, *19*, 533–548.
- de Almeida, A. T., & Vetschera, R. (2012). A note on scale transformations in the PROMETHEE V method. *European Journal of Operational Research*, *219*, 198–200. doi:10.1016/j.ejor.2011.12.034
- Altuntas, S., Dereli, T., & Yilmaz, M. K. (2012). Multi-criteria decision making methods based weighted SERVQUAL scales to measure perceived service quality in hospitals: A case study from Turkey. *Total Quality Management & Business Excellence*, *23*, 1379–1395.
- Altuzarra, A., Moreno-Jiménez, J. M., & Salvador, M. (2007). A Bayesian prioritization procedure for AHP-group decision making. *European Journal of Operational Research*, *182*, 367–382. doi:10.1016/j.ejor.2006.07.025
- Aminbakhsh, S., Gunduz, M., & Sonmez, R. (2013). Safety risk assessment using analytic hierarchy process (AHP) during planning and budgeting of construction projects. *Journal of Safety Research*, *46*, 99–105.
- Angilella, S., Corrente, S., Greco, S., & Słowiński, R. (2014). MUSA-INT: Multicriteria customer satisfaction analysis with interacting criteria. *Omega*, *42*, 189–200. doi:10.1016/j.omega.2013.05.006
- Angilella, S., & Mazzù, S. (2015). The financing of innovative SMEs: A multicriteria credit rating model. *European Journal of Operational Research*, *244*, 540–554. doi: <http://dx.doi.org/10.1016/j.ejor.2015.01.033>
- Aragonés-Beltrán, P., Aznar, J., Ferris-Oñate, J., & García-Melón, M. (2008). Valuation of urban industrial land: An analytic network process approach. *European Journal of Operational Research*, *185*, 322–339. doi:10.1016/j.ejor.2006.09.076
- Araz, C., Mizrak Ozfirat, P., & Ozkarahan, I. (2007). An integrated multicriteria decision-making methodology for outsourcing management. *Computers & Operations Research*, *34*, 3738–3756.
- Ataei, M., Shahsavany, H., & Mikaeil, R. (2013). Monte Carlo Analytic Hierarchy Process (MAHP) approach to selection of optimum mining method. *International Journal of Mining Science and Technology*, *23*, 573–578.

- Ayağ, Z. (2005). An integrated approach to evaluating conceptual design alternatives in a new product development environment. *International Journal of Production Research*, 43, 687–713.
- Ayağ, Z. & Özdemir, R. (2007). An analytic network process-based approach to concept evaluation in a new product development environment. *Journal of Engineering Design*, 18, 209–226.
- Azadeh, A., Ghaderi, S. F., & Izadbakhsh, H. (2008). Integration of DEA and AHP with computer simulation for railway system improvement and optimization. *Applied Mathematics and Computation*, 195, 775–785.
- Bagočius, V., Zavadskas, E. K., & Turskis, Z. (2013). Multi-criteria selection of a deep-water port in Klaipėda. *Procedia Engineering*, 57, 144–148.
- Bagočius, V., Zavadskas, E. K., & Turskis, Z. (2014). Multi-person selection of the best wind turbine based on the multi-criteria integrated additive-multiplicative utility function. *Journal of Civil Engineering and Management*, 20, 590–599.
- Bahraminasab, M., & Jahan, A. (2011). Material selection for femoral component of total knee replacement using comprehensive VIKOR. *Materials & Design*, 32, 4471–4477.
- Bai, C. & Sarkis, J. (2013). A grey-based DEMATEL model for evaluating business process management critical success factors. *International Journal of Production Economics*, 146, 281–292.
- Baky, I. A. (2014). Interactive TOPSIS algorithms for solving multi-level non-linear multi-objective decision-making problems. *Applied Mathematical Modelling*, 38, 1417–1433.
- Baky, I. & Abo-Sinna, M. A. (2013). TOPSIS for bi-level MODM problems. *Applied Mathematical Modelling*, 37, 1004–1015.
- Baležentis, A., & Baležentis, T. (2011). Assessing the efficiency of Lithuanian transport sector by applying the methods of MULTIMOORA and data envelopment analysis. *Transport*, 26, 263–270.
- Baležentis, T., Baležentis, A., & Brauers, W. K. (2011). Multi-objective optimization of well-being in the European Union member states. *Ekonomika Istraživanja-Economic Research*, 24(4), 1–15.
- Banaitiene, N., Banaitis, A., Kaklauskas, A., & Zavadskas, E. K. (2008). Evaluating the life cycle of a building: A multivariant and multiple criteria approach. *Omega*, 36, 429–441.
- Barker, T. J., & Zabinsky, Z. B. (2011). A multicriteria decision making model for reverse logistics using analytical hierarchy process. *Omega*, 39, 558–573.
- Beccali, M., Cellura, M., & Mistretta, M. (2003). Decision-making in energy planning. Application of the Electre method at regional level for the diffusion of renewable energy technology. *Renewable Energy*, 28, 2063–2087.
- Behzadian, M., Kazemzadeh, R. B., Albadvi, A., & Aghdasi, M. (2010). PROMETHEE: A comprehensive literature review on methodologies and applications. *European Journal of Operational Research*, 200, 198–215.
- Behzadian, M., Khanmohammadi Otahsara, S., Yazdani, M., & Ignatius, J. (2012). A state-of-the-art survey of TOPSIS applications. *Expert Systems with Applications*, 39, 13051–13069.
- Belton, V., & Stewart, T. (2002). *Multiple criteria decision analysis: An integrated approach* Springer.
- Benítez, J., Delgado-Galván, X., Izquierdo, J., & Pérez-García, R. (2012). Improving consistency in AHP decision-making processes. *Applied Mathematics and Computation*, 219, 2432–2441.
- Bentes, A. V., Carneiro, J., da Silva, J. F., & Kimura, H. (2012). Multidimensional assessment of organizational performance: Integrating BSC and AHP. *Journal of Business Research*, 65, 1790–1799.
- Bernasconi, M., Choirat, C., & Seri, R. (2014). Empirical properties of group preference aggregation methods employed in AHP: Theory and evidence. *European Journal of Operational Research*, 232, 584–592.
- Bertolini, M., Braglia, M., & Carmignani, G. (2006). Application of the AHP methodology in making a proposal for a public work contract. *International Journal of Project Management*, 24, 422–430.
- Beynon, M. (2002a). An analysis of distributions of priority values from alternative comparison scales within AHP. *European Journal of Operational Research*, 140, 104–117. doi:10.1016/S0377-2217(01)00221-1

- Beynon, M. (2002b). DS/AHP method: A mathematical analysis, including an understanding of uncertainty. *European Journal of Operational Research*, 140, 148–164.
- Beynon, M. J. (2005). Understanding local ignorance and non-specificity within the DS/AHP method of multi-criteria decision making. *European Journal of Operational Research*, 163, 403–417.
- Beynon, M. J., & Wells, P. (2008). The lean improvement of the chemical emissions of motor vehicles based on preference ranking: A PROMETHEE uncertainty analysis. *Omega*, 36, 384–394.
- Bilbao-Terol, A., Arenas-Parra, M., Cañal-Fernández, V., & Antomil-Ibias, J. (2014). Using TOPSIS for assessing the sustainability of government bond funds. *Omega*, 49, 1–17.
- Bisdorff, R. (2002). Electre-like clustering from a pairwise fuzzy proximity index. *European Journal of Operational Research*, 138, 320–331.
- Bojković, N., Anić, I., & Pejić-Tarle, S. (2010). One solution for cross-country transport-sustainability evaluation using a modified ELECTRE method. *Ecological Economics*, 69, 1176–1186.
- Bortot, S., & Marques Pereira, R. A. (2013). Inconsistency and non-additive capacities: The analytic hierarchy process in the framework of choquet integration. *Fuzzy sets and systems*, 213, 6–26.
- Bouyssou, D., & Marchant, T. (2007). An axiomatic approach to noncompensatory sorting methods in MCDM, II: More than two categories. *European Journal of Operational Research*, 178, 246–276.
- Bouyssou, D., & Marchant, T. (2015). On the relations between ELECTRE TRI-B and ELECTRE TRI-C and on a new variant of ELECTRE TRI-B. *European Journal of Operational Research*, 242, 201–211. doi:10.1016/j.ejor.2014.09.057
- Bouyssou, D., Marchant, T., Pirlot, M., Tsoukiàs, A., & Vincke, P. (2006). *Evaluation and Decision Models with Multiple Criteria Stepping stones for the analyst*. In Boston, MA: Springer Science+Business Media Inc.
- Bouyssou, D., & Pirlot, M. (2009). An axiomatic analysis of concordance–discordance relations. *European Journal of Operational Research*, 199, 468–477.
- Brauers, W. K. (2004). *Optimization methods for a stakeholder society, a revolution in economic thinking by multi-objective optimization, series: Nonconvex optimization and its applications* (Vol. 342). Boston/Dordrecht/London: Kluwer Academic Publishers.
- Brauers, W. K. M. (2013). Multi-objective seaport planning by MOORA decision making. *Annals of Operations Research*, 206, 39–58.
- Brauers, W. K. M., & Ginevičius, R. (2009). Robustness in regional development studies. The case of Lithuania. *Journal of Business Economics and Management*, 10, 121–140.
- Brauers, W. K. M., Kildienė, S., Zavadskas, E. K., & Kaklauskas, A. (2013). The construction sector in twenty European countries during the recession 2008–2009–country ranking by MULTIMOORA. *International Journal of Strategic Property Management*, 17, 58–78.
- Brauers, W. K. M., Kracka, M., & Zavadskas, E. K. (2012). Lithuanian case study of masonry buildings from the Soviet period. *Journal of civil engineering and management*, 18, 444–456.
- Brauers, W., & Zavadskas, E. K. (2006). The MOORA method and its application to privatization in a transition economy. *Control and Cybernetics*, 35, 445–469.
- Brauers, W. K. M. & Zavadskas, E. K. (2010). Project management by MULTIMOORA as an instrument for transition economies. *Technological and Economic Development of Economy*, 16, 5–24.
- Brauers, W. K. M., Zavadskas, E. K., Peldschus, F., & Turskis, Z. (2008). Multi-objective decision-making for road design. *Transport*, 23, 183–193.
- Brauers, W. K. M., Zavadskas, E. K., Turskis, Z., & Vilutiene, T. (2008). Multi-objective contractor's ranking by applying the Moora method. *Journal of Business Economics and Management*, 9, 245–255.
- Brent, A. C., Rogers, D. E. C., Ramabitsa-Siimane, T. S. M., & Rohwer, M. B. (2007). Application of the analytical hierarchy process to establish health care waste management systems that minimise infection risks in developing countries. *European Journal of Operational Research*, 181, 403–424.
- Brito, A. J., de Almeida, A. T., & Mota, C. M. (2010). A multicriteria model for risk sorting of natural gas pipelines based on ELECTRE TRI integrating Utility Theory. *European Journal of Operational Research*, 200, 812–821.

