European Journal of Operational Research 250 (2016) 1–29

Contents lists available at ScienceDirect

European Journal of Operational Research

journal homepage: www.elsevier.com/locate/ejor

Invited Review

ELECTRE: A comprehensive literature review on methodologies and applications

Kannan Govindan*, Martin Brandt Jepsen

Department of Business and Economics, University of Southern Denmark, Campusvej 55, Odense M-5230, Denmark

ARTICLE INFO

Article history:
Received 23 September 2014
Accepted 7 July 2015
Available online 17 July 2015

Keywords:
Multiple criteria decision aiding (MCDA)
Outranking
ELECTRE
Literature review

ABSTRACT

Multi-criteria decision analysis (MCDA) is a valuable resource within operations research and management science. Various MCDA methods have been developed over the years and applied to decision problems in many different areas. The outranking approach, and in particular the family of ELECTRE methods, continues to be a popular research field within MCDA, despite its more than 40 years of existence. In this paper, a comprehensive literature review of English scholarly papers on ELECTRE and ELECTRE-based methods is performed. Our aim is to investigate how ELECTRE and ELECTRE-based methods have been considered in various areas. This includes area of applications, modifications to the methods, comparisons with other methods, and general studies of the ELECTRE methods. Although a significant amount of literature on ELECTRE is in a language different from English, we focus only on English articles, because many researchers may not be able to perform a study in some of the other languages. Each paper is categorized according to its main focus with respect to ELECTRE, i.e. if it considers an application, performs a review, considers ELECTRE with respect to the problem of selecting an MCDA method or considers some methodological aspects of ELECTRE. A total of 686 papers are included in the review. The group of papers considering an application of ELECTRE consists of 544 papers, and these are further categorized into 13 application areas and a number of sub-areas. In addition, all papers are classified according to the country of author affiliation, journal of publication, and year of publication. For the group of applied papers, the distribution by ELECTRE version vs. application area and ELECTRE version vs. year of publication are provided. We believe that this paper can be a valuable source of information for researchers and practitioners in the field of MCDA and ELECTRE in particular.

1. Introduction

Decision-making is an important part of most human activities, regardless if we are performing daily activities, professional or political work. Some decisions may be relatively simple, especially if the consequences of a bad decision are small, while others can be very complex and have significant effects. Real-life decision problems will, in general, involve several conflicting points of view (criteria) that should be taken into account conjointly, in order to arrive at a reasonable decision.

Research devoted to such problems is most often referred to as multi-criteria decision making or multiple criteria decision making (MCDM). Some authors prefer the name multiple criteria decision aid or aiding (MCDA), e.g. Roy (1990), while others use the name multiple criteria decision analysis. We will use MCDA as it is considered most appropriate for ELECTRE methods (Figueira, Greco, Roy, & Slowinski, 2013). Many different methods have been proposed to assist in MCDA problems (Zavadskas & Turskis, 2011). A common trait for these methods is that they attempt to manage "at best" the conflicting character of the various criteria, in order to assist a decision maker in making a qualified decision.

MCDA is a sub-field of operations research or management science and has attracted increasing attention of researchers for more than half a century. A considerable amount of literature has been published on various MCDA methods and their applications (Köksalan, Wallenius, & Zionts, 2011). For some of the most popular methods, the amount of literature can make it very hard for anyone to form a general overview of the potential of such a method. In addition, literature in other languages than English is common for some methods, which makes it inaccessible to many researchers.

Researchers wanting to obtain deep insight into a particular MCDA method with which they are not familiar will, of course, have to perform a literature review themselves. This is, however, a very time-consuming process, and in such cases the use of an existing review paper focusing on the specific method can save a lot of time. For other researchers performing a study of MCDA applications in a

* Corresponding author. Tel.: +45 65503188.
E-mail address: gov@sam.sdu.dk (K. Govindan).

http://dx.doi.org/10.1016/j.ejor.2015.07.019
0377-2217/

specific area, such a review may be even more valuable if it also contains categorized descriptions of applications of the method.

Various classifications of MCDA methods have been proposed in the literature (Mendoza & Martins, 2006). One of the early categorizations classifies MCDA methods into two groups according to the size of the set of alternatives under consideration. Multi-attribute decision making (MADM) methods are designed for problems with a pre-defined discrete set of alternatives, whereas multi-objective decision making (MODM) methods are for problems where the alternatives are not pre-defined (Hwang & Yoon, 1981). It should be noted that the terms MADM and MCDA (or MCDM) sometimes are used interchangeably in the literature (Triantaphyllou, 2000), which may lead to some confusion. Another classification proposed by Belton and Stewart (2002) considers three types of MCDA methods: (1) value measurement models, where each alternative is assigned a numerical score that can be used to indicate the degree to which a given alternative is preferred to another; (2) goal, aspiration or reference level models that attempt to select alternatives, which are closest to achieve some pre-defined goals or aspirations; (3) outranking models, which are based on pairwise comparisons of alternatives against each other (or against a pre-defined norm) on each criterion, followed by a procedure that aggregates and exploits the information, in order to determine the strength of evidence supporting that one alternative should be favored over another (Mendoza & Martins, 2006).

A number of review papers have been published on some of the most popular MCDA methods. These papers generally fall into one of three categories:

(1) Categorization and description of applications of the method. These reviews focus on a specific method and provide a categorization of the papers according to the application areas, in which the method has been considered. Examples are Behzadian, Otaghsara, Yazdani, and Ignatius (2012) (TOPSIS) and Vaidya and Kumar (2006) (AHP).
(2) Methodological developments of the method. Here the focus is on reviewing papers concerned with the methodological developments of a given method. Examples are Wallenius et al. (2008) (MAUT) and Figueira et al. (2013) (ELECTRE).
(3) Papers focusing on both of the above, e.g. Behzadian, Kazemzadeh, Albadvi, and Aghdasi (2010) (PROMETHEE).

With respect to the family of ELECTRE methods, Figueira et al. (2013) provided an updated version of a book chapter by Figueira, Mousseau, and Roy (2005), which gives a thorough review of the background and the developments of the methods in the family as well as some of their extensions. Several other papers include ELECTRE within a general review of MCDA or outranking methods, e.g. Roy (1991) and Roy and Vincke (1981), a general review of a specific range of MCDA methods, e.g. Zopounidis and Doumpos (2002b) or a review of decision aiding within a specific application area, e.g. Lahdelma, Salminen, and Hokkanen (2000) and Xidonas and Psarras (2009). However, to our knowledge, no existing papers on ELECTRE fall into the first or the third category of reviews.

In this paper, we provide a comprehensive review and categorization of English journal articles[1] on ELECTRE. The main focus is on papers dealing with applications or developments of ELECTRE and ELECTRE-based methods, but papers on developments of concepts used within ELECTRE are also included. In addition, review papers dealing with a specific application area, such as environmental or financial management, are included, as long as they describe applications of one or more ELECTRE methods. Finally, we also include papers considering the problem of selecting an appropriate MCDA method, provided that an ELECTRE method is one of the methods under consideration. We focus on journal papers for three reasons: first of all because they contain valuable information for researchers studying ELECTRE, secondly because the periodical nature of journals ensures that they continuously provide the latest research results, and finally because they generally are more accessible via online databases than other sources, such as books, book chapters, and conference proceedings. Of course the exclusion of non-English literature and literature other than journal articles will limit the review.

The rest of the paper is structured as follows: In Section 2, the history and a few of the fundamental concepts of ELECTRE are briefly reviewed. Section 3 presents the research methodology used for the literature review. In Section 4, the main classification scheme is explained in detail. The main classification of the 686 papers as well as the definition of categories for application areas and subsequently categorization of the 544 applied papers is presented in Section 5. Section 6 introduces five other classifications of the papers. Finally, in Section 7 we present our conclusions and a number of possible future research directions.