- Brunelli, M., Critch, A., & Fedrizzi, M. (2013). A note on the proportionality between some consistency indices in the AHP. *Applied Mathematics and Computation*, 219, 7901–7906.
- Bruno, G., Esposito, E., Genovese, A., & Passaro, R. (2012). AHP-based approaches for supplier evaluation: Problems and perspectives. *Journal of Purchasing and Supply Management*, 18, 159–172.
- Buchanan, J., & Vanderpooten, D. (2007). Ranking projects for an electricity utility using ELECTRE III. *International Transactions in Operational Research*, 14, 309–323.
- Bunruamkaew, K., & Murayam, Y. (2011). Site suitability evaluation for ecotourism using GIS & AHP: A case study of Surat Thani Province, Thailand. *Procedia – Social and Behavioral Sciences*, 21, 269–278.
- Büyüközkan, G., & Berkol, Ç. (2011). Designing a sustainable supply chain using an integrated analytic network process and goal programming approach in quality function deployment. *Expert Systems with Applications*, 38, 13731–13748.
- Büyüközkan, G., & Öztürkcan, D. (2010). An integrated analytic approach for Six Sigma project selection. *Expert Systems with Applications*, 37, 5835–5847.
- Buyurgan, N., & Saygin, C. (2008). Application of the analytical hierarchy process for real-time scheduling and part routing in advanced manufacturing systems. *Journal of Manufacturing Systems*, 27, 101–110.
- Çalışkan, H. (2013). Selection of boron based tribological hard coatings using multi-criteria decision making methods. *Materials & Design*, 50, 742–749.
- Çalışkan, H., Kurşuncu, B., Kurbanoglu, C., & Güven, Ş. Y. (2013). Material selection for the tool holder working under hard milling conditions using different multi criteria decision making methods. *Materials & Design*, 45, 473–479.
- Carlucci, D., & Schiuma, G. (2009). Applying the analytic network process to disclose knowledge assets value creation dynamics. *Expert Systems with Applications*, 36, 7687–7694.
- Cavallaro, F. (2010). A comparative assessment of thin-film photovoltaic production processes using the ELECTRE III method. *Energy Policy*, 38, 463–474.
- Cavallini, C., Giorgetti, A., Citti, P., & Nicolaie, F. (2013). Integral aided method for material selection based on quality function deployment and comprehensive VIKOR algorithm. *Materials & Design*, 47, 27–34.
- Cay, T., & Uyan, M. (2013). Evaluation of reallocation criteria in land consolidation studies using the Analytic Hierarchy Process (AHP). *Land Use Policy*, 30, 541–548.
- Chakraborty, S., & Zavadska, E. K. (2014). Applications of WASPAS method in manufacturing decision making. *Informatica*, 25, 1–20.
- Chan, F. T. S., Ip, R. W. L., & Lau, H. (2001). Integration of expert system with analytic hierarchy process for the design of material handling equipment selection system. *Journal of Materials Processing Technology*, 116, 137–145.
- Chang, C.-L. & Hsu, C.-H. (2009). Multi-criteria analysis via the VIKOR method for prioritizing land-use restraint strategies in the Tseng-Wen reservoir watershed. *Journal of Environmental Management*, 90, 3226–3230.
- Chang, A.-Y., Hu, K.-J., & Hong, Y.-L. (2013). An ISM-ANP approach to identifying key agile factors in launching a new product into mass production. *International Journal of Production Research*, 51, 582–597.
- Chang, C.-W., Wu, C.-R., Lin, C.-T., & Chen, H.-C. (2007). An application of AHP and sensitivity analysis for selecting the best slicing machine. *Computers & Industrial Engineering*, 52, 296–307.
- Chang, Y.-H., Wey, W.-M., & Tseng, H.-Y. (2009). Using ANP priorities with goal programming for revitalization strategies in historic transport: A case study of the Alishan Forest Railway. *Expert Systems with Applications*, 36, 8682–8690.
- Charnes, A., Cooper, W. W., Lewin, A. Y., & Seiford, L. M. (2013). *Data envelopment analysis: Theory, methodology, and applications*. Dordrecht: Springer Science & Business Media.
- Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2, 429–444.
- Chatterjee, P., Athawale, V. M., & Chakraborty, S. (2009). Selection of materials using compromise ranking and outranking methods. *Materials & Design*, 30, 4043–4053.
- Chatterjee, P., Athawale, V. M., & Chakraborty, S. (2011). Materials selection using complex proportional assessment and evaluation of mixed data methods. *Materials & Design*, 32, 851–860.

- Chatterjee, P., & Chakraborty, S. (2012). Material selection using preferential ranking methods. *Materials & Design*, 35, 384–393.
- Chauhan, A., & Vaish, R. (2012). Magnetic material selection using multiple attribute decision making approach. *Materials & Design*, 36, 1–5.
- Chen, C.-A. (2014). Suitable Festival Activities for Taiwan's Tourism and Nation Branding with the Application of the PR AHP Program. *Asia Pacific Journal of Tourism Research*, 19(12), 1381–1398.
- Chen, S.-Y. (2009). Identifying and prioritizing critical intellectual capital for e-learning companies. *European Business Review*, 21, 438–452.
- Chen, T.-Y. (2015). The inclusion-based TOPSIS method with interval-valued intuitionistic fuzzy sets for multiple criteria group decision making. *Applied Software Computing*, 26, 57–73.
- Chen, T., Jin, Y., Qiu, X., & Chen, X. (2014). A hybrid fuzzy evaluation method for safety assessment of food-waste feed based on entropy and the analytic hierarchy process methods. *Expert Systems with Applications*, 41, 7328–7337.
- Chen, Y.-C., Lien, H.-P., & Tzeng, G.-H. (2010). Measures and evaluation for environment watershed plans using a novel hybrid MCDM model. *Expert Systems with Applications*, 37, 926–938.
- Chen, C.-T., Pai, P.-F., & Hung, W.-Z. (2010). An integrated methodology using linguistic PROMETHEE and maximum deviation method for third-party logistics supplier selection. *International Journal of Computational Intelligence Systems*, 3, 438–451.
- Chen, R.-S., & Shyu, J. Z. (2006). Selecting a weapon system using zero-one goal programming and analytic network process. *Journal of Information and Optimization Sciences*, 27, 379–399.
- Chen, C.-H., & Tzeng, G.-H. (2011). Creating the aspired intelligent assessment systems for teaching materials. *Expert Systems with Applications*, 38, 12168–12179.
- Chen, M. K., & Wang, S.-C. (2010). The critical factors of success for information service industry in developing international market: Using analytic hierarchy process (AHP) approach. *Expert Systems with Applications*, 37, 694–704.
- Chen, S.-P., & Wu, W.-Y. (2010). A systematic procedure to evaluate an automobile manufacturer–distributor partnership. *European Journal of Operational Research*, 205, 687–698. doi:10.1016/j.ejor.2010.01.036
- Chen, Y., Yu, J., & Khan, S. (2010). Spatial sensitivity analysis of multi-criteria weights in GIS-based land suitability evaluation. *Environmental Modelling & Software*, 25, 1582–1591.
- Cheng, C.-B. (2008). Solving a sealed-bid reverse auction problem by multiple-criterion decision-making methods. *Computers & Mathematics with Applications*, 56, 3261–3274.
- Chin, K.-S., Xu, D.-L., Yang, J.-B., & Ping-Kit Lam, J. (2008). Group-based ER–AHP system for product project screening. *Expert Systems with Applications*, 35, 1909–1929.
- Chinese, D., Nardin, G., & Saro, O. (2011). Multi-criteria analysis for the selection of space heating systems in an industrial building. *Energy*, 36, 556–565.
- Chou, T.-Y., Lin, W.-T., Lin, C.-Y., Chou, W.-C., & Huang, P.-H. (2004). Application of the PROMETHEE technique to determine depression outlet location and flow direction in DEM. *Journal of Hydrology*, 287, 49–61.
- Chu, M.-T., Shyu, J., Tzeng, G.-H., & Khosla, R. (2007). Comparison among three analytical methods for knowledge communities group-decision analysis. *Expert Systems with Applications*, 33, 1011–1024.
- Chwolka, A. & Raith, M. G. (2001). Group preference aggregation with the AHP – implications for multiple-issue agendas. *European Journal of Operational Research*, 132, 176–186. doi:10.1016/S0377-2217(00)00121-1
- Corrente, S., Figueira, J. R., & Greco, S. (2014). The SMAA-PROMETHEE method. *European Journal of Operational Research*, 239, 514–522. doi:10.1016/j.ejor.2014.05.026
- Corrente, S., Greco, S., & Słowiński, R. (2012). Multiple criteria hierarchy process in robust ordinal regression. *Decision Support Systems*, 53, 660–674. doi:10.1016/j.dss.2012.03.004
- Corrente, S., Greco, S., & Słowiński, R. (2013). Multiple Criteria Hierarchy Process with ELECTRE and PROMETHEE. *Omega*, 41, 820–846. doi:10.1016/j.omega.2012.10.009
- Cortés-Aldana, F. A., García-Melón, M., Fernández-de-Lucio, I., Aragónés-Beltrán, P., & Poveda-Bautista, R. (2009). University objectives and socioeconomic results: A multicriteria measuring of alignment. *European Journal of Operational Research*, 199(3), 811–822. doi:10.1016/j.ejor.2009.01.065

- e Costa, C. A. B., & Vansnick, J.-C. (2008). A critical analysis of the eigenvalue method used to derive priorities in AHP. *European Journal of Operational Research*, 187, 1422–1428.
- Dadelo, S., Turskis, Z., Zavadskas, E. K., & Dadelienė, R. (2012). Multiple criteria assessment of elite security personal on the basis of ARAS and expert methods. *Journal of economic computation and economic cybernetics studies and research*, 4, 1–23.
- Daim, T. U., Udbye, A., & Balasubramanian, A. (2012). Use of analytic hierarchy process (AHP) for selection of 3PL providers. *Journal of Manufacturing Technology Management*, 24, 28–51.
- De Feo, G., & De Gisi, S. (2010). Using an innovative criteria weighting tool for stakeholders involvement to rank MSW facility sites with the AHP. *Waste Management*, 30, 2370–2382.
- Dėjus, T., & Antuchevičienė, J. (2013). Assessment of health and safety solutions at a construction site. *Journal of Civil Engineering and Management*, 19, 728–737.
- Del Vasto-Terrientes, L., Valls, A., Słowiński, R., & Zielniewicz, P. (2015). ELECTRE-III-H: An outranking-based decision aiding method for hierarchically structured criteria. *Expert Systems with Applications*, 42, 4910–4926. <http://dx.doi.org/10.1016/j.eswa.2015.02.016>
- Dembczyński, K., Greco, S., & Słowiński, R. (2009). Rough set approach to multiple criteria classification with imprecise evaluations and assignments. *European Journal of Operational Research*, 198, 626–636. doi:10.1016/j.ejor.2008.09.033
- Dhouib, D. & Elloumi, S. (2011). A new multi-criteria approach dealing with dependent and heterogeneous criteria for end-of-life product strategy. *Applied Mathematics and Computation*, 218, 1668–1681.
- Di Gironimo, G., Carfora, D., Esposito, G., Labate, C., Mozzillo, R., Renno, F., Lanzotti, A., & Siuko, M. (2013). Improving concept design of divertor support system for FAST tokamak using TRIZ theory and AHP approach. *Fusion Engineering and Design*, 88, 3014–3020.
- Dias, L. C. & Mousseau, V. (2006). Inferring Electre's veto-related parameters from outranking examples. *European Journal of Operational Research*, 170, 172–191.
- Dias, L. s., Mousseau, V., Figueira, J., & Climaco, J. (2002). An aggregation/disaggregation approach to obtain robust conclusions with ELECTRE TRI. *European Journal of Operational Research*, 138, 332–348.
- Dong, Y., Hong, W.-C., Xu, Y., & Yu, S. (2013). Numerical scales generated individually for analytic hierarchy process. *European Journal of Operational Research*, 229, 654–662.
- Dong, Y., Xu, Y., Li, H., & Dai, M. (2008). A comparative study of the numerical scales and the prioritization methods in AHP. *European Journal of Operational Research*, 186, 229–242. doi:10.1016/j.ejor.2007.01.044
- Dou, Y., Zhu, Q., & Sarkis, J. (2014). Evaluating green supplier development programs with a grey-analytical network process-based methodology. *European Journal of Operational Research*, 233, 420–431. doi:10.1016/j.ejor.2013.03.004
- Doumpos, M., Marinakis, Y., Marinaki, M., & Zopounidis, C. (2009). An evolutionary approach to construction of outranking models for multicriteria classification: The case of the ELECTRE TRI method. *European Journal of Operational Research*, 199, 496–505. doi:10.1016/j.ejor.2008.11.035
- Du, Y., Gao, C., Hu, Y., Mahadevan, S., & Deng, Y. (2014). A new method of identifying influential nodes in complex networks based on TOPSIS. *Physica A: Statistical Mechanics and its Applications*, 399, 57–69.
- Dymova, L., Sevastjanov, P., & Tikhonenko, A. (2013). A direct interval extension of TOPSIS method. *Expert Systems with Applications*, 40, 4841–4847.
- Džiugaitė-Tumėnienė, R., & Lapinskienė, V. (2014). The multicriteria assessment model for an energy supply system of a low energy house. *Engineering Structures and Technologies*, 6, 33–41.
- Effat, H. A., & Hassan, O. A. (2013). Designing and evaluation of three alternatives highway routes using the Analytical Hierarchy Process and the least-cost path analysis, application in Sinai Peninsula, Egypt. *The Egyptian Journal of Remote Sensing and Space Science*, 16, 141–151.
- Entani, T., & Sugihara, K. (2012). Uncertainty index based interval assignment by Interval AHP. *European Journal of Operational Research*, 219, 379–385.
- Erdoğan, Ş., Aras, H., & Koç, E. (2006). Evaluation of alternative fuels for residential heating in Turkey using analytic network process (ANP) with group decision-making. *Renewable and Sustainable Energy Reviews*, 10, 269–279.

- Erensal, Y. C., Gürbüz, T., & Esra Albayrak, Y. (2010). A multi-criteria decision model for architecturing competence in human performance technology. *International Journal of Computational Intelligence Systems*, 3, 815–831.
- Ergu, D., Kou, G., Peng, Y., & Shi, Y. (2011). A simple method to improve the consistency ratio of the pair-wise comparison matrix in ANP. *European Journal of Operational Research*, 213, 246–259.
- Erol, Ö., & Kılış, B. (2012). An energy source policy assessment using analytical hierarchy process. *Energy Conversion and Management*, 63, 245–252.
- Figueira, J. R., Greco, S., & Roy, B. (2009). ELECTRE methods with interaction between criteria: An extension of the concordance index. *European Journal of Operational Research*, 199, 478–495.
- Figueira, J.R., Greco, S., Roy, B., & Słowiński, R. (2013) An overview of ELECTRE methods and their recent extensions. *Journal of Multi-Criteria Decision Analysis* 20, 61-85.
- Figueira, J. R., Greco, S., & Słowiński, R. (2009). Building a set of additive value functions representing a reference preorder and intensities of preference: GRIP method. *European Journal of Operational Research*, 195, 460–486. doi:10.1016/j.ejor.2008.02.006
- Figueira, J., & Roy, B. (2002). Determining the weights of criteria in the ELECTRE type methods with a revised Simos' procedure. *European Journal of Operational Research*, 139, 317–326. doi:10.1016/S0377-2217(01)00370-8
- Fishburn, P. (1978). A Survey of Multiattribute/Multicriterion Evaluation Theories. In S. Zionts (Ed.), *Multiple Criteria Problem Solving* (pp. 181–224). Berlin: Springer-Verlag.
- Fontela, E., & Gabus, A. (1976). *The DEMATEL observer; DEMATEL 1976 Report*. Switzerland Geneva: Battelle Geneva Research Center, USA.
- Gal, T., Stewart, T., & Hanne, T. (1999). *Multicriteria decision making: Advances in MCDM models, algorithms, theory, and applications* (Vol. 21). Dordrecht: Springer Science & Business Media.
- García-Cascales, M. S., & Lamata, M. T. (2012). On rank reversal and TOPSIS method. *Mathematical and Computer Modelling*, 56, 123–132.
- Gass, S. I., & Rapsák, T. (2004). Singular value decomposition in AHP. *European Journal of Operational Research*, 154, 573–584. doi:10.1016/S0377-2217(02)00755-5
- Georgopoulou, E., Sarafidis, Y., Mirasgedis, S., Zaimi, S., & Lalas, D. P. (2003). A multiple criteria decision-aid approach in defining national priorities for greenhouse gases emissions reduction in the energy sector. *European Journal of Operational Research*, 146, 199–215. doi:10.1016/S0377-2217(02)00250-3
- Ghaffghazi, S., Sowlati, T., Sokhansanj, S., & Melin, S. (2010). A multicriteria approach to evaluate district heating system options. *Applied Energy*, 87, 1134–1140.
- Ghosh, A. & Das, S. (2013). Raw Jute Grading By Multi-Criteria Decision Making Method. *Journal of Natural Fibers*, 10, 136–146.
- Giannoulis, C. & Ishizaka, A. (2010). A Web-based decision support system with ELECTRE III for a personalised ranking of British universities. *Decision Support Systems*, 48, 488–497.
- Goh, H. H., Kok, B. C., Yeo, H. T., Lee, S. W., & Mohd. Zin, A. A. (2013). Combination of TOPSIS and AHP in load shedding scheme for large pulp mill electrical system. *International Journal of Electrical Power & Energy Systems*, 47, 198–204.
- Greco, S., Kadziński, M., Mousseau, V., & Słowiński, R. (2011). ELECTREGKMS: Robust ordinal regression for outranking methods. *European Journal of Operational Research*, 214, 118–135. doi:10.1016/j.ejor.2011.03.045
- Greco, S., Kadziński, M., Mousseau, V., & Słowiński, R. (2012). Robust ordinal regression for multiple criteria group decision: UTAGMS-GROUP and UTADISGMS-GROUP. *Decision Support Systems*, 52, 549–561. doi:10.1016/j.dss.2011.10.005
- Greco, S., Kadziński, M., & Słowiński, R. (2011). Selection of a representative value function in robust multiple criteria sorting. *Computers & Operations Research*, 38, 1620–1637. doi:10.1016/j.cor.2011.02.003
- Greco, S., Matarazzo, B., & Słowiński, R. (2013). Beyond Markowitz with multiple criteria decision aiding. *Journal of Business Economics*, 83, 29–60. doi:10.1007/s11573-012-0644-2
- Greco, S., Mousseau, V., & Słowiński, R. (2014). Robust ordinal regression for value functions handling interacting criteria. *European Journal of Operational Research*, 239, 711–730. doi:10.1016/j.ejor.2014.05.022

- Gudienė, N., Banaitis, A., Podvezko, V., & Banaitienė, N. (2014). Identification and evaluation of the critical success factors for construction projects in Lithuania: AHP approach. *Journal of Civil Engineering and Management*, 20, 350–359.
- Hajejeh, M., & Al-Othman, A. (2005). Application of the analytical hierarchy process in the selection of desalination plants. *Desalination*, 174, 97–108.
- Haldar, A., Ray, A., Banerjee, D., & Ghosh, S. (2012). A hybrid MCDM model for resilient supplier selection. *International Journal of Management Science and Engineering Management*, 7, 284–292.
- Handfield, R., Walton, S. V., Sroufe, R., & Melnyk, S. A. (2002). Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process. *European Journal of Operational Research*, 141, 70–87.
- Hasanzadeh, M., Danehkar, A., & Azizi, M. (2013). The application of Analytical Network Process to environmental prioritizing criteria for coastal oil jetties site selection in Persian Gulf coasts (Iran). *Ocean & Coastal Management*, 73, 136–144.
- Hashemkhani Zolfani, S., Aghdaie, M. H., Derakhti, A., Zavadskas, E. K., & Morshed Varzandeh, M. H. (2013). Decision making on business issues with foresight perspective; an application of new hybrid MCDM model in shopping mall locating. *Expert Systems with Applications*, 40, 7111–7121.
- Hashemkhani Zolfani, S. & Bahrami, M. (2014). Investment prioritizing in high tech industries based on SWARA-COPRAS approach. *Technological and Economic Development of Economy*, 20, 534–553.
- Hashemkhani Zolfani, S., Esfahani, M. H., Bitarafan, M., Zavadskas, E. K., & Arefi, S. L. (2013). Developing a new hybrid MCDM method for selection of the optimal alternative of mechanical longitudinal ventilation of tunnel pollutants during automobile accidents. *Transport*, 28, 89–96.
- Hashemkhani Zolfani, S., & Sapauskas, J. (2013). New application of SWARA method in prioritizing sustainability assessment indicators of energy system. *Engineering Economics*, 24, 408–414.
- Ho, W. (2008). Integrated analytic hierarchy process and its applications—a literature review. *European Journal of Operational Research*, 186, 211–228.
- Ho, L.-H., Feng, S.-Y., Lee, Y.-C., & Yen, T.-M. (2012). Using modified IPA to evaluate supplier's performance: Multiple regression analysis and DEMATEL approach. *Expert Systems with Applications*, 39, 7102–7109.
- Hongwei, Y., Zhanpeng, J., Shaoqi, S., & Ruihua, L. (2004). Integrated assessment for anaerobic biodegradability of organic compounds using the analytical hierarchy process. *Ecotoxicology and Environmental Safety*, 59, 249–255.
- Hornig, J.-S., Liu, C.-H., Chou, S.-F., & Tsai, C.-Y. (2013). Creativity as a critical criterion for future restaurant space design: Developing a novel model with DEMATEL application. *International Journal of Hospitality Management*, 33, 96–105.
- Hosseini Nasab, H., & Milani, A. S. (2012). An improvement of quantitative strategic planning matrix using multiple criteria decision making and fuzzy numbers. *Applied Soft Computing*, 12, 2246–2253.
- Hsieh, L.-F., Lin, L.-H., & Lin, Y.-Y. (2008). A service quality measurement architecture for hot spring hotels in Taiwan. *Tourism Management*, 29, 429–438.
- Hsu, L.-C. (2014). Using a decision-making process to evaluate efficiency and operating performance for listed semiconductor companies. *Technological and Economic Development of Economy*, 21, 1–31.
- Hsu, P.-F., & Chen, B.-Y. (2008). Integrated analytic hierarchy process and entropy to develop a durable goods chain store franchisee selection model. *Asia Pacific Journal of Marketing and Logistics*, 20, 44–54.
- Hsu, C.-W., Kuo, T.-C., Chen, S.-H., & Hu, A. H. (2013). Using DEMATEL to develop a carbon management model of supplier selection in green supply chain management. *Journal of Cleaner Production*, 56, 164–172.
- Hsu, L.-C. (2014). Using a decision-making process to evaluate efficiency and operating performance for listed semiconductor companies. *Technological and Economic Development of Economy*, 21, 301–331.
- Hu, S.-K., Lu, M.-T., & Tzeng, G.-H. (2014). Exploring smart phone improvements based on a hybrid MCDM model. *Expert Systems with Applications*, 41, 4401–4413.