2. A brief history and overview of ELECTRE methods

The first ELECTRE method was presented by Benayoun, Roy, and Sussman (1966) who reported on the works of the European consultancy company SEMA with respect to a specific real world problem. But the first journal article did not appear until 1968, when Roy (1968) described the method in detail. Later, it was renamed to ELECTRE I. The name ELECTRE Iv (v for veto) is sometimes used when veto thresholds are taken into account, but is not considered an official name (Figueira et al., 2005). Several other ELECTRE methods were developed during the following two decades: ELECTRE II (Roy & Bertier, 1971), ELECTRE III (Roy, 1978), ELECTRE IV (Roy & Hugonnard, 1982), ELECTRE TRI (Yu, 1992; Roy & Bouyssou, 1993) and ELECTRE IS (Roy & Bouyssou, 1993). ELECTRE TRI was later renamed to ELECTRE TRI-B (Figueira, Greco, Roy, & Słowiński, 2010), when a new version, ELECTRE TRI-C (Almeida-Dias, Figueira, & Roy, 2010) was developed, but most of the literature still use the name ELECTRE TRI for the original version. To avoid conflicts with the naming in the articles, we will use the name ELECTRE TRI instead of ELECTRE TRI-B for the remainder of this paper. Recently, ELECTRE TRI-nC, was presented by Almeida-Dias, Figueira, and Roy (2012) as an extension of ELECTRE TRI-C. All methods, except ELECTRE I, Iv and II, take into account the concept of pseudo-criteria (Roy & Vincke, 1984). Thanks to indifference and preference thresholds, this concept allows to model imperfect knowledge, which may be a result of uncertainty, imprecision, and ill-determination of certain data. A more detailed history and overview of the ELECTRE methods can be found in Figueira et al. (2005) (see also Roy & Vanderpooten, 1996b).

Obviously, each of the ELECTRE versions differs operationally. But they also differ with respect to the types of problems they can be used for. Roy (1977) defined four types of MCDA *problematics* representing different objectives in relation to how a decision maker (DM) would like to analyze a problem, and what types of results are required. ELECTRE I, Iv and IS are applicable to what is referred to as the *choice problematic* or *problematic* α, where the objective is to select a smallest set of best alternatives. ELECTRE II, III and IV were designed for the task of constructing an ordering of the alternatives from the best to the worst. This is called the *ranking problematic* or *problematic* γ. ELECTRE II is based on true criteria, whereas the other two methods use pseudo-criteria. ELECTRE III and ELECTRE IV differ on a number of points, but the main difference is that the latter does not use criteria weights. In fact, it is the only method in the family with this characteristic. ELECTRE TRI, TRI-C and TRI-nC are for the *sorting problematic*, also called *problematic* β, in which the objective is to assign alternatives to a set of pre-defined categories. The final problematic is the *description problematic* or *problematic* δ, which is included in

[1] Section 2 contains references to a few original works in French, but these are not included in the review sections.

the other three, but also can be considered in its own right if only a description of the problem is possible (Roy, 1996).

All ELECTRE methods belong to the family of outranking methods (Roy, 1991), one of the classic families of methods within MCDA. Each method consists of two phases: aggregation and exploitation. In the aggregation phase, within a Multi-Criteria Aggregation Procedure (MCAP) the concordance and non-discordance concepts are used to make pairwise comparisons of the alternatives, the alternatives being characterized by their performances on the different criteria. In methods dealing with problematic α or problematic γ, the alternatives are compared against themselves. In problematic β methods, however, the alternatives under consideration are compared against a set of reference alternatives characterized by norms on the different criteria. These pairwise comparisons of the alternatives lead to build one or more outranking relations depending on the specific method in question. An outranking relation is a preference model which takes into account three types of situations: preference, indifference, and incomparability. The second phase consists of an exploitation procedure (EP) specific for the ELECTRE method in question. The EP is utilized to exploit the outranking relation previously constructed by the MCAP, and it is aimed at constructing and presenting the type of results that are expected for the given problematic (Figueira et al., 2013).

Software packages have been developed for some of the ELECTRE methods[2]: ELECTRE IS, ELECTRE III–IV and ELECTRE TRI. The latter also incorporates ELECTRE TRI Assistant (see Mousseau, Slowinski, & Zielniewicz, 2000), which allows the user to infer the criteria weights of an ELECTRE TRI model from assignment examples. There are also a few other general software implementations relevant for ELECTRE: ELECCALC (Kiss, Martel, & Nadeau, 1994) can be used to estimate the parameters of an ELECTRE II model. IRIS[3] (Dias & Mousseau, 2003) allows the user to infer the parameters of a model, based on a modified ELECTRE TRI method. SRF[4] (Figueira & Roy, 2002) can be used to determine the criteria weights for ELECTRE methods (Figueira et al., 2005). In addition, there are a number of software implementations of ELECTRE-based methods as well as application specific implementations of ELECTRE. These are too numerous to mention here, but a few examples are: SADAGE (Leyva-Lopez & Sanchez, 2005; Leyva-Lopez, Sanchez, & Contreras, 2008), a combination of ELECTRE III and a genetic algorithm, ESSE (Vlahavas, Stamelos, Refanidis, & Tsoukias, 1999), which incorporates ELECTRE II and ELECTRE IV for software evaluation, and Skills Evaluator (Anestis, Grigoroudis, Krassadaki, Matsatsinis, & Siskos, 2006), where ELECTRE TRI can be used for evaluation of information technology skills and qualifications of job applicants. Decision Deck project,[5] an open source project that implements different MCDA methods, includes some ELECTRE methods. Finally, we should mention the recent ELECTRE software implemented in Excel "ELECTRE Toolkit for Excel[6]" that performs ELECTRE III and IV methods within Excel.

3. Research methodology

The first published journal paper on ELECTRE is a French article, by Roy (1968). It is not included in this review because it is not in English, but the year 1968 was chosen as a starting point for collecting the articles. Several library databases were used in the process of searching and collecting articles for the review, including ScienceDirect, Taylor & Francis, Wiley, Springer, Cambridge, IOS Press, Palgrave, Sage, IEEExplore, EBSCO, ProQuest, Emerald, Oxford, ASCE, etc. In addition, we also used the database hosts Web of Science and Scopus as well as relevant cross-references found in the reviewed articles to identify and subsequently search and collect papers from individual journals and publishers, which were not included in the library databases accessible to us.

The searching and collecting of papers was performed between February and June 2013. Our main search phrase was simply "ELECTRE," but we also used "concordance," "discordance," and "outranking." Initially we only searched title, abstract, and keywords, but when we looked at the cross-references in the papers found, it soon became clear that this would be too restrictive for a comprehensive literature review. Therefore we decided to use full text search with respect to the search term "ELECTRE." Of course this increased the number of search results substantially. Each paper found during the search was quickly skimmed, in order to determine whether it should be saved for further investigation or disregarded right away. This initial search through databases provided 683 papers to study further. After reviewing each paper more carefully, 611 of the papers were found to be relevant for the study. The second stage of the search was performed during the review and included relevant cross-references and their corresponding journals and publishers. Here we found 58 papers. Based on comments made by the referees during the peer review process, we decided to include 17 of the 72 papers that we initially left out. Thus, the final number of papers included in the study is 686. Comment papers to any of the 686 papers, as well as corresponding reply papers are not directly included in the review. We regard these as an integral part of the original paper and provide only references in a footnote to the paper in question. A total of 10 comment and reply papers were identified.

We started the categorization by placing each paper into one of three groups according to its main focus with respect to ELECTRE: application, review, or development. A fourth group had to be created during the review, because some papers dedicated to the selection of an appropriate MCDA method did not fit well in the other groups. Although these papers did not follow the initial idea for which papers to include, they are still interesting in a study on ELECTRE, because they compare one or more ELECTRE methods to other methods. The four groups and the types of data collected for the review are explained in detail in Section 4.

Applied papers were further categorized according to application area. They span several areas, which are not easily separated. Assigning a paper to one specific category is inherently highly subjective and depends on how the categories are defined. We defined an initial set of categories, inspired by the review papers by Behzadian et al. (2010, 2012), but the definition of the categories turned out to be a dynamic process. Some categories were split in two, some joined, and some renamed. Also a few new categories were defined. The final set of 13 categories is listed in Section 5.1. Fig. 1 presents the framework for the systematic literature review (Govindan, 2013; Govindan, Soleimani, & Kannan, 2015).

4. Definition of the main classification scheme

For the main classification, each paper was placed into one of the four groups: (a) applied papers; (b) survey, review and overview papers; (c) papers on MCDA method and model selection; (d) preference disaggregation and theoretical and non-application papers.