- Hu, Y.-C. (2010). A single-layer perceptron with PROMETHEE methods using novel preference indices. *Neurocomputing*, 73, 2920–2927.
- Hu, Y.-C., & Chen, C.-J. (2011). A PROMETHEE-based classification method using concordance and discordance relations and its application to bankruptcy prediction. *Information Sciences*, 181(22), 4959–4968.
- Hu, H.-Y., Lee, Y.-C., Yen, T.-M., & Tsai, C.-H. (2009). Using BPNN and DEMATEL to modify importance–performance analysis model—A study of the computer industry. *Expert Systems with Applications*, 36, 9969–9979.
- Hu, Y.-C., & Tsai, J.-F. (2006). Backpropagation multi-layer perceptron for incomplete pairwise comparison matrices in analytic hierarchy process. *Applied Mathematics and Computation*, 180, 53–62.
- Huang, Y.-S., Chang, W.-C., Li, W.-H., & Lin, Z.-L. (2013). Aggregation of utility-based individual preferences for group decision-making. *European Journal of Operational Research*, 229, 462–469. doi:10.1016/j.ejor.2013.02.043
- Huang, P. C., Tong, L. I., Chang, W. W., & Yeh, W. C. (2011). A two-phase algorithm for product part change utilizing AHP and PSO. *Expert Systems with Applications*, 38, 8458–8465.
- Huck, N. (2010). Pairs trading and outranking: The multi-step-ahead forecasting case. *European Journal of Operational Research*, 207, 1702–1716. doi:10.1016/j.ejor.2010.06.043
- Huo, L.-A., Lan, J., & Wang, Z. (2011). New parametric prioritization methods for an analytical hierarchy process based on a pairwise comparison matrix. *Mathematical and Computer Modelling*, 54, 2736–2749.
- Hwang, C. L., & Lin, M. J. (1967). *Group decision making under multiple criteria: Methods and applications*: Springer-Verlag.
- Hwang, C. L., & Masud, A. S. M. (1979). *Multiple objective decision making, methods and applications: A state-of-the-art survey*: Springer-Verlag.
- Hwang, C., & Yoon, K. (1981). *Multiple attribute decision making: Methods and applications, A state of the art survey*. New York, NY: Springer-Verlag.
- İç, Y. T. (2012). An experimental design approach using TOPSIS method for the selection of computer-integrated manufacturing technologies. *Robotics and Computer-Integrated Manufacturing*, 28, 245–256.
- İç, Y. T. (2014). A TOPSIS based design of experiment approach to assess company ranking. *Applied Mathematics and Computation*, 227, 630–647.
- İc, Y. T., Yurdakul, M., & Eraslan, E. (2012). Development of a component-based machining centre selection model using AHP. *International Journal of Production Research*, 50, 6489–6498.
- Ilankumaran, M., Karthikeyan, M., Ramachandran, T., Boopathiraja, M., & Kirubakaran, B. (2015). Risk analysis and warning rate of hot environment for foundry industry using hybrid MCDM technique. *Safety Science*, 72, 133–143. doi:10.1016/j.ssci.2014.08.011.
- Iniestra, J. G., & Gutiérrez, J. G. (2009). Multicriteria decisions on interdependent infrastructure transportation projects using an evolutionary-based framework. *Applied Soft Computing*, 9, 512–526.
- Ishizaka, A., & Nemery, P. (2011). Selecting the best statistical distribution with PROMETHEE and GAIA. *Computers & Industrial Engineering*, 61, 958–969.
- Ishizaka, A., & Nemery, P. (2014). Assigning machines to incomparable maintenance strategies with ELECTRE-SORT. *Omega*, 47, 45–59.
- Ivanović, I., Grujičić, D., Macura, D., Jović, J., & Bojović, N. (2013). One approach for road transport project selection. *Transport Policy*, 25, 22–29.
- Ivlev, I., Kneppo, P., & Bartak, M. (2014). Multicriteria decision analysis: A multifaceted approach to medical equipment management. *Technological and Economic Development of Economy*, 20, 576–589.
- Jadidi, O., Hong, T. S., & Firouzi, F. (2009). TOPSIS extension for multi-objective supplier selection problem under price breaks. *International Journal of Management Science and Engineering Management*, 4, 217–229.
- Jadidi, O., Sai Hong, T., Firouzi, F., & Yusuff, R. M. (2009). An optimal grey based approach based on TOPSIS concepts for supplier selection problem. *International Journal of Management Science and Engineering Management*, 4, 104–117.
- Jahan, A., & Edwards, K. (2013). VIKOR method for material selection problems with interval numbers and target-based criteria. *Materials & Design*, 47, 759–765.

- Jahan, A., Mustapha, F., Ismail, M. Y., Sapuan, S., & Bahraminasab, M. (2011). A comprehensive VIKOR method for material selection. *Materials & Design*, 32, 1215–1221.
- Jahanshahloo, G. R., Hosseinzadeh Lotfi, F., & Davoodi, A. (2009). Extension of TOPSIS for decision-making problems with interval data: Interval efficiency. *Mathematical and Computer Modelling*, 49, 1137–1142.
- Jahanshahloo, G. R., Khodabakhshi, M., Hosseinzadeh Lotfi, F., & Moazami Goudarzi, M. (2011). A cross-efficiency model based on super-efficiency for ranking units through the TOPSIS approach and its extension to the interval case. *Mathematical and Computer Modelling*, 53, 1946–1955.
- Jahanshahloo, G. R., Lotfi, F. H., & Izadikhah, M. (2006a). An algorithmic method to extend TOPSIS for decision-making problems with interval data. *Applied Mathematics and Computation*, 175, 1375–1384.
- Jahanshahloo, G. R., Lotfi, F. H., & Izadikhah, M. (2006b). Extension of the TOPSIS method for decision-making problems with fuzzy data. *Applied Mathematics and Computation*, 181, 1544–1551.
- Jalao, E. R., Wu, T., & Shunk, D. (2014). An intelligent decomposition of pairwise comparison matrices for large-scale decisions. *European Journal of Operational Research*, 238, 270–280. doi:10.1016/j.ejor.2014.03.032
- Jana, T. K., Bairagi, B., Paul, S., Sarkar, B., & Saha, J. (2013). Dynamic schedule execution in an agent based holonic manufacturing system. *Journal of Manufacturing Systems*, 32, 801–816.
- Jeng, D. J.-F., & Bailey, T. (2012). Assessing customer retention strategies in mobile telecommunications: Hybrid MCDM approach. *Management Decision*, 50, 1570–1595.
- Jiang, G.-M., Hu, Z.-P., & Jin, J.-Y. (2007). Quantitative evaluation of real estate's risk based on AHP and simulation. *Systems Engineering - Theory & Practice*, 27, 77–81.
- Jovanovic, J., Krivokapic, Z., & Vujovic, A. (2013). Evaluation of environmental impacts using backpropagation neural network. *Kybernetes*, 42, 698–710.
- Ju, Y. & Wang, A. (2013). Extension of VIKOR method for multi-criteria group decision making problem with linguistic information. *Applied Mathematical Modelling*, 37, 3112–3125.
- Kadziński, M., Greco, S., & Słowiński, R. (2012a). Extreme ranking analysis in robust ordinal regression. *Omega*, 40, 488–501. doi:10.1016/j.omega.2011.09.003
- Kadziński, M., Greco, S., & Słowiński, R. (2012b). Selection of a representative set of parameters for robust ordinal regression outranking methods. *Computers & Operations Research*, 39, 2500–2519. doi:10.1016/j.cor.2011.12.023
- Kadziński, M., Greco, S., & Słowiński, R. (2013). RUTA: A framework for assessing and selecting additive value functions on the basis of rank related requirements. *Omega*, 41, 735–751. doi:10.1016/j.omega.2012.10.002
- Kadziński, M., & Słowiński, R. (2013). DIS-CARD: A new method of multiple criteria sorting to classes with desired cardinality. *Journal of Global Optimization*, 56, 1143–1166. doi:10.1007/s10898-012-9945-9
- Kaklauskas, A., Zavadskas, E. K., Naimavicienė, J., Krutinis, M., Plakys, V., & Venskus, D. (2010). Model for a complex analysis of intelligent built environment. *Automation in Construction*, 19, 326–340.
- Kaklauskas, A., Zavadskas, E. K., Raslanas, S., Ginevicius, R., Komka, A., & Malinauskas, P. (2006). Selection of low-e windows in retrofit of public buildings by applying multiple criteria method COPRAS: A Lithuanian case. *Energy and Buildings*, 38, 454–462.
- Kalibatas, D., Zavadskas, E. K., & Kalibatiene, D. (2012). A method of multi-attribute assessment using ideal alternative: Choosing an apartment with optimal indoor environment. *International Journal of Strategic Property Management*, 16, 338–353.
- Kallas, Z., & Gil, J. M. (2012). Combining contingent valuation with the analytical hierarchy process to decompose the value of rabbit meat. *Food Quality and Preference*, 24, 251–259.
- Kallas, Z., Lambarra, F., & Gil, J. M. (2011). A stated preference analysis comparing the analytical hierarchy process versus Choice Experiments. *Food Quality and Preference*, 22, 181–192.
- Kanapeckiene, L., Kaklauskas, A., Zavadskas, E. K., & Seniut, M. (2010). Integrated knowledge management model and system for construction projects. *Engineering Applications of Artificial Intelligence*, 23, 1200–1215.
- Kang, H.-Y., & Lee, A. H. (2010). A new supplier performance evaluation model: A case study of integrated circuit (IC) packaging companies. *Kybernetes*, 39, 37–54.

- Kao, C. (2010). Weight determination for consistently ranking alternatives in multiple criteria decision analysis. *Applied Mathematical Modelling*, 34, 1779–1787.
- Karande, P. & Chakraborty, S. (2012). A Fuzzy-MOORA approach for ERP system selection. *Decision Science Letters*, 1, 11–21.
- Karimi-Nasab, M., & Seyedhoseini, S. M. (2013). Multi-level lot sizing and job shop scheduling with compressible process times: A cutting plane approach. *European Journal of Operational Research*, 231, 598–616. doi:10.1016/j.ejor.2013.06.021
- Kasanen, E., Wallenius, H., Wallenius, J., & Zionts, S. (2000). A study of high-level managerial decision processes, with implications for MCDM research. *European Journal of Operational Research*, 120, 496–510. doi:10.1016/S0377-2217(98)00388-9
- Kasirian, M., & Yusuff, R. (2013). An integration of a hybrid modified TOPSIS with a PGP model for the supplier selection with interdependent criteria. *International Journal of Production Research*, 51, 1037–1054.
- Kayastha, P., Dhital, M. R., & De Smedt, F. (2013). Application of the analytical hierarchy process (AHP) for landslide susceptibility mapping: A case study from the Tinau watershed, west Nepal. *Computers & Geosciences*, 52, 398–408.
- Keeney, R. L., Raiffa, H., & Rajala, D. W. (1979). Decisions with multiple objectives: Preferences and value trade-offs. *Systems, Man and Cybernetics, IEEE Transactions on*, 9, 403–403.
- Keršulienė, V., & Turskis, Z. (2011). Integrated fuzzy multiple criteria decision making model for architect selection. *Technological and Economic Development of Economy*, 17, 645–666.
- Keršulienė, V., Zavadskas, E. K., & Turskis, Z. (2010). Selection of rational dispute resolution method by applying new step-wise weight assessment ratio analysis (Swara). *Journal of Business Economics and Management*, 11, 243–258.
- Khademi, N., Mohaymany, A. S., Shahi, J., & Zerguini, S. (2012). An algorithm for the analytic network process (ANP) structure design. *Journal of Multi-Criteria Decision Analysis*, 19, 33–55.
- Khan, S. & Faisal, M. N. (2008). An analytic network process model for municipal solid waste disposal options. *Waste Management*, 28, 1500–1508.
- Khorshidi, R., & Hassani, A. (2013). Comparative analysis between TOPSIS and PSI methods of materials selection to achieve a desirable combination of strength and workability in Al/SiC composite. *Materials & Design*, 52, 999–1010.
- Kildienė, S., Zavadskas, E. K., & Tamošaitienė, J. (2014). Complex assessment model for advanced technology deployment. *Journal of Civil Engineering and Management*, 20, 280–290.
- Kirytopoulos, K., Leopoulos, V., & Voulgaridou, D. (2008). Supplier selection in pharmaceutical industry: An analytic network process approach. *Benchmarking: An International Journal*, 15, 494–516.
- Kirytopoulos, K., Voulgaridou, D., Platis, A., & Leopoulos, V. (2011). An effective Markov based approach for calculating the Limit Matrix in the analytic network process. *European Journal of Operational Research*, 214, 85–90. doi:10.1016/j.ejor.2011.03.043
- Köksalan, M. M., Wallenius, J., & Zionts, S. (2011). *Multiple criteria decision making: From early history to the 21st century*. Singapore: World Scientific.
- Konidari, P., & Mavrakīs, D. (2007). A multi-criteria evaluation method for climate change mitigation policy instruments. *Energy Policy*, 35, 6235–6257.
- Kou, G., & Lin, C. (2014). A cosine maximization method for the priority vector derivation in AHP. *European Journal of Operational Research*, 235, 225–232. doi:10.1016/j.ejor.2013.10.019
- Kou, G., Peng, Y., & Lu, C. (2014). MCDM approach to evaluating bank loan default models. *Technological and Economic Development of Economy*, 20, 292–311.
- Kracka, M., Brauers, W. K. M., & Zavadskas, E. K. (2010, May 19–21). Buildings external walls and windows effective selection by applying multiple criteria method. In P. Vainiūnas, E. K. Zavadskas (Eds.), *The 10th International Conference Modern Building Materials, Structures and Techniques: Selected papers* (Vol. 1, pp. 436–441). Lithuania. Vilnius: Technika.
- Kracka, M., & Zavadskas, E. K. (2013). Panel building refurbishment elements effective selection by applying multiple-criteria methods. *International Journal of Strategic Property Management*, 17, 210–219.
- Kuo, R. & Lin, Y. (2012). Supplier selection using analytic network process and data envelopment analysis. *International Journal of Production Research*, 50, 2852–2863.

- Kuo, Y., Yang, T., Cho, C., & Tseng, Y.-C. (2008). Using simulation and multi-criteria methods to provide robust solutions to dispatching problems in a flow shop with multiple processors. *Mathematics and Computers in Simulation*, 78, 40–56.
- Kurilovas, E., & Zilinskiene, I. (2013). New MCEQLS AHP method for evaluating quality of learning scenarios. *Technological and Economic Development of Economy*, 19, 78–92.
- Kwong, C. K., & Tam, S. M. (2002). Case-based reasoning approach to concurrent design of low power transformers. *Journal of Materials Processing Technology*, 128, 136–141.
- Lai, Y.-T., Wang, W.-C., & Wang, H.-H. (2008). AHP-and simulation-based budget determination procedure for public building construction projects. *Automation in Construction*, 17, 623–632.
- Lai, V. S., Wong, B. K., & Cheung, W. (2002). Group decision making in a multiple criteria environment: A case using the AHP in software selection. *European Journal of Operational Research*, 137, 134–144.
- Latinopoulos, D., & Kechagia, K. (2015). A GIS-based multi-criteria evaluation for wind farm site selection. A regional scale application in Greece. *Renewable Energy*, 78, 550–560. doi:10.1016/j.renene.2015.01.041
- Lee, C., Lee, H., Seol, H., & Park, Y. (2012). Evaluation of new service concepts using rough set theory and group analytic hierarchy process. *Expert Systems with Applications*, 39, 3404–3412.
- Lee, K.-L. (2010). Two-phase fuzzy approach for evaluating service strategies in an airport's international logistic system. *Journal of the Chinese Institute of Industrial Engineers*, 27, 209–225.
- Lee, H., Lee, S., & Park, Y. (2009). Selection of technology acquisition mode using the analytic network process. *Mathematical and Computer Modelling*, 49, 1274–1282.
- Lee, P. T.-W., & Lin, C.-W. (2013). The cognition map of financial ratios of shipping companies using DEMATEL and MMDE. *Maritime Policy & Management*, 40, 133–145.
- Lee, W.-S. & Tu, W.-S. (2011). Combined MCDM techniques for exploring company value based on Modigliani-Miller theorem. *Expert Systems with Applications*, 38, 8037–8044.
- Leung, L. C., & Cao, D. (2001). On the efficacy of modeling multi-attribute decision problems using AHP and Sinarchy. *European Journal of Operational Research*, 132, 39–49. doi:10.1016/S0377-2217(00)00111-9
- Leyva-López, J. C., & Fernández-González, E. (2003). A new method for group decision support based on ELECTRE III methodology. *European Journal of Operational Research*, 148, 14–27.
- Li, C.-W., & Tzeng, G.-H. (2009). Identification of a threshold value for the DEMATEL method using the maximum mean de-entropy algorithm to find critical services provided by a semiconductor intellectual property mall. *Expert Systems with Applications*, 36, 9891–9898.
- Li, H., Adeli, H., Sun, J., & Han, J.-G. (2011). Hybridizing principles of TOPSIS with case-based reasoning for business failure prediction. *Computers & Operations Research*, 38, 409–419.
- Li, Y., Hu, Y., Zhang, X., Deng, Y., & Mahadevan, S. (2014). An evidential DEMATEL method to identify critical success factors in emergency management. *Applied Soft Computing*, 22, 504–510.
- Li, M., Jin, L., & Wang, J. (2014). A new MCDM method combining QFD with TOPSIS for knowledge management system selection from the user's perspective in intuitionistic fuzzy environment. *Applied Soft Computing*, 21, 28–37.
- Li, Y.-M., Lai, C.-Y., & Kao, C.-P. (2011). Building a qualitative recruitment system via SVM with MCDM approach. *Applied Intelligence*, 35, 75–88.
- Li, H. & Sun, J. (2009). Hybridizing principles of the Electre method with case-based reasoning for data mining: Electre-CBR-I and Electre-CBR-II. *European Journal of Operational Research*, 197, 214–224. doi:10.1016/j.ejor.2008.05.024
- Liao, C.-N., & Kao, H.-P. (2010). Supplier selection model using Taguchi loss function, analytical hierarchy process and multi-choice goal programming. *Computers & Industrial Engineering*, 58, 571–577.
- Lin, C.-T., Chen, C.-B., & Ting, Y.-C. (2010). A decision support system for a purchasing model using an integration of MCDM and linear programming. *Journal of Information and Optimization Sciences*, 31, 1249–1261.
- Lin, M.-I., Lee, Y.-D., & Ho, T.-N. (2011). Applying integrated DEA/AHP to evaluate the economic performance of local governments in China. *European Journal of Operational Research*, 209, 129–140.

- Lin, M.-C., Wang, C.-C., Chen, M.-S., & Chang, C. A. (2008). Using AHP and TOPSIS approaches in customer-driven product design process. *Computers in Industry*, 59, 17–31.
- Lin, C.-C., Wang, W.-C., & Yu, W.-D. (2008). Improving AHP for construction with an adaptive AHP approach (A³). *Automation in Construction*, 17, 180–187.
- Lin, Y., Cheng, H.-P., Tseng, M.-L., & Tsai, J. C. C. (2010). Using QFD and ANP to analyze the environmental production requirements in linguistic preferences. *Expert Systems with Applications*, 37, 2186–2196.
- Lin, Y.-H., Chiu, C.-C., & Tsai, C.-H. (2008). The study of applying ANP model to assess dispatching rules for wafer fabrication. *Expert Systems with Applications*, 34, 2148–2163.
- Lin, Y.-K. & Yeh, C.-T. (2012). Multi-objective optimization for stochastic computer networks using NSGA-II and TOPSIS. *European Journal of Operational Research*, 218, 735–746. doi:10.1016/j.ejor.2011.11.028
- Liou, J. J. (2012). Developing an integrated model for the selection of strategic alliance partners in the airline industry. *Knowledge-Based Systems*, 28, 59–67.
- Liou, J. J. H. (2012). Developing an integrated model for the selection of strategic alliance partners in the airline industry. *Knowledge-Based Systems*, 28, 59–67.
- Liou, J. J. H., Tsai, C.-Y., Lin, R.-H., & Tzeng, G.-H. (2011). A modified VIKOR multiple-criteria decision method for improving domestic airlines service quality. *Journal of Air Transport Management*, 17, 57–61.
- Liu, P. (2009). Multi-attribute decision-making method research based on interval vague set and TOPSIS method. *Technological and Economic Development of Economy*, 15(3), 453–463.
- Liu, S., Chan, F. T., & Ran, W. (2013). Multi-attribute group decision-making with multi-granularity linguistic assessment information: An improved approach based on deviation and TOPSIS. *Applied Mathematical Modelling*, 37, 10129–10140.
- Liu, H.-C., Fan, X.-J., Li, P., & Chen, Y.-Z. (2014). Evaluating the risk of failure modes with extended MULTIMOORA method under fuzzy environment. *Engineering Applications of Artificial Intelligence*, 34, 168–177.
- Liu, H.-C., Liu, L., & Wu, J. (2013). Material selection using an interval 2-tuple linguistic VIKOR method considering subjective and objective weights. *Materials & Design*, 52, 158–167.
- Liu, Y.-J., Mao, S.-J., Li, M., & Yao, J.-M. (2007). Study of a comprehensive assessment method for coal mine safety based on a hierarchical grey analysis. *Journal of China University of Mining and Technology*, 17, 6–10.
- Liu, H.-C., Mao, L.-X., Zhang, Z.-Y., & Li, P. (2013). Induced aggregation operators in the VIKOR method and its application in material selection. *Applied Mathematical Modelling*, 37, 6325–6338.
- Liu, C.-H., Tzeng, G.-H., & Lee, M.-H. (2012). Improving tourism policy implementation—The use of hybrid MCDM models. *Tourism Management*, 33, 413–426.
- Liu, H.-C., You, J.-X., Fan, X.-J., & Chen, Y.-Z. (2014). Site selection in waste management by the VIKOR method using linguistic assessment. *Applied Soft Computing*, 21, 453–461.
- Liu, H.-C., You, J.-X., Lu, C., & Shan, M.-M. (2014). Application of interval 2-tuple linguistic MULTIMOORA method for health-care waste treatment technology evaluation and selection. *Waste Management*, 34, 2355–2364.
- Lourenço, R. P., & Costa, J. P. (2004). Using ELECTRE TRI outranking method to sort MOMILP nondominated solutions. *European Journal of Operational Research*, 153, 271–289. doi:10.1016/S0377-2217(03)00150-4
- Lupo, T. (2015). Fuzzy ServPerf model combined with ELECTRE III to comparatively evaluate service quality of international airports in Sicily. *Journal of Air Transport Management*, 42, 249–259.
- MacCrimmon, K. R., & Rand, C. (1968). *Decisionmaking among multiple-attribute alternatives: a survey and consolidated approach*. Santa Monica, Calif.: Rand Corp.
- Macharis, C., Springael, J., De Brucker, K., & Verbeke, A. (2004). PROMETHEE and AHP: The design of operational synergies in multicriteria analysis: Strengthening PROMETHEE with ideas of AHP. *European Journal of Operational Research*, 153, 307–317.
- Mahdi, I. M., & Alreshaid, K. (2005). Decision support system for selecting the proper project delivery method using analytical hierarchy process (AHP). *International Journal of Project Management*, 23, 564–572.