4.2. Group a

Papers in group *a* can either contain a numerical application or present the results of an ELECTRE (-based) method or discuss how such an application could be carried out. Also papers containing a presentation of an algorithm or a decision support system (DSS) for a specific area are included in this group, as long as ELECTRE plays a part in the system. Besides the trivial information, such as year of publication and authors, we recorded the following information for

[2] http://www.lamsade.dauphine.fr/spip.php?article558
[3] http://www.uc.pt/en/feuc/ldias/software/iris
[4] http://www.lamsade.dauphine.fr/spip.php?article558
[5] http://www.decision-deck.org/project
[6] http://japarthur.typepad.com/electre_toolkit/

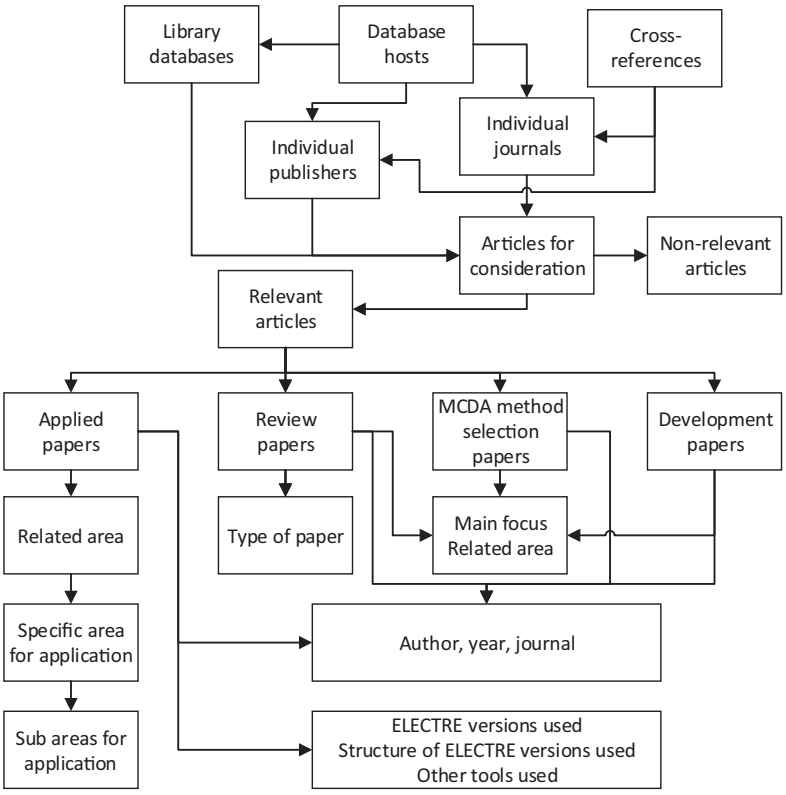

Fig. 1. Framework for the literature review.

each paper: the specific task for which ELECTRE was used, the ELECTRE version(s) used, if the aggregation and/or exploitation phase was modified, and other tools or methods used.

In the tables in Section 5 and in Appendix A, the ELECTRE versions are indicated with an 'E' followed by the version name, e.g. ELECTRE TRI is shown as ETRI. If fuzzy or interval numbers are used for evaluations or parameter values, then the word 'Fuzzy,' respectively, 'Interval' is put in front of the version name. A number of papers refer to the ELECTRE I based net concordance/discordance procedure, proposed by van Delft and Nijkamp (1976) as ELECTRE II. This is indicated as 'NCD referred to as EII.'

With respect to modifications of the aggregation and/or exploitation phase, these are indicated as follows:

- P: The original ELECTRE algorithm was used. Modifications, such as the use of interval or fuzzy numbers are also included, as long as the overall structure of the original algorithm is evident.
- MA: The aggregation phase was either replaced or it was modified, such that the original algorithm structure of the phase cannot be recognized.
- ME: The exploitation phase was either replaced or it was modified, such that the original algorithm structure of the phase cannot be recognized.
- MA+ME: Both phases were either replaced or modified, but it is still clear that the used method is based on the given ELECTRE version.
- NC: This means that an approach similar to the PROMETHEE net flow was used as a replacement for the exploitation phase of ELECTRE III.
- NCD: The ELECTRE I based net concordance/discordance procedure was used.
- ND: The sum of the differences between values of the concordance and discordance matrix of ELECTRE I was used to create a ranking.
- RD: A modified discordance matrix is used in ELECTRE I or II, where the original indices are subtracted from 1.
- CA: Some version of concordance analysis based on ELECTRE I was used.
- Concepts: Only concepts from the given ELECTRE version was used.
- U: It was not possible to determine if any of the phases were modified.

If more than one ELECTRE version was used, then a comma separates the indications. If a given ELECTRE version was applied in more than one way, then an '&' is used to separate the indications.

4.2. Group b

Group *b* includes literature reviews and surveys of decision aiding for various areas as well as papers providing an overview or a review of one or more decision aiding methods. In this group, we define a review as a paper, in which a larger literature review is conducted for a specific application area or a specific methodology. A survey is defined as a paper investigating or discussing the possible use or behavior of one or more methods within an application area. Finally, an overview is a paper providing theoretical or methodological overviews or reviews of a specific method or range of methods. Common to all papers included in the 'survey, review and overview' group is the fact that they include ELECTRE in one way or another. We recorded the main focus of each paper, as well as the possible area the paper can be linked to.

4.3. Group c

Group *c* is for papers presenting or discussing methodologies for selecting an appropriate MCDA model or method. Most papers in this group consider several methods and attempt to provide an algorithm

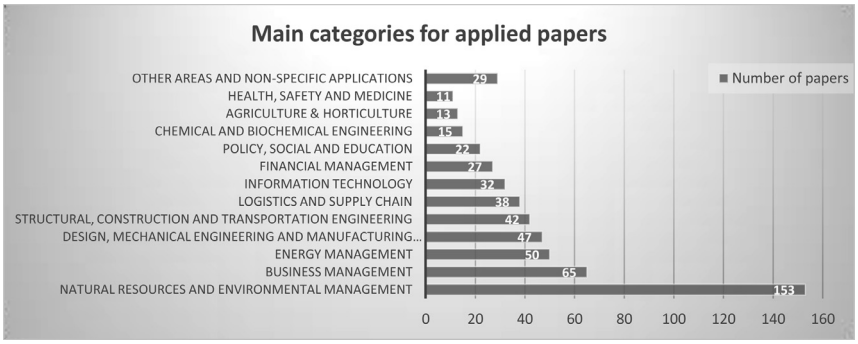

Fig. 2. Distribution of applied papers according to main categories.

or a set of guidelines to assist in the selection process. Application based comparison papers, which apply different methods to one or more given problems are not included in the group, since they are already presented as applied papers in group *a*. The main focus of each paper, as well as the possible area the paper can be linked to, was recorded.

4.4. Group d

Many of the papers placed in group *d* actually contain an application of an ELECTRE method and could as such have been assigned to group *a*. If, however, the main focus of a paper was identified as preference disaggregation in relation to ELECTRE, axiomatic characterization of ELECTRE methods or theoretical development of concepts used in ELECTRE, it was considered more appropriate for group *d*. Papers that consider ELECTRE or ELECTRE based methods, but do not contain, or at least discuss, an application of ELECTRE are also assigned to this group. Here we recorded the main focus, and if an example was provided, we also recorded the related area.

5. Main classification and categorization of papers

In this section, the 686 papers are presented table-wise according to the main classification scheme. Due to space limitations, however, the tables for group a papers had to be moved to Appendix A. For each of the tables, a small sub-set of papers is selected and briefly described, before presenting the corresponding table.

5.1. Group a: Applied papers

A total of 544 papers were found relevant for this group. Each paper was categorized into one of 13 categories. Each category includes papers from application areas, which were found to be similar in some respects, except for the last category. Four of the categories can be described by a single larger concept. These are: business management; energy management; information technology; financial management. The remaining categories are: natural resources and environmental management; design, mechanical engineering and manufacturing systems; structural, construction and transportation engineering; logistics and supply chain; policy, social and education; chemical and biochemical engineering; agriculture and horticulture; health, safety and medicine; other areas and non-specific applications. Fig. 2 shows the distribution of the papers, according to the 13 categories.

In a possible area specific study, some papers may very well be considered appropriate even though they are assigned to a category for a different area in the current paper. For this reason, in each main category Sections 5.1.1–5.1.13 we will discuss other categories and sub-categories that could have been considered for some of the papers, and provide a few examples but without going into detail with the specific papers.

5.1.1. Natural resources and environmental management

Natural resources and environmental management (NRE) is by far the most popular application area for ELECTRE methods. But it is also a very broad area. Therefore five sub-categories were defined in order to provide a better separation of the papers: water management; waste management; land management, geology and cartography; forestry, natural reserves and ecotourism; other papers on NRE. The sub-categories are further explained in Sections 5.1.1.1–5.1.1.5. Fig. 3 shows the distribution of applied papers in NRE according to sub-categories. Other categories that could have been considered for some of the papers in this category are: agriculture, e.g. Azmi, Araghinejad, and Sarmadi (2011) and Pedras and Pereira (2009), structural/rehabilitation engineering, e.g. Le Gauffre et al. (2007) and Tlili and Nafi (2012), chemical engineering, e.g. Karagiannidis and Perkoulidis (2009) and Laforest, Raymond, and Piatyszek (2013), location problems, e.g. Banias, Achillas, Vlachokostas, Moussiopoulos, and Tarsenis (2010) and Duckstein, Treichel, and Elmagnouni (1994), energy management, e.g. Opricovic and Tzeng (2007) and Perkoulidis, Papageorgiou, Karagiannidis, and Kalogirou (2010), forestry, e.g. Tecle, Fogel, and Duckstein (1988b).

5.1.1.1. Water management. The largest sub-category, water management, contains almost half of all papers in NRE and more than twice as many as the second largest sub-category. For convenience, the table has been split into three sub-sub-categories: water resources; drainage, wastewater, eutrophication and sediment; watershed management.

Water resources. With respect to water resources, the specific application areas include development planning and operations planning for reservoirs and basins, resources planning for irrigation systems, development and maintenance of water distribution networks, water quality assessment and impact assessment of environmental policies on water resources. Papers on drainage, wastewater, eutrophication and sediment mostly contains applications related to management and treatment strategies of wastewater and wastewater systems, but a few papers consider the problems of eutrophication and sediment management. Watershed management papers are typically concerned with management practices of watersheds, with respect to preservation, environmental issues and flood and erosion risks.

David and Duckstein (1976) provided the earliest paper in this category. They applied ELECTRE I for comparing five alternative long-range development schemes of an existing water resources system in a river basin in Hungary, based on 12 criteria. The same case study was later used by Duckstein and Opricovic (1980) as well as Bender and Simonovic (2000), who applied compromise programming (CP) and fuzzy CP, respectively, and compared the results to those obtained by David and Duckstein (1976). Another case study, involving the assessment of 25 alternative development plans on 13 criteria for a river basin in USA was used in three different papers: Gershon, Duckstein, and McAniff (1982) employed ELECTRE I and II for this

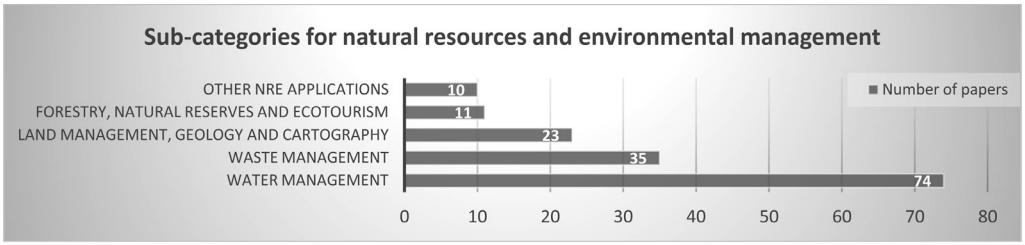

Fig. 3. Distribution of applied papers in NRE according to sub-categories.

problem. For larger problems they suggested ELECTRE I to be used as a screening method to reduce the set of alternatives and ELECTRE II to obtain a ranking of the remaining alternatives. Duckstein, Gershon, and McAniff (1982) also used ELECTRE I and II, but in addition they applied CP and multi-attribute utility theory (MAUT), in order to compare these methods. They believed that CP was most appropriate for the problem. Gershon and Duckstein (1983) continued along this line and used cooperative game theory (CGT) as well as the other four methods. They concluded that it does not make sense to attempt to select a single best method.

Roy, Slowinski, and Treichel (1992) presented a methodology for a decision problem related to water supply systems (WSSs) in Poland. In the first part of the analysis, they used ELECTRE III to set up a priority order of water users, who should be connected to a WSS, based on seven socio-economic criteria. ELECTRE III was also used by Roy and Slowinski (1993) for the same case study, in order to illustrate a proposed criterion of distance used on the pre-orders obtained.

Duckstein et al. (1994) used ELECTRE III and three other methods in a hypothetical problem of finding a location for a well on a circular island. A total of 13 locations were compared on three criteria representing pumping yield, costs, and water-shortage risk. This problem was also used by Czyzak and Slowinski (1996) to illustrate a fuzzy method, based on ELECTRE III and possibility and necessity measures.

Raju, Duckstein, and Arondel (2000) used ELECTRE TRI in the initial stage of an analysis of management strategies for irrigation systems in Spain. A large number of alternative strategies were sorted into eight categories based on evaluations on 10 criteria. After selecting a single strategy from each category, using a sum of squared error methodology, ELECTRE III and IV and three other methods were used in a group decision process to rank the selected alternatives. More recently, Trojan and Morais (2012a) proposed a group decision approach for the ranking of maintenance strategies for water distribution networks, based on individual applications of ELECTRE II and aggregation through the use of the Copeland method. Four decision makers (DMs) considered six environmental and economic criteria when evaluating the 15 alternatives.

Proulx, Rodriguez, Sérodes, and Bouchard (2007) combined ELECTRE III with a geographical information system (GIS), in order to identify locations within a water distribution system most susceptible to taste and odor problems. For this purpose, a group of experts used the Simos' procedure to determine the weights of the seven criteria used in the analysis. Silva, Morais, and de Almeida (2010) proposed a group decision model to support a hydrographic basin committee in controlling the environmental degradation of a basin. The model was based on individual applications of PROMETHEE II followed by an application of ELECTRE IV, where the DMs were used as criteria and the PROMETHEE flows as evaluations. Table A-1 in Appendix A shows a list of the papers on water resources.

Drainage, wastewater, eutrophication and sediment. Tecle, Fogel, and Duckstein (1988a) utilized ELECTRE I, CP and CGT to compare 15 alternative wastewater management schemes on 12 criteria. ELECTRE III was applied by Martin, Ruperd, and Legret (2007) to a theoretical problem in urban stormwater drainage management. Eight best management practices were evaluated on six groups of criteria. Assessments in the analysis were based on data obtained from a large French survey as well as through previous studies. Carrico, Covas, Almeida, Leitao, and Alegre (2012) compared ELECTRE III and TRI for a case study aimed at prioritizing sewers in need of rehabilitation. They concluded that ELECTRE III is easier for a DM to understand, both in regard to the results and with respect to the parameters.

In order to prioritize sites along the northern coast of Spain according to the needs for sediment management, Guerra, Viguri, and Voulvoulis (2009) employed four MCDA methods, including ELECTRE II, using seven criteria with data obtained from chemical analyses and toxicity tests as well as environmental and socio-economic assessments. Moriki and Karydis (1994) performed an eutrophication assessment of coastal areas in Greece, using an ELECTRE I based concordance analysis and two other methods. Table A-2 in Appendix A summarizes the papers in the drainage, wastewater, eutrophication and sediment category.

Watershed management. Hansen and Goicoechea (1979) suggested the use of ELECTRE I for a problem analyzed in a previous paper concerning the evaluation of eight alternative flood-prevention programs, based on six criteria. Elshorbagy (2006) used ELECTRE II to evaluate the performance of soil covers, based on simulated data representing reconstructed watersheds over a period of 61 years using historical meteorological records. A two-phase procedure, based on a GIS and ELECTRE III, was developed by Macary, Ombredane, and Uny (2010) in order to identify zones within watersheds subjected to erosion risks and classify them into risk classes. Two small watersheds in France were considered in the study. Recently, Ceccato, Giannini, and Giupponi (2011) utilized ELECTRE III together with a group decision rule within a DSS developed as a part of a larger framework aimed at improving participatory processes in water management. The case study involved the ranking of strategies for handling flood risks. In Table A-3 in Appendix A, a summary of watershed management papers is given.

5.1.1.2. Waste management. The waste management category contains several papers concerned with location problems, mainly in relation to landfills and waste management facilities. Other problems handled in this category involve the selection of waste handling strategies and waste management systems. ELECTRE III is the most popular ELECTRE version in this category, with 24 out of 35 papers using the method.

Using ELECTRE III and IV in both cases, Hokkanen and Salminen (1997a) conducted two different case studies on the selection of a municipal solid waste (MSW) management system for two regions in Finland. Eight criteria were used in evaluating the 11, respectively 22, alternatives under consideration. The latter of these cases was also analyzed in Hokkanen and Salminen (1997b), who applied ELECTRE III. Later Salminen, Hokkanen, and Lahdelma (1998) considered both case studies as well as a location problem and a land-use problem, in a comparative analysis of ELECTRE III, PROMETHEE I and II and the simple multi-attribute rating technique (SMART). They suggested using ELECTRE III, if only one method has to be chosen. Otherwise different MCDA methods should be used.