- Makan, A., Malamis, D., Assobhei, O., Loizidou, M., & Mountadar, M. (2012). Multi-criteria decision analysis for the selection of the most suitable landfill site: Case of Azemmour, Morocco. *International Journal of Management Science and Engineering Management*, 7, 96–109.
- Manca, D. & Brambilla, S. (2011). A methodology based on the Analytic Hierarchy Process for the quantitative assessment of emergency preparedness and response in road tunnels. *Transport Policy*, 18, 657–664.
- Maniya, K. & Bhatt, M. (2011). A multi-attribute selection of automated guided vehicle using the AHP/M-GRA technique. *International Journal of Production Research*, 49, 6107–6124.
- Mareschal, B., Brans, J. P., & Vincke, P. (1984). PROMETHEE: A new family of outranking methods in multicriteria analysis. ULB Institutional Repository, ULB–Universite Libre de Bruxelles, Brussels.
- Marinoni, O. (2004). Implementation of the analytical hierarchy process with VBA in ArcGIS. *Computers & Geosciences*, 30, 637–646.
- Martin, C., Ruperd, Y., & Legret, M. (2007). Urban stormwater drainage management: The development of a multicriteria decision aid approach for best management practices. *European Journal of Operational Research*, 181, 338–349. doi:10.1016/j.ejor.2006.06.019
- Martin, H., Spano, G., Küster, J., Collu, M., & Kolios, A. (2013). Application and extension of the TOPSIS method for the assessment of floating offshore wind turbine support structures. *Ships and Offshore Structures*, 8, 477–487.
- Mau-Crimmins, T., de Steiguer, J. E., & Dennis, D. (2005). AHP as a means for improving public participation: a pre–post experiment with university students. *Forest Policy and Economics*, 7, 501–514.
- May, J. H., Shang, J., Tjader, Y. C., & Vargas, L. G. (2013). A new methodology for sensitivity and stability analysis of analytic network models. *European Journal of Operational Research*, 224, 180–188. doi:10.1016/j.ejor.2012.07.035
- Mayyas, A., Shen, Q., Mayyas, A., abdelhamid, M., Shan, D., Qattawi, A., & Omar, M., (2011). Using Quality Function Deployment and Analytical Hierarchy Process for material selection of Body-In-White. *Materials & Design*, 32, 2771–2782.
- Miettinen, K. (1999). *Nonlinear multiobjective optimization* (Vol. 12). Dordrecht: Springer Science & Business Media.
- Millet, I., & Saaty, T. L. (2000). On the relativity of relative measures – Accommodating both rank preservation and rank reversals in the AHP. *European Journal of Operational Research*, 121, 205–212. doi:10.1016/S0377-2217(99)00040-5
- Mishra, S., Khasnabis, S., & Swain, S. (2013). Multi-entropy perspective transportation infrastructure investment decision making. *Transport Policy*, 30, 1–12.
- Moeinaddini, M., Khorasani, N., Danehkar, A., Darvishsefat, A. A., & Zienalyan, M. (2010). Siting MSW landfill using weighted linear combination and analytical hierarchy process (AHP) methodology in GIS environment (case study: Karaj). *Waste Management*, 30, 912–920.
- Mohajeri, N. & Amin, G. R. (2010). Railway station site selection using analytical hierarchy process and data envelopment analysis. *Computers & Industrial Engineering*, 59, 107–114.
- Mohammadi, F., Sadi, M. K., Nateghi, F., Abdullah, A., & Skitmore, M. (2014). A hybrid quality function deployment and cybernetic analytic network process model for project manager selection. *Journal of Civil Engineering and Management*, 20, 795–809.
- Monghasemi, S., Nikoo, M. R., Khaksar Fasaee, M. A., & Adamowski, J. (2015). A novel multi criteria decision making model for optimizing time–cost–quality trade-off problems in construction projects. *Expert Systems with Applications*, 42, 3089–3104. doi:10.1016/j.eswa.2014.11.032
- Mousavi, S. M., Tavakkoli-Moghaddam, R., Heydar, M., & Ebrahimnejad, S. (2013). Multi-criteria decision making for plant location selection: An integrated Delphi–AHP–PROMETHEE methodology. *Arabian Journal for Science and Engineering*, 38, 1255–1268.
- Mousseau, V., & Dias, L. (2004). Valued outranking relations in ELECTRE providing manageable disaggregation procedures. *European Journal of Operational Research*, 156, 467–482.
- Mousseau, V., Figueira, J., & Naux, J. P. (2001). Using assignment examples to infer weights for ELECTRE TRI method: Some experimental results. *European Journal of Operational Research*, 130, 263–275. doi:10.1016/S0377-2217(00)00041-2

- Nakagawa, Y., Nasu, S., Saito, T., & Yamaguchi, N. (2010). Analytic hierarchy based policy design method (AHPo) for solving societal problems that require a multifaceted approach. *European Journal of Operational Research*, 207, 1545–1553. doi:10.1016/j.ejor.2010.07.011
- Nigim, K. A., Suryanarayanan, S., Gorur, R., & Farmer, R. G. (2003). The application of analytical hierarchy process to analyze the impact of hidden failures in special protection schemes. *Electric Power Systems Research*, 67, 191–196.
- Nikou, S., & Mezei, J. (2013). Evaluation of mobile services and substantial adoption factors with Analytic Hierarchy Process (AHP). *Telecommunications Policy*, 37, 915–929.
- Nixon, J., Dey, P., Ghosh, S., & Davies, P. (2013). Evaluation of options for energy recovery from municipal solid waste in India using the hierarchical analytical network process. *Energy*, 59, 215–223.
- Norese, M. F. (2006). ELECTRE III as a support for participatory decision-making on the localisation of waste-treatment plants. *Land Use Policy*, 23, 76–85.
- Oberschmidt, J., Geldermann, J., Ludwig, J., & Schmehl, M. (2010). Modified PROMETHEE approach for assessing energy technologies. *International Journal of Energy Sector Management*, 4, 183–212.
- Oddershede, A., Arias, A., & Cancino, H. (2007). Rural development decision support using the Analytic Hierarchy Process. *Mathematical and Computer Modelling*, 46, 1107–1114.
- Ojha, A., Das, B., Mondal, S., & Maiti, M. (2010). A stochastic discounted multi-objective solid transportation problem for breakable items using Analytical Hierarchy Process. *Applied Mathematical Modelling*, 34, 2256–2271.
- Ong, S. K., Koh, T. H., & Nee, A. Y. C. (2001). Assessing the environmental impact of materials processing techniques using an analytical hierarchy process method. *Journal of Materials Processing Technology*, 113, 424–431.
- Opricovic, S. (1998). *Multicriteria optimization of civil engineering systems* (in Serbian) (p. 302). Belgrade: Faculty of Civil Engineering.
- Opricovic, S., & Tzeng, G. H. (2002). Multicriteria planning of post-earthquake sustainable reconstruction. *Computer-Aided Civil and Infrastructure Engineering*, 17, 211–220.
- Opricovic, S., & Tzeng, G.-H. (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. *European Journal of Operational Research*, 156, 445–455.
- Orencio, P. M., & Fujii, M. (2013). A localized disaster-resilience index to assess coastal communities based on an analytic hierarchy process (AHP). *International Journal of Disaster Risk Reduction*, 3, 62–75.
- Othman, M. R., Repke, J.-U., & Wozny, G. (2010). Incorporating negative values in AHP using rule-based scoring methodology for ranking of sustainable chemical process design options. *Computer Aided Chemical Engineering*, 28, 1045–1050.
- Oztaysi, B. (2014). A decision model for information technology selection using AHP integrated TOPSIS-Grey: The case of content management systems. *Knowledge-Based Systems*, 70, 44–54.
- Padma, T. & Balasubramanie, P. (2009). Knowledge based decision support system to assist work-related risk analysis in musculoskeletal disorder. *Knowledge-Based Systems*, 22, 72–78.
- Papadopoulos, A., & Karagiannidis, A. (2008). Application of the multi-criteria analysis method Electre III for the optimisation of decentralised energy systems. *Omega*, 36, 766–776.
- Park, J. H., Park, I. Y., Kwun, Y. C., & Tan, X. (2011). Extension of the TOPSIS method for decision making problems under interval-valued intuitionistic fuzzy environment. *Applied Mathematical Modelling*, 35, 2544–2556.
- Parreiras, R. O., & Vasconcelos, J. A. (2007). A multiplicative version of Promethee II applied to multiobjective optimization problems. *European Journal of Operational Research*, 183, 729–740. doi:10.1016/j.ejor.2006.10.002
- Parthasarathy, S., & Sharma, S. (2014). Determining ERP customization choices using nominal group technique and analytical hierarchy process. *Computers in Industry*, 65, 1009–1017.
- Partovi, F. Y., & Corredoira, R. A. (2002). Quality function deployment for the good of soccer. *European Journal of Operational Research*, 137, 642–656. doi:10.1016/S0377-2217(01)00072-8
- Pazand, K., Hezarkhani, A., & Ataei, M. (2012). Using TOPSIS approaches for predictive porphyry Cu potential mapping: A case study in Ahar-Arasbaran area (NW, Iran). *Computers & Geosciences*, 49, 62–71.

- Peng, Y. (2012). Regional earthquake vulnerability assessment using a combination of MCDM methods. *Annals of Operations Research*, November, 1–4.
- Peng, Y., Wang, G., & Wang, H. (2012). User preferences based software defect detection algorithms selection using MCDM. *Information Sciences*, 191, 3–13.
- Percin, S. (2009). Evaluation of third-party logistics (3PL) providers by using a two-phase AHP and TOPSIS methodology. *Benchmarking: An International Journal*, 16, 588–604.
- Perez-Vega, S., Peter, S., Salmeron-Ochoa, I., Nieva-de la Hidalga, A., & Sharratt, P. N. (2011). Analytical hierarchy processes (AHP) for the selection of solvents in early stages of pharmaceutical process development. *Process Safety and Environmental Protection*, 89, 261–267.
- Pinter, U., & Pšunder, I. (2013). Evaluating construction project success with use of the M-TOPSIS method. *Journal of Civil Engineering and Management*, 19, 16–23.
- Podvezko, V., & Sivilevičius, H. (2013). The use of AHP and rank correlation methods for determining the significance of the interaction between the elements of a transport system having a strong influence on traffic safety. *Transport*, 28, 389–403.
- Queiruga, D., Walther, G., González-Benito, J., & Spengler, T. (2008). Evaluation of sites for the location of WEEE recycling plants in Spain. *Waste Management*, 28, 181–190.
- Rabbani, A., Zamani, M., Yazdani-Chamzini, A., & Zavadskas, E. K. (2014). Proposing a new integrated model based on sustainability balanced scorecard (SBSC) and MCDM approaches by using linguistic variables for the performance evaluation of oil producing companies. *Expert Systems with Applications*, 41, 7316–7327.
- Rahman, S., Odeyinka, H., Perera, S., & Bi, Y. (2012). Product-cost modelling approach for the development of a decision support system for optimal roofing material selection. *Expert Systems with Applications*, 39, 6857–6871. doi:10.1016/j.eswa.2012.01.010
- Rajesh, R., & Ravi, V. (2015). Supplier selection in resilient supply chains: A grey relational analysis approach. *Journal of Cleaner Production*, 86, 343–359.
- Raju, K. S., Duckstein, L., & Arondel, C. (2000). Multicriterion analysis for sustainable water resources planning: A case study in Spain. *Water Resources Management*, 14, 435–456.
- Ramanathan, R. (2007). Supplier selection problem: Integrating DEA with the approaches of total cost of ownership and AHP. *Supply Chain Management: An International Journal*, 12, 258–261.
- Ramesh, V., & Kodali, R. (2012). A decision framework for maximising lean manufacturing performance. *International Journal of Production Research*, 50, 2234–2251.
- Ren, J., Manzardo, A., Toniolo, S., & Scipioni, A. (2013). Sustainability of hydrogen supply chain. Part II: Prioritizing and classifying the sustainability of hydrogen supply chains based on the combination of extension theory and AHP. *International Journal of Hydrogen Energy*, 38, 13845–13855.
- Reza, B., Sadiq, R., & Hewage, K. (2011). Sustainability assessment of flooring systems in the city of Tehran: An AHP-based life cycle analysis. *Construction and Building Materials*, 25, 2053–2066.
- Rezaei, J., & Ortt, R. (2013). Multi-criteria supplier segmentation using a fuzzy preference relations based AHP. *European Journal of Operational Research*, 225, 75–84. doi:10.1016/j.ejor.2012.09.037
- Rezaiyan, S., & Jozi, S. A. (2012). Health-Safety and Environmental Risk Assessment of Refineries Using of Multi Criteria Decision Making Method. *APCBEE Procedia*, 3, 235–238.
- Roig-Tierno, N., Baviera-Puig, A., Buitrago-Vera, J., & Mas-Verdu, F. (2013). The retail site location decision process using GIS and the analytical hierarchy process. *Applied Geography*, 40, 191–198.
- Roszkowska, E. & Wachowicz, T. (2015). Application of fuzzy TOPSIS to scoring the negotiation offers in ill-structured negotiation problems. *European Journal of Operational Research*, 242, 920–932.
- Rousis, K., Moustakas, K., Malamis, S., Papadopoulos, A., & Loizidou, M. (2008). Multi-criteria analysis for the determination of the best WEEE management scenario in Cyprus. *Waste Management*, 28, 1941–1954.
- Rousos, E.-P., & Lee, B. S. (2012). Multicriteria analysis in shipping investment evaluation. *Maritime Policy & Management*, 39, 423–442.
- Roy, B. (1968). Classement et choix en présence de points de vue multiples. *RAIRO-Operations Research-Recherche Opérationnelle*, 2, 57–75.

- Roy, B. (1971). Problems and methods with multiple objective functions. *Mathematical Programming*, 1, 239–266.
- Roy, B. (1978). ELECTRE III: Un algorithme de classements fondé sur une représentation floue des préférences en présence de critères multiples. *Cahiers du CERO*, 20, 3–24.
- Roy, B. (1996). *Multicriteria methodology for decision aiding*. Dordrecht/Boston: Kluwer Academic Publishers.
- Roy, B. (2005) Paradigms and challenges. In J. Figueira, S. Greco, & M. Ehrgott (Eds.), *Multiple-criteria decision analysis. state of the art surveys* (pp. 3–24). New York, NY: Springer.
- Roy, B., & Bertier, P. (1972) *La Méthode ELECTRE II*. Présentée à la 6^{ème} conférence internationale de recherche opérationnelle, Metra international, Paris.
- Roy, B. & Słowiński, R. (2008). Handling effects of reinforced preference and counter-veto in credibility of outranking. *European Journal of Operational Research*, 188, 185–190. doi:10.1016/j.ejor.2007.04.005
- Ruzgys, A., Volvačiovias, R., Ignatavičius, Č., & Turskis, Z. (2014). Integrated evaluation of external wall insulation in residential buildings using SWARA-TODIM MCDM method. *Journal of Civil Engineering and Management*, 20, 103–110.
- Saaty, T. L. (1971). On polynomials and crossing numbers of complete graphs. *Journal of Combinatorial Theory, Series A*, 10, 183–184.
- Saaty, T. L. (1980). *The analytic hierarchy process: Planning, priority setting, resources allocation*. New York, NY: McGraw.
- Saaty, T. (1988). What is the analytic hierarchy process? In G. Mitra, H. Greenberg, F. Lootsma, M. Rijkaert, & H. Zimmermann (Eds.), *Mathematical Models for Decision Support 48* (pp. 109–121). Berlin: Springer.
- Saaty, T. L. (1996). *Decision making with dependence and feedback: the analytic network process: The organization and prioritization of complexity*. Pittsburgh: Rws Publications.
- Sabharwall, P., Kim, E. S., & Patterson, M. (2012). Evaluation methodology for advance heat exchanger concepts using analytical hierarchy process. *Nuclear Engineering and Design*, 248, 108–116.
- Sadeghi, M., & Ameli, A. (2012). An AHP decision making model for optimal allocation of energy subsidy among socio-economic subsectors in Iran. *Energy Policy*, 45, 24–32.
- Sadeghzadeh, K., & Salehi, M. B. (2011). Mathematical analysis of fuel cell strategic technologies development solutions in the automotive industry by the TOPSIS multi-criteria decision making method. *International Journal of Hydrogen Energy*, 36, 13272–13280.
- Safari, M., Ataei, M., Khalokakaie, R., & Karamozian, M. (2010). Mineral processing plant location using the analytic hierarchy process – A case study: The Sangan iron ore mine (phase I). *Mining Science and Technology (China)*, 20, 691–695.
- Sahin, O., Mohamed, S., Warnken, J., & Rahman, A. (2013). Assessment of sea-level rise adaptation options: Multiple-criteria decision-making approach involving stakeholders. *Structural Survey*, 31, 283–300.
- Sambasivan, M., & Fei, N. Y. (2008). Evaluation of critical success factors of implementation of ISO 14001 using analytic hierarchy process (AHP): A case study from Malaysia. *Journal of Cleaner Production*, 16, 1424–1433.
- San Cristóbal, J. R. (2011). Multi-criteria decision-making in the selection of a renewable energy project in Spain: The Vikor method. *Renewable Energy*, 36, 498–502.
- Sánchez-Lozano, J. M., Henggeler Antunes, C., García-Cascales, M. S., & Dias, L. C. (2014). GIS-based photovoltaic solar farms site selection using ELECTRE-TRI: Evaluating the case for Torre Pacheco, Murcia, Southeast of Spain. *Renewable Energy*, 66, 478–494.
- Sarkis, J., & Sundarraj, R. P. (2002). Hub location at Digital Equipment Corporation: A comprehensive analysis of qualitative and quantitative factors. *European Journal of Operational Research*, 137, 336–347. doi:10.1016/S0377-2217(01)00138-2
- Sayadi, M. K., Heydari, M., & Shahanaghi, K. (2009). Extension of VIKOR method for decision making problem with interval numbers. *Applied Mathematical Modelling*, 33, 2257–2262.
- Şener, Ş., Şener, E., Nas, B., & Karagüzel, R. (2010). Combining AHP with GIS for landfill site selection: A case study in the Lake Beyşehir catchment area (Konya, Turkey). *Waste Management*, 30, 2037–2046.
- Şengül, Ü., Eren, M., Eslamian Shiraz, S., Gezder, V., & Şengül, A. B. (2015). Fuzzy TOPSIS method for ranking renewable energy supply systems in Turkey. *Renewable Energy*, 75, 617–625.

- Shanian, A., Milani, A. S., Carson, C., & Abeyaratne, R. C. (2008). A new application of ELECTRE III and revised Simos' procedure for group material selection under weighting uncertainty. *Knowledge-Based Systems*, 21, 709–720.
- Shen, L., Muduli, K., & Barve, A. (2013). Developing a sustainable development framework in the context of mining industries: AHP approach. *Resources Policy*. Advance online publication. doi:10.1016/j.resourpol.2013.10.006
- Shidpour, H., Shahrokhi, M., & Bernard, A. (2013). A multi-objective programming approach, integrated into the TOPSIS method, in order to optimize product design; in three-dimensional concurrent engineering. *Computers & Industrial Engineering*, 64, 875–885.
- Shih, H.-S. (2008). Incremental analysis for MCDM with an application to group TOPSIS. *European Journal of Operational Research*, 186, 720–734.
- Shih, H.-S., Shyur, H.-J., & Lee, E. S. (2007). An extension of TOPSIS for group decision making. *Mathematical and Computer Modelling*, 45, 801–813.
- Shiue, Y.-C., & Lin, C.-Y. (2012). Applying analytic network process to evaluate the optimal recycling strategy in upstream of solar energy industry. *Energy and Buildings*, 54, 266–277.
- Shyjith, K., Ilankumaran, M., & Kumanan, S. (2008). Multi-criteria decision-making approach to evaluate optimum maintenance strategy in textile industry. *Journal of Quality in Maintenance Engineering*, 14, 375–386.
- Shyur, H.-J. (2006). COTS evaluation using modified TOPSIS and ANP. *Applied Mathematics and Computation*, 177, 251–259.
- Singh, H., & Kumar, R. (2013). Hybrid methodology for measuring the utilization of advanced manufacturing technologies using AHP and TOPSIS. *Benchmarking: An International Journal*, 20, 169–185.
- Šiožinytė, E., & Antucevičienė, J. (2013). Solving the problems of daylighting and tradition continuity in a reconstructed vernacular building. *Journal of civil engineering and management*, 19, 873–882.
- Soltani, A., Hewage, K., Reza, B., & Sadiq, R. (2015). Multiple stakeholders in multi-criteria decision-making in the context of Municipal Solid Waste Management: A review. *Waste Management*, 35, 318–328.
- Stankevičienė, J., Sviderskė, T., & Miečinskienė, A. (2014). Dependence of sustainability on country risk indicators in EU Baltic Sea region countries. *Journal of Business Economics and Management*, 15, 646–663.
- Streimikiene, D., Balezentis, T., Krisciukaitienė, I., & Balezentis, A. (2012). Prioritizing sustainable electricity production technologies: MCDM approach. *Renewable and Sustainable Energy Reviews*, 16, 3302–3311.
- Taillandier, P., & Taillandier, F. (2012). Multi-criteria diagnosis of control knowledge for cartographic generalisation. *European Journal of Operational Research*, 217, 633–642. doi:10.1016/j.ejor.2011.10.004
- Tang, H.-W. V. (2011). Optimizing an immersion ESL curriculum using analytic hierarchy process. *Evaluation and Program Planning*, 34, 343–352.
- Tao, L., Chen, Y., Liu, X., & Wang, X. (2012). An integrated multiple criteria decision making model applying axiomatic fuzzy set theory. *Applied Mathematical Modelling*, 36, 5046–5058.
- Tervonen, T., Figueira, J. R., Lahdelma, R., Dias, J. A., & Salminen, P. (2009). A stochastic method for robustness analysis in sorting problems. *European Journal of Operational Research*, 192, 236–242. doi:10.1016/j.ejor.2007.09.008
- Theißen, S., & Spinler, S. (2014). Strategic analysis of manufacturer-supplier partnerships: An ANP model for collaborative CO2 reduction management. *European Journal of Operational Research*, 233, 383–397. doi:10.1016/j.ejor.2013.08.023
- Tian, W., Bai, J., Sun, H., & Zhao, Y. (2013). Application of the analytic hierarchy process to a sustainability assessment of coastal beach exploitation: A case study of the wind power projects on the coastal beaches of Yancheng, China. *Journal of Environmental Management*, 115, 251–256.
- Tjader, Y. C., Shang, J. S., & Vargas, L. G. (2010). Offshore outsourcing decision making: A policy-maker's perspective. *European Journal of Operational Research*, 207, 434–444. doi:10.1016/j.ejor.2010.03.042
- Tong, K. W., Kwong, C. K., & Ip, K. W. (2003). Optimization of process conditions for the transfer molding of electronic packages. *Journal of Materials Processing Technology*, 138, 361–365.

- Tong, L.-I., Wang, C.-H., Chen, C.-C., & Chen, C.-T. (2004). Dynamic multiple responses by ideal solution analysis. *European Journal of Operational Research*, 156(2), 433–444. doi:10.1016/S0377-2217(03)00017-1
- Triantaphyllou, E. (2001). Two new cases of rank reversals when the AHP and some of its additive variants are used that do not occur with the multiplicative AHP. *Journal of Multi-Criteria Decision Analysis*, 10, 11–25.
- Tsai, W.-H., Lin, S.-J., Lee, Y.-F., Chang, Y.-C., & Hsu, J.-L. (2013). Construction method selection for green building projects to improve environmental sustainability by using an MCDM approach. *Journal of Environmental Planning and Management*, 56, 1487–1510.
- Tsaur, R.-C. (2011). Decision risk analysis for an interval TOPSIS method. *Applied Mathematics and Computation*, 218, 4295–4304.
- Tsoutsos, T., Drandaki, M., Frantzeskaki, N., Iosifidis, E., & Kiosses, I. (2009). Sustainable energy planning by using multi-criteria analysis application in the island of Crete. *Energy Policy*, 37, 1587–1600.
- Turskis, Z. & Zavadskas, E. K. (2010b). A novel method for multiple criteria analysis: Grey additive ratio assessment (ARAS-G) method. *Informatica*, 21, 597–610.
- Tzeng, G.-H., & Huang, J.-J. (2011). *Multiple attribute decision making: Methods and applications*. Boca Raton: CRC Press.
- Tzeng, G.-H., & Huang, C.-Y. (2012). Combined DEMATEL technique with hybrid MCDM methods for creating the aspired intelligent global manufacturing & logistics systems. *Annals of Operations Research*, 197, 159–190.
- Ülengin, F., Kabak, Ö., Önsel, Ş., Ülengin, B., & Aktaş, E. (2010). A problem-structuring model for analyzing transportation–environment relationships. *European Journal of Operational Research*, 200, 844–859. doi:10.1016/j.ejor.2009.01.023
- Ulubeyli, S., & Kazaz, A. (2009). A multiple criteria decision-making approach to the selection of concrete pumps. *Journal of Civil Engineering and Management*, 15, 369–376.
- Uyan, M. (2013). GIS-based solar farms site selection using analytic hierarchy process (AHP) in Karapınar region, Konya/Turkey. *Renewable and Sustainable Energy Reviews*, 28, 11–17.
- Vafaeipour, M., Hashemkhani Zolfani, S., Morshed Varzandeh, M. H., Derakhti, A., & Keshavarz Eshkalag, M. (2014). Assessment of regions priority for implementation of solar projects in Iran: New application of a hybrid multi-criteria decision making approach. *Energy Conversion and Management*, 86, 653–663.
- Vaidya, O. S. & Kumar, S. (2006). Analytic hierarchy process: An overview of applications. *European Journal of Operational Research*, 169, 1–29.
- Venkata Rao, R. (2004). Evaluation of metal stamping layouts using an analytic hierarchy process method. *Journal of Materials Processing Technology*, 152, 71–76.
- Verdecho, M.-J., Alfaro-Saiz, J.-J., Rodriguez-Rodriguez, R., & Ortiz-Bas, A. (2012). A multi-criteria approach for managing inter-enterprise collaborative relationships. *Omega*, 40, 249–263.
- Vetschera, R. & De Almeida, A. T. (2012). A PROMETHEE-based approach to portfolio selection problems. *Computers & Operations Research*, 39, 1010–1020.
- Vinodh, S. & Jeya Girubha, R. (2012). PROMETHEE based sustainable concept selection. *Applied Mathematical Modelling*, 36, 5301–5308.
- Vinodh, S., Shivraman, K., & Viswesh, S. (2011). AHP-based lean concept selection in a manufacturing organization. *Journal of Manufacturing Technology Management*, 23, 124–136.
- Vučijak, B., Kupusović, T., Midžić-Kurtagić, S., & Čerić, A. (2013). Applicability of multicriteria decision aid to sustainable hydropower. *Applied Energy*, 101, 261–267.
- Wabiri, N. & Amusa, H. (2010). Quantifying South Africa's crude oil import risk: A multi-criteria portfolio model. *Economic Modelling*, 27, 445–453.
- Waeyenbergh, G., Vannieuwenhuysse, B., & Pintelon, L. (2004). A model to determine the cleanliness measurement interval in an automotive paint shop. *Journal of Quality in Maintenance Engineering*, 10, 37–46.
- Wang, Y.-M., & Chin, K.-S. (2009). A new approach for the selection of advanced manufacturing technologies: DEA with double frontiers. *International Journal of Production Research*, 47, 6663–6679.
- Wang, G., Qin, L., Li, G., & Chen, L. (2009). Landfill site selection using spatial information technologies and AHP: A case study in Beijing, China. *Journal of Environmental Management*, 90, 2414–2421.