A number of different methods, including the net concordance/discordance method based on ELECTRE I, was used by Cheng, Chan, and Huang (2002, 2003) to solve a landfill location problem in Canada, where 11 alternatives were compared on 12 environmental and socio-economic criteria. Norese and Toso (2004) and Norese (2006) used ELECTRE III in a group decision setting to determine suitable locations for a waste disposal plant and an incinerator in a district in Italy. A collective modeling process was used for all parameters, except the criteria weights, which were determined individually. Results were then plotted using SURMESURE to help estimate the degree of consensus.

Karagiannidis and Perkoulidis (2009) presented a framework for evaluating different anaerobic digestion technologies for treating organic MSW. Five technologies were ranked in an ELECTRE III analysis, based on four criteria: GHG emissions, energy recovered, material recovered, and operating costs. The same case study was used by El Hanandeh and El-Zein (2010) to illustrate a modified version of ELECTRE III, which they named ELECTRE SS, where the exploitation phase is carried out multiple times in a Monte-Carlo simulation.

As a part of an integrated assessment of a proposed Waste-to-Energy facility within a region in Greece, Perkoulidis et al. (2010) applied ELECTRE III, in order to find the best option for managing MSW. For this purpose, four scenarios were identified and compared on four criteria. Achillas, Vlachokostas, Moussiopoulos, and Banias (2010) presented an approach based on ELECTRE III for locating electrical and electronic waste treatment plants. The proposed methodology was applied to a case study in Greece, where 22 alternative locations were compared on nine criteria. Coronado, Dosal, Coz, Viguri, and Andres (2011) developed a two-step procedure for estimating the quantity of construction and demolition waste (CDW) generated and evaluating management alternatives for handling CDW. The methodology was applied in a case study in for Cantabria in Spain. In the second part of the analysis, ELECTRE II and three other MCDA methods were applied in order to rank the 13 alternatives according to eight socio-economic and environmental criteria. Table A-4 in Appendix A gives an overview of the papers related to waste management.

5.1.1.3. Land management, geology and cartography. Land use management, risk zoning, earthquake vulnerability assessment and corridor siting are some of the problems related to papers in this category. Others are directly related to geology and some to cartography. More than a third of the papers in the category use some integration of MCDA and a GIS.

This category contains a series of papers from Dutch authors, who introduced several modifications to the ELECTRE I method, some of which have been widely used in the literature. Nijkamp (1975) proposed vector normalization and weight multiplication of the decision matrix for ELECTRE I. This approach was then applied to a problem concerning the selection of a land reclamation project in the Netherlands. Van Delft and Nijkamp (1976) applied the ELECTRE I based net concordance/discordance method as well as a version with a modified discordance matrix for selecting a planning strategy for a new industrial area in the Netherlands. Nijkamp and Vos (1977) developed what was referred to as a new concordance analysis method. The method generally uses the same concepts as ELECTRE I, but a 'satisfying norm' is used in the creation of the outranking relation. They applied it in the same context as in Nijkamp (1975).

A methodology based on ELECTRE TRI was proposed by Merad, Verdel, Roy, and Kouniali (2004) for risk zoning of areas subjected to mining-induced hazards. A case study was presented, involving the Lorraine Iron mining basin in France, where a number of hazard zones were identified. The zones were assigned to four risk classes, using two groups of criteria related to the probability and intensity of a possible collapse and the value and vulnerability of assets. Abedi, Torabi, Norouzi, and Hamzeh (2012) analyzed a mineral prospectivity mapping problem in a case study for an area in a province in Iran. A version of ELECTRE III was employed, where the exploitation phase was carried out using flows as in PROMETHEE II, in order to create a ranking of the prospective zones.

Chakhar and Mousseau (2008) developed a framework to facilitate the incorporation and use of outranking methods in GIS. Within this framework, ELECTRE TRI was used to assign spatial units to a set of pre-defined categories. The parameter inference procedure from Mousseau and Slowinski (1998a) was also incorporated. An implementation of the proposed framework was applied to a hypothetical corridor identification problem using real data from a region in France. Papers from the land management, geology and cartography category are listed in Table A-5 in Appendix A.

5.1.1.4. Forestry, natural reserves and ecotourism. Papers in this category are concerned with selecting management strategies or assessing projects related to forestry or natural reserves or selecting activities for ecotourism.

Kangas, Kangas, Leskinen, and Pykäläinen (2001a) and Kangas, Kangas, and Pykäläinen (2001b) applied a modified ELECTRE III and PROMETHEE II to a decision problem in forest management planning and the results were compared to those from the original study, which were obtained using an AHP variant. The exploitation phase of ELECTRE III was replaced with the minimum-procedure proposed by Pirlot (1995).

Jeffreys (2004) used ELECTRE II and the weighted summation method (WSM) to compare eight farm forestry management practices in Australia. A DSS to help forest managers make appropriate choices in silvicultural systems was presented by Pauwels, Lejeune, and Rondeux (2007). The system is based on a growth model, which allows consequences of different scenarios to be observed through simulation. Ranking of scenarios is carried out using ELECTRE III. Ok, Okan, and Yilmaz (2011) compared the results from applications of AHP, ELECTRE I and III in a study on ecotourism planning in Turkey. Seven alternative activities, such as trekking and cycling were evaluated on seven environmental, economic and social criteria. Table A-6 in Appendix A gives a summary of the papers on forestry, natural reserves and ecotourism.

5.1.1.5. Other papers on natural resources and environmental management. The last sub-category in NRE contains the papers that do not fit in one of the other sub-categories. Most are concerned with problems related to emissions and air quality, but also problems related to end-of-life (EOL) products, environmental deterioration and selecting environmental indicators are studied.

Siskos, Lombard, and Oudiz (1986) applied ELECTRE III and dominance analysis, in order to compare and to rank industrial control options against the release of a chemical pollutant into the atmosphere. The study involved four representative manufacturing plants in France. Bufardi, Sakara, Gheorghe, Kiritsis, and Xirouchakis (2003) used ELECTRE III as the decision module, within a methodology for selecting the best scenario regarding the treatment of an EOL product. An illustrative example was provided, where the product is a telephone. A procedure to validate indicators used in environmental and social impact assessments was proposed by Cloquell-Ballester, Cloquell-Ballester, Monterde-Diaz, and Siurana (2006). In the final stage of the method, the indicators have to be sorted into categories. In a case study, involving four indicators, three MCDA methods were compared for handling the final stage. ELECTRE TRI was found to be most suitable for this task. Achillas, Vlachokostas, Moussiopoulos, and Banias (2011) presented a three-stage methodological approach to prioritize strategies aimed at reducing environmental deterioration in urban areas. ELECTRE III was incorporated in the last stage of the model, in order to provide a final ranking of the strategies. The method was applied in a case study of the metropolitan area of Thessaloniki in Greece. Papers from this last sub-category under NRE are listed in Table A-7 in Appendix A.

5.1.2. Business management

With 65 papers, business management is the second largest main category for the applied papers. Four sub-categories that seem to fit the specific application areas of the papers were defined. The sub-categories are: performance and benchmarking; human resources; investment decisions; other business management applications. They are further explained in Sections 5.1.2.1–5.1.2.4. Other categories that could have been used for some papers are financial management, e.g. Oktem and Ergul (2012), environmental management, e.g. Infante, Mendonca, Purcidonio, and Valle (2013), and information technology, e.g. Sobral and Costa (2012).

5.1.2.1. Performance and benchmarking. Papers in this category typically compare businesses or economic sectors on a number of indicators, mostly financial, in order to obtain a classification or a ranking of the alternatives according to their relative performance.

An approach based on ELECTRE III was used by Augusto, Lisboa, Yasin, and Figueira (2008) to rank the performance of Portuguese firms in different economic sectors. A set of 12 criteria weights was devised in collaboration with the DM through the use of the revised Simos' procedure presented in Figueira and Roy (2002). Rankings of the 392 firms included in the study were obtained by employing ELECTRE III. Amiri, Nosratian, Jamshidi, and Kazemi (2008) proposed the use of interval data in ELECTRE I and illustrated the approach for the assessment of 15 bank branches in Iran. Bilich and da Silva (2008) used ELECTRE TRI for evaluating intellectual capital (IC) within companies and subsequently to assist in optimizing the IC through simulation. In the evaluation phase, 19 software producing technology companies were sorted into six pre-defined efficiency categories, based on 10 criteria.

Rigopoulos, Psarras, and Askounis (2008b) proposed a fuzzy multi-criteria procedure for nominal classification problems. The method constructs outranking relations using an approach similar to ELECTRE III and TRI, but uses entrance thresholds, representing the minimum requirements for an alternative to be included in a category. They applied the method for the classification of a Greek bank's retailers. In Rigopoulos, Psarras, and Askounis (2008a) a similar approach was implemented into a DSS called NeXClass, and this DSS was also used in Rigopoulos and Anagnostopoulos (2010) and Rigopoulos et al. (2010). Papers on performance and benchmarking are summarized in Table A-8 in Appendix A.

5.1.2.2. Human resources. ELECTRE applications in human resources management consider personnel selection, evaluation, allocation and education as well as the assessment of the working climate.

Siskos, Grigoroudis, Krassadaki, and Matsatsinis (2007) presented a methodology to evaluate information technology skills and qualifications. The system evaluates candidates in two phases. Candidates who pass the first phase, are sorted in the second phase into four pre-defined categories using ELECTRE TRI. A software implementation was presented in Anestis et al. (2006).

An ELECTRE I extension, based on intuitionistic fuzzy sets (IFS) was proposed by Wu and Chen (2011) and illustrated on an example, in which a company has to choose a project manager from a group of candidates. The method uses the concepts of a score function, accuracy function, and hesitancy degree of an IF value in order to create three concordance and three discordance sets, which are then aggregated into one concordance and one discordance matrix. Dominance matrices are calculated through a procedure, which does not use thresholds.

A two-step model was presented by Certa, Enea, Galante, and La Fata (2009), in order to allocate human resources to research and development (R&D) projects taking into account skill levels and the importance of each skill with regard to the project. The second step uses ELECTRE III on a set of selected solutions, with the output from the previous step as criteria. Table A-9 in Appendix A contains a summary of papers on human resources.

5.1.2.3. Investment decisions. Investment decision papers are typically concerned with evaluating possible project or business investments or selecting a project or business to support, through private or public funding.

Costa, de Almeida, and de Miranda (2003) proposed the use of ELECTRE TRI to support investment decisions related to information systems (IS). A case study from the literature was used as an illustration, where a portfolio of ISs was sorted into categories according to how soon they should be considered. Alexopoulos, Siskos, Tsotsolas, and Hristodoulakis (2012) presented an application of ELECTRE II, concerning the selection of an editorial strategy for a large Greek publishing company. A total of 12 publishing actions were considered according to nine criteria representing social, economic and business aspects. Criteria weights were determined through the revised Simos' procedure.

ELECTRE IV was used by Gomes, Rangel, and Moreira (2009) and Rangel, Gomes, and Moreira (2009) as a proposed tool to assist a private institution in Brazil in selecting projects to support financially. Socio-economic criteria as well as the interests of the institution itself were taken into account in the analysis. A list of papers on investment decisions can be found in Table A-10 in Appendix A.

5.1.2.4. Other business management applications. Other business management applications include various decisions related to contracts, marketing, outsourcing and accounting as well as products and clients' classifications. Also negotiation procedures and forecasting models are considered by some papers in this category.

Swenson and McCahon (1991) employed five different MCDA techniques, to illustrate the correctness of a decision to eliminate a sports program from University sponsorship due to budget reduction. De Almeida (2007) used an ELECTRE I based decision model for outsourcing contracts selection, where the criteria are utility functions, incorporating uncertainties in some of the information. The three utility functions for the illustrated problem of selecting between six alternative contracts take into account cost, delivery time, and dependability.

The idea of negotiations conducted by means of software support tools was considered by Wachowicz (2010), who proposed two approaches for use in the pre-negotiation phase. One of the approaches incorporated ELECTRE TRI in order to evaluate offers. Sobral and Costa (2012) proposed an extension of ELECTRE TRI for aiding in group decisions in cases where the group members act in a non-cooperative way. The method, which was named ELECTRE TRI-NG, is based on concepts from game theory and establishes a negotiation process between decision makers. It was applied in a numerical example, concerning the classification of five products into three categories according to market share, brand strength, competition and production process.

Xu and Ouenniche (2012) suggested the use of MCDA to evaluate the performance of forecasting models. A total of 10 different forecasting models were compared on three performance measures, using ELECTRE III and PROMETHEE I and II with several different criteria weightings. The papers on other business management applications are listed in Table A-11 in Appendix A.

5.1.3. Energy management

Two sub-categories were defined for the energy management category. The first one is large scale energy management, which, as the name indicates, is for papers concerned with decisions related to large scale power distribution and generation. The second sub-category is for papers concerned with energy management within a building or for a small set of customers. This category also contains papers which could have been categorized differently:

water management, e.g. De and Hipel (1987), location problems, e.g. Barda, Dupuis, and Lencioni (1990), performance and benchmarking, e.g. Atici and Ulucan (2011), investment decisions, e.g. Capros, Papathanassiou, and Samouilidis (1988), mechanical engineering, e.g. Avgelis and Papadopoulos (2009) and Rutman, Inard, Bailly, and Allard (2005).

5.1.3.1. Large scale energy management. All papers related to different decision problems for large scale energy supply and power generation fall into this category. Most papers are concerned with project assessment, plant location, and technology selection.

Roy and Bouyssou (1986) compared ELECTRE III and MAUT through a case study, where nine potential nuclear power plant sites were evaluated on six criteria. Barda et al. (1990) used ELECTRE III for finding suitable sites for installing thermal power plants in three coastal regions of Algeria. The case study involved 23 alternative sites evaluated on 14 criteria. An extension of ELECTRE III, named ELECTRE GD, was proposed by Leyva-Lopez and Fernandez-Gonzalez (2003) for group decisions in MCDA, where the exploitation phase was handled by a genetic algorithm. The method was applied to an example problem of identifying the best possible location for an electricity power plant in the European Union.

A two-stage procedure to assist in decision-aiding related to electric energy planning was proposed by Clímaco, Martins, and De Almeida (1990). In the second stage of the method, ELECTRE IV was used to rank a selected set of solutions. The method was applied in a case study concerned with the planning of electricity generation. Georgopoulou, Lalas, and Papagiannakis (1997) utilized ELECTRE III to compare eight energy supply strategies for the island of Crete in Greece, based on 15 economic, technical, political and environmental criteria.

Karakosta, Doukas, and Psarras (2008, 2009) used ELECTRE TRI to assess sustainable energy technologies for electricity generation in accordance with the Clean Development Mechanism (CDM) under the Kyoto Protocol. A total of 16 alternative technologies were sorted into three priority categories, based on six environmental, social and economic criteria. Stakeholders from five countries were involved in the process.

Madlener, Antunes, and Dias (2009) compared the results obtained from applications of data envelopment analysis (DEA) and ELECTRE TRI in a study aimed at assessing the performances of 41 biogas plants located in Austria. For the ELECTRE TRI analysis, four efficiency categories and five economic, environmental, and social criteria were defined. The IRIS software (see Dias and Mousseau, 2003), which does not require precise values for the criteria weights and the cutting level, was used in the analysis.

Oliveira, Antunes, and Gomes (2011, 2013) incorporated ELECTRE TRI into evolutionary algorithms, in order to focus the search according to a DM's preferences and reduce the computational effort. The algorithms presented in the papers are called EvABOR (Evolutionary Algorithm Based on an Outranking Relation) I, II and III. The algorithms were tested on a combinatorial problem in electrical networks.

ELECTRE IS was used by Haurant, Oberti, and Muselli (2011) for a selection problem, concerning a number of proposed photovoltaic plant projects on farming fields. The case study involved four regions, and ELECTRE IS was applied several times for each region, using different criteria weightings and thresholds. Eight criteria related were used in the study and weightings were determined through application of the revised Simos' procedure. Table A-12 in Appendix A lists papers assigned to the large scale energy management category.

5.1.3.2. HVAC systems and small scale energy management. Some of the problems considered by papers in this category are: selecting an HVAC (heat, ventilation and air conditioning) system, determining working conditions of an HVAC, determining retrofitting strategies for buildings, and identifying energy sources for residential houses.

Most papers related to HVAC systems could just as well have been assigned to a sub-category under mechanical engineering. Indoor environment could also have been a fitting name for papers on HVAC, but that label would raise the question of whether it should have its own main category, and if not, where would it be best subcategorized? In general, however, energy consumption tends to be a large issue for these papers and therefore we decided to put them here.

Roulet et al. (2002) presented a methodology for rating or ranking office buildings or retrofit scenarios. The methodology suggests principle components analysis (PCA) to be used for rating the alternatives according to different energy consumption and comfort criteria. ELECTRE III or IV is suggested when additional considerations, such as environmental impacts and costs should be included. ELECTRE III was used to rank six office buildings according to eight criteria.