- Wang, X., & Triantaphyllou, E. (2008). Ranking irregularities when evaluating alternatives by using some ELECTRE methods. *Omega*, 36, 45–63.
- Wang, W.-C., Yu, W.-D., Yang, I.-T., Lin, C.-C., Lee, M.-T., & Cheng, Y.-Y. (2013). Applying the AHP to support the best-value contractor selection—lessons learned from two case studies in Taiwan. *Journal of Civil Engineering and Management*, 19, 24–36.
- Wey, W.-M. & Wu, K.-Y. (2007). Using ANP priorities with goal programming in resource allocation in transportation. *Mathematical and Computer Modelling*, 46, 985–1000.
- Wong, J. K. W. & Li, H. (2008). Application of the analytic hierarchy process (AHP) in multi-criteria analysis of the selection of intelligent building systems. *Building and Environment*, 43, 108–125.
- Wu, C.-R., Lin, C.-T., & Tsai, P.-H. (2010). Evaluating business performance of wealth management banks. *European Journal of Operational Research*, 207(2), 971–979. doi:10.1016/j.ejor.2010.04.034
- Wu, C.-S., Lin, C.-T., & Lee, C. (2010). Optimal marketing strategy: A decision-making with ANP and TOPSIS. *International Journal of Production Economics*, 127, 190–196.
- Wu, W.-W. (2008). Choosing knowledge management strategies by using a combined ANP and DEMATEL approach. *Expert Systems with Applications*, 35, 828–835.
- Xu, X. (2001). The SIR method: A superiority and inferiority ranking method for multiple criteria decision making. *European Journal of Operational Research*, 131, 587–602.
- Xu, K., Kong, C., Li, J., Zhang, L., & Wu, C. (2011). Suitability evaluation of urban construction land based on geo-environmental factors of Hangzhou, China. *Computers & Geosciences*, 37, 992–1002.
- Yalcin, A. (2008). GIS-based landslide susceptibility mapping using analytical hierarchy process and bivariate statistics in Ardesen (Turkey): Comparisons of results and confirmations. *CATENA*, 72, 1–12.
- Yalcin, A., Reis, S., Aydinoglu, A. C., & Yomralioglu, T. (2011). A GIS-based comparative study of frequency ratio, analytical hierarchy process, bivariate statistics and logistics regression methods for landslide susceptibility mapping in Trabzon, NE Turkey. *CATENA*, 85, 274–287.
- Yang, T., Chen, M.-C., & Hung, C.-C. (2007). Multiple attribute decision-making methods for the dynamic operator allocation problem. *Mathematics and Computers in Simulation*, 73, 285–299.
- Yavuz, M., Iphar, M., & Once, G. (2008). The optimum support design selection by using AHP method for the main haulage road in WLC Tuncbilek colliery. *Tunnelling and Underground Space Technology*, 23, 111–119.
- Yeh, C.-H. & Willis, R. J. (2001). A validation procedure for multi criteria analysis application to the selection of scholarship students. *Asia Pacific Management Review*, 6, 39–52.
- Ying, X., Zeng, G.-M., Chen, G.-Q., Tang, L., Wang, K.-L., & Huang, D.-Y. (2007). Combining AHP with GIS in synthetic evaluation of eco-environment quality – A case study of Hunan Province, China. *Ecological Modelling*, 209, 97–109.
- Yue, Z. & Jia, Y. (2013). An application of soft computing technique in group decision making under interval-valued intuitionistic fuzzy environment. *Applied Soft Computing*, 13, 2490–2503.
- Yurdakul, M. (2004). AHP as a strategic decision-making tool to justify machine tool selection. *Journal of Materials Processing Technology*, 146, 365–376.
- Yurdakul, M. & Ic, Y. T. (2009). Application of correlation test to criteria selection for multi criteria decision making (MCDM) models. *The International Journal of Advanced Manufacturing Technology*, 40, 403–412.
- Zangeneh, A., Jadid, S., & Rahimi-Kian, A. (2009). A hierarchical decision making model for the prioritization of distributed generation technologies: A case study for Iran. *Energy Policy*, 37, 5752–5763.
- Zavadskas, E. K. & Antucheviciene, J. (2007). Multiple criteria evaluation of rural building's regeneration alternatives. *Building and Environment*, 42, 436–451.
- Zavadskas, E. K., Kaklauskas, A., Banaitis, A., & Kvederyte, N. (2004). Housing credit access model: The case for Lithuania. *European Journal of Operational Research*, 155, 335–352.
- Zavadskas, E. K., Kaklauskas, A., & Sarka, V. (1994). The new method of multicriteria complex proportional assessment of projects. *Technological and Economic Development of Economy*, 1, 131–139.

- Zavadskas, E. K., Kaklauskas, A., Trinkunas, V., & Trinkuniene, E. (2004). Innovations in construction e-business systems: Improving materials selection. *Foundations of civil and environmental engineering*. Poznań: Publishing House of Poznan University of Technology. ISSN 1642-9303. No. 5 (pp. 47–56).
- Zavadskas, E. K., Kaklauskas, A., Turskis, Z., & Tamošaitiene, J. (2008). Selection of the effective dwelling house walls by applying attributes values determined at intervals. *Journal of Civil Engineering and Management*, 14, 85–93.
- Zavadskas, E. K., Kaklauskas, A., Turskis, Z., Tamosaitiene, J., & Kalibatas, D. (2011). Assessment of the indoor environment of dwelling houses by applying the COPRAS-G method: Lithuania case study. *Environmental Engineering and Management Journal*, 10, 637–647.
- Zavadskas, E. K., Kaklauskas, A., & Vilutiene, T. (2009). Multicriteria evaluation of apartment blocks maintenance contractors: Lithuanian case study. *International Journal of Strategic Property Management*, 13, 319–338.
- Zavadskas, E. K., Skibniewski, M. J., & Antucheviciene, J. (2014). Performance analysis of Civil Engineering Journals based on the Web of Science® database. *Archives of Civil and Mechanical Engineering*, 14, 519–527.
- Zavadskas, E. K. & Turskis, Z. (2010). A new additive ratio assessment (ARAS) method in multicriteria decision-making. *Technological and Economic Development of Economy*, 16(2), 159–172.
- Zavadskas, E. K., Turskis, Z., Antucheviciene, J., & Zakarevicius, A. (2012). Optimization of weighted aggregated sum product assessment. *Elektronika ir elektrotechnika*, 122(6), 3–6.
- Zavadskas, E. K., Turskis, Z., & Bagočius, V. (2015). Multi-criteria selection of a deep-water port in the Eastern Baltic Sea. *Applied Soft Computing*, 26, 180–192.
- Zavadskas, E. K., Turskis, Z., & Kildienė, S. (2014). State of art surveys of overviews on MCDM/MADM methods. *Technological and Economic Development of Economy*, 20, 165–179.
- Zavadskas, E. K., Turskis, Z., Tamošaitiene, J., & Marina, V. (2008). Multicriteria selection of project managers by applying grey criteria. *Technological and Economic Development of Economy*, 14(4), 462–477.
- Zavadskas, E. K., Turskis, Z., & Vilutiene, T. (2010). Multiple criteria analysis of foundation instalment alternatives by applying Additive Ratio Assessment (ARAS) method. *Archives of Civil and Mechanical Engineering*, 10, 123–141.
- Zavadskas, E. K., Turskis, Z., Volvačiovias, R., & Kildiene, S. (2013). Multi-criteria assessment model of technologies. *Studies in Informatics and Control*, 22, 249–258.
- Zavadskas, E. K., & Vilutienė, T. (2006). A multiple criteria evaluation of multi-family apartment block's maintenance contractors: I – Model for maintenance contractor evaluation and the determination of its selection criteria. *Building and Environment*, 41, 621–632.
- Zeleny, M., & Cochrane, J. L. (1982). *Multiple criteria decision making* McGraw-Hill New York, 34, 1011–1022.
- Zhang, Y., Deng, X., Wei, D., & Deng, Y. (2012). Assessment of E-Commerce security using AHP and evidential reasoning. *Expert Systems with Applications*, 39, 3611–3623.
- Zhang, Y., Fan, Z.-P., & Liu, Y. (2010). A method based on stochastic dominance degrees for stochastic multiple criteria decision making. *Computers & Industrial Engineering*, 58, 544–552.
- Zhang, Y., Sun, Y., & Qin, J. (2012). Sustainable development of coal cities in Heilongjiang province based on AHP method. *International Journal of Mining Science and Technology*, 22, 133–137.
- Zhang, H. & Yu, L. (2012). MADM method based on cross-entropy and extended TOPSIS with interval-valued intuitionistic fuzzy sets. *Knowledge-Based Systems*, 30, 115–120.
- Zhu, X., & Dale, A. P. (2001). JavaAHP: A web-based decision analysis tool for natural resource and environmental management. *Environmental Modelling & Software*, 16, 251–262.
- Zhu, X., Li, J., Wu, D., Wang, H., & Liang, C. (2013). Balancing accuracy, complexity and interpretability in consumer credit decision making: A C-TOPSIS classification approach. *Knowledge-Based Systems*, 52, 258–267.
- Zhu, X., Wang, F., Liang, C., Li, J., & Sun, X. (2012). Quality credit evaluation based on TOPSIS: Evidence from air-conditioning market in China. *Procedia Computer Science*, 9, 1256–1262.
- Zhu, B., Xu, Z., Zhang, R., & Hong, M. (2015). Generalized analytic network process. *European Journal of Operational Research*, 244, 277–288. <http://dx.doi.org/10.1016/j.ejor.2015.01.011>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.