In order to compare four integrated cooling–heating systems for use in an office building, Mröz and Thiel (2005) used ELECTRE III in an analysis, where four systems were evaluated on their energy consumption, CO_2 emissions, investment costs and exploitation costs. Simulation tools were used by Avgelis and Papadopoulos (2009) to model the operation of six different HVAC systems in a university building, in order to measure the effects on energy consumption, thermal comfort, indoor air quality, and economic and environmental costs. ELECTRE III was then used to rank the systems for three different scenarios regarding energy costs and inflation, based on the simulation results as well as the economic and life cycle costs of acquiring a system.

Catalina, Virgone, and Blanco (2010, 2011) applied ELECTRE III in order to select an appropriate multi-source energy system for residential houses. They considered three criteria: energy reduction, payback time, and CO_2 reduction for ranking the 144 alternatives in the study. A summary of papers on HVAC systems and small scale energy management is given in Table A-13 in Appendix A.

5.1.4. Design, mechanical engineering and manufacturing systems

Material and equipment selection and classification as well as product design are some of the most prevalent issues handled by papers in this category. Other papers consider various problems related to the setup and maintenance of manufacturing systems and production lines. With only six out of 47 papers dated before 2006, this category must be said to be a fairly new topic for ELECTRE applications. A few other categories that could have been used for some papers are: safety management, e.g. Tervonen et al. (2009b), construction engineering, e.g. Thiel (2000), investment decisions, e.g. Chin, Duckstein, and Wymore (1991), information technology, e.g. Wäscher and Müller (1986).

Shanian and Savadogo (2006a,b,c) considered a problem of selecting between candidate materials for use in the production of bipolar plates for polymer electrolyte fuel cells. They used ELECTRE IV, ELECTRE I and net concordance/discordance, ELECTRE III, respectively. The entropy method was used to determine criteria weightings in the second of these papers, while the revised Simos' method was used in the last.

A problem in textile production for selecting a certain machine part for a rotor yarn spun was considered by Kaplan, Araz, and Goktepe (2006). This machine part was considered to have a large effect on the quality of the final product, so each of 10 alternative parts was used to create a yarn sample, using the same machine settings. These yarn samples were then compared on multiple criteria in a combined AHP/ELECTRE III analysis.

A part similarity measuring method, based on ELECTRE IS and OWL (Web Ontology Language) for use when searching in a parts database was used by Mun and Ramani (2011) for a case study concerning mold parts. ELECTRE I and II were utilized by Armaghan and Renaud (2012), within a case based reasoning (CBR) framework, where five machines for producing steel parts were compared on

eight criteria. Two weighting scenarios and a number of different thresholds were used in a robustness analysis.

Frenette, Beauregard, Abi-Zeid, Derome, and Salenikovich (2010) applied ELECTRE II in order to select a design for light-frame wood wall assemblies for use in a two-story residential building in Canada. Five alternative assemblies were evaluated on six criteria. Three of the criteria were cost-related; one was related to environmental impacts and two to the material characteristics of which one was based on computer simulation.

The SMAA-TRI procedure for parameter stability analysis of ELECTRE TRI was used by Tervonen et al. (2009b) for classifying nanomaterials into risk classes, taking into account ecotoxicity and environmental risk criteria based on material properties.

An extension of ELECTRE I for aiding in group decisions, using linguistic assessments represented as intuitionistic fuzzy numbers was proposed by Vahdani, Mousavi, Moghaddam, and Hashemi (2013). They presented an illustrative example, where a company producing tractor components desires to renew the manufacturing system. Three DMs had to consider five systems on five criteria. A methodology based on the ε-constraint method and ELECTRE III for dynamically supporting decisions related to the maintenance of a multi-component system was presented by Certa, Enea, and Lupo (2013). The method proceeds by using the ε-constraint method to create a set of Pareto solutions, which are then ranked using ELECTRE III.

Chatterjee, Athawale, and Chakraborty (2010) applied VIKOR as well as ELECTRE I together with the net concordance/discordance (the latter was called ELECTRE II) method to two illustrative examples for the selection of industrial robots. One of the examples involved the selection of a robot for pick-n-place operations. Ramos, Garcia, Gómez-Bravo, and Morón (2010) combined maneuver planning techniques for non-holonomic robots with MCDA techniques in order to automatically select the best alternative from a set of solutions generated by probabilistic methods. ELECTRE I and II and PROMETHEE I and II were tested on a problem involving a robot, which was given specific supply tasks in a kitchen. All four methods provided good results similar to the choices a human operator would make. Table A-14 in Appendix A summarizes the papers related to design, mechanical engineering and manufacturing systems.

5.1.5. Structural, construction and transportation engineering

An alternative common theme for many of the papers in this category is infrastructure and housing. Some of the issues considered include: development, construction, maintenance and management of transportation networks and large infrastructures, public transportation management, housing assessments and construction project management. Other categories, which could have been used for some papers are: design, mechanical engineering and manufacturing systems, e.g. Ulubeyli and Kazaz (2009), logistics and supply chain, e.g. Bojkovic, Anic, and Tarle (2010), business management, e.g. Zielina (2010), investment decisions, e.g. Giuliano (1985), location problems, e.g. Ka (2011), and safety management, e.g. Brito, de Almeida, and Mota (2010).

Roy, Present, and Silhol (1986) reported on an ELECTRE III based selection procedure adopted by a large public transportation operator (PTO) in Paris to determine which metro stations should be chosen for renovation. The procedure was designed to be carried out once every year and took into account seven criteria representing views of passengers as well as goals and constraints in relation to the operator. Earlier, Roy and Hugonnard (1982) presented a first application of ELECTRE IV for a decision problem for the same PTO concerning the ranking of 12 suburban line extension projects on the Paris metro system. Six criteria were used to evaluate the projects and the results corresponded well to the actual decisions made.

Route options for a section of a proposed motorway through Dublin City Port were evaluated by Rogers and Bruen (2000), using ELECTRE III on the basis of one cost criterion and seven environmental criteria. The procedures developed by Rogers and Bruen (1998a,b) were used to determine the thresholds and the criteria weights in the model. The same case study had been considered earlier by Rogers and Bruen (1996), who used ELECTRE IV with slightly different data. They also presented an application of ELECTRE II in another case study for choosing a road by-pass alignment for a rural village.

Tsamboulas, Yiotis, and Panou (1999) performed a comparative analysis of ELECTRE (I, II, III, and IV) and four other MCDA methods in terms of transparency, simplicity, robustness, and accountability in relation to the assessment of transport projects. For this purpose, the methods were applied to a small example involving three transport infrastructure investment projects. In order to evaluate national transport systems, Bojkovic et al. (2010) developed a methodology, taking into account the economic, environmental and social impacts. The method is based on a modified ELECTRE I, in which a modification of the concordance index and the introduction of an additional threshold, ensures a cycle-free relational graph. Both the original ELECTRE I as well as the proposed method was applied in a case study involving 10 European countries.

An approach integrating ELECTRE TRI and Utility Theory was presented by Brito et al. (2010), in order to perform a risk assessment and categorization analysis of natural gas pipelines. They applied the model to a pipeline grid, which was segmented into 12 different sections. A total of 10 accidental scenarios were considered and the segments were sorted into three risk categories. The method takes into account uncertainties of the scenarios, as well as the DM's risk attitude. Parameters were defined, using several procedures from the literature and a sensitivity analysis was also performed.

In the context of project management, de Miranda Mota and de Almeida (2012) proposed an ELECTRE TRI-C model, in order to assign priorities to activities within a project. The case study presented in the paper involved a project on the construction of an electricity substation, for which 25 activities were considered according to three categories and five criteria.

A hybrid decision aiding method, based on ELECTRE III and PROMETHEE II, using interval values for all parameters and scores was presented by Balali, Zahraie, and Roozbahani (2014). A possible extension for group decision was also proposed, based on a comparison of two approaches previously developed for PROMETHEE. The case study, in which the method and the extension were tested on, involved eight possible structural systems for use in multi-housing construction projects, three groups of DMs, and 16 criteria. A list of papers in the structural, construction and transportation engineering category is given in Table A-15 in Appendix A.

5.1.6. Logistics and supply chain management

Three sub-categories have been defined for logistics and supply chain management (LSCM), two of which represent some of the traditional problems in the area, facility layout, location, and supplier selection. Other papers on LSCM, which do not fit into one of these, are assigned to the last sub-category: other logistics and supply chain management applications. Papers assigned to the LSCM category are a natural fit, so we will not attempt to give examples of other categories to which to assign them. In fact, several of the other categories hold papers which could have been put here, especially papers dealing with location problems. We have, however, chosen to put more weight into the overall application areas (i.e. main categories). In our opinion, this approach gives a more homogenous categorization.

5.1.6.1. Facility layout and location. Plant, factory, warehouse and distribution center location, as well as general facility layout, are some of the problems handled by papers in this sub-category.

Ashayeri and Rongen (1997) considered a problem concerning the location of a European distribution center for a major telecom company, by applying a proposed framework based on a grid model to

obtain a center of gravity followed by an application of ELECTRE I to select a location. In order to point out some similarities between MAVT and outranking approaches, Stewart and Losa (2003) used an illustrative example, where first ELECTRE IS and then MAVT was applied to a problem of locating a new branch office for a small service company. An extension of ELECTRE I, based on the use of intuitionistic fuzzy sets represented as triangular intuitionistic fuzzy numbers was presented by Devi and Yadav (2013). The method was applied to an example where four DMs had to select a suitable location for a plant, based on six criteria such as skill level of workers, expansion possibilities, cost, etc. Covas, Silva, and Dias (2013) proposed a methodology for identifying appropriate regions for the location of a sustainable data center. ELECTRE TRI was incorporated through the IRIS software, which allows uncertainty in the criteria weights. The case study used to illustrate the method involved 62 Portuguese parishes as possible locations, for which four groups of criteria (social, economic, environmental, and risk related) were considered separately, in order to sort the locations into four categories.

An example problem concerning the layout of 20 departments to be placed within a square area, based on four criteria, was used by Aiello, Enea, and Galante (2006) to illustrate a proposed two-step procedure using a genetic search algorithm and ELECTRE III. Facility layout and location papers are listed in Table A-16 in Appendix A.

5.1.6.2. Supplier selection. Most problems studied by papers in this section concern the selection of suppliers of physical goods, but also supplier selection problems related to project management and strategic partnerships are considered.

A supplier selection problem in project management was studied by Alencar, de Almeida, and Morais (2010) using a numerical illustration on the selection of sub-contractors for a given project. They used a group decision model aggregating individual preferences of the DMs. Initially, each DM performed an ELECTRE II analysis, using his/her own preferences. Then a new decision matrix was formed, where DMs were used as criteria and the rankings as scores. Finally an overall ranking was obtained through an ELECTRE IV analysis. The numerical example was derived from data used by Alencar and de Almeida (2008), who presented a group decision model based on ELECTRE IV and VIP analysis and applied it for a contractor selection problem.

Montazer, Saremi, and Ramezani (2009) considered a problem where a company acting as a master contractor must choose from a number of sub-contractors. They used a modified ELECTRE III where the credibility index is modified to produce fuzzy triangular numbers and the exploitation phase is based on the use of the Yager index. A fuzzy group decision model based on ELECTRE I was proposed by Marbini and Tavana (2011). The method was applied to data from a supplier selection problem for a high-tech manufacturing company, where three DMs evaluated three suppliers on five criteria. The last step of the model uses a fuzzy ELECTRE I approach, where Hamming distances are used for comparing the alternatives on the criteria. A summary of supplier selection papers is given in Table A-17 in Appendix A.

5.1.6.3. Other logistics and supply chain management applications. Issues related to inventory decisions, vehicle fleet planning, transportation modes, e-supply chains and supply chain design are some problems studied in papers in this sub-category.

Sawicka, Weglinski, and Witort (2010) applied ELECTRE III in an assessment of four alternative redesign scenarios of a part of the logistic system in an electronics company in Poland. Seven criteria were used in the analysis, such as costs, delivery time, flexibility etc.

A case study concerning the selection of an electronic supply chain management framework for a manufacturer of quality wind turbines was studied by Zandi, Tavana, and Martin (2011), who presented a fuzzy group decision method, which proceeds in several steps and is based on a combination of fuzzy AHP, fuzzy ELECTRE I, and Real Options Analysis.

Borade and Bansod (2011) compared the results from applications of ELECTRE I, TOPSIS, and MAPPAC in an assessment of five neural network based forecasting methods for use in inventory related decisions in a supply chain. All three analyses were based on five criteria: supplier and retailer costs and profits and total supply chain costs. Papers in the other logistics and supply chain applications category are listed in Table A-18 in Appendix A.

5.1.7. Information technology

Even though the information technology category is relatively small, it has been divided into four sub-categories, because these divisions appeared naturally from the identified specific application areas. The sub-categories are: software evaluation, network selection, e-commerce and m-commerce, and other information technology applications. Other possible categories for some of the papers are: investment decisions, e.g. Paschetta and Tsoukias (2000) and health management, e.g. Gomez and Carnero (2011).

5.1.7.1. Software evaluation. Software evaluations are used in software investment and development decisions.

Vlahavas et al. (1999) used a small example on the evaluation of three commercial expert system shells, in order to illustrate the use of an implementation of a system for software evaluation. Three MCDA tools were incorporated in the system, two of which are of the ELECTRE type. ELECTRE II was used in the example. The system was later utilized by Stamelos, Vlahavas, Refanidis, and Tsoukiás (2000), who evaluated a number of proposals for the evolution of an information system in a large transport organization. ELECTRE II was also used in this problem. A decision process where a large Italian company in the late 1990s decided to acquire a GIS was presented by Paschetta and Tsoukias (2000). Six tenders had to be evaluated on a hierarchy of attributes, consisting of seven main attributes, each having one or two sub-levels, with 184 attributes at the bottom. A modified ELECTRE TRI procedure consisting of a number of consecutive steps was used to aggregate the levels. Software evaluation papers are summarized in Table A-19 in Appendix A.

5.1.7.2. Network selection. Papers in this sub-category consider vertical handover (VHO) decisions in wireless networks or comparisons of wired and wireless technologies.

Alkhawlani (2011) used simulation to illustrate an operator algorithm based on ELECTRE I and fuzzy logic for handling VHO between wireless networks. The algorithm proceeds in two steps: in the first step fuzzy logic is applied in parallel in order to compare the alternatives on each single criterion. Then, the output of the first step is used as input in an ELECTRE I analysis. Charilas, Panagopoulos, and Markaki (2014) developed a heuristic algorithm based on fuzzy AHP, ELECTRE III and TOPSIS, to assess alternative wired and wireless technologies for use in digital broadcasting. Table A-20 in Appendix A shows a list of the papers on network selection.

5.1.7.3. E-commerce and m-commerce. Various assessments of e-commerce and m-commerce systems and technologies are performed by papers in this category.

Guo (2010) used a combined AHP/ELECTRE I approach in an illustrated example for mobile-commerce partner selection, where four hypothetical partners were compared on 13 criteria. The possible use of near field communication (NFC) in the payment market in Switzerland was studied by Ondrus and Pigneur (2009). The study included two analyses: one containing only classical payment alternatives and one, where also the future use of NFC was considered. Five groups of stakeholders were involved in the analyses, in which a group extension of ELECTRE I, together with a weighted sum method, was used for the assessment of the alternatives. E-commerce and m-commerce papers are listed in Table A-21 in Appendix A.

5.1.7.4. Other information technology applications. Some examples of applications in this sub-category include the use of MCDA in data mining, intrusion detection, software release planning, image retrieval, assessment of websites, and evaluation of software development projects.

An example of the assessment of 10 computer development projects was used by Nowak (2004) to illustrate a procedure based on ELECTRE III, where concordance, discordance, and credibility indices are defined using expected utilities and evaluations as probability distributions.

Ngo-The and Ruhe (2008) considered a case study for the development planning of a web-based decision support system. An evolutionary approach was used to create a set of qualified and diversified solutions, which were then subjected to an ELECTRE IS analysis.

Elements of ELECTRE I were incorporated into a method proposed by Mastrogiannis, Boutsinas, and Giannikos (2009), with the aim of improving the performance of existing data mining classification algorithms. The method selects the best decision rule extracted from an algorithm and classifies accordingly the object under consideration. The method was tested on three such algorithms, using five databases containing only categorical data. A content-based image retrieval problem was used by Rotter (2014) in an application of a proposed algorithm based on ELECTRE III. The algorithm can assist in information retrieval, when the user cannot define precise search criteria. It was referred to as backward ELECTRE, and attempts to define criteria on the basis of a user-provided ranking of a number of samples. Then when the criteria have been defined, the ordinary ELECTRE III is applied to obtain a full ranking. The papers in the other information technology applications category are summarized in Table A-22 in Appendix A.

5.1.8. Financial management

Since almost half of the papers on financial management (FM) are related to portfolio and investment management, a sub-category was defined for these. Remaining papers on FM are assigned to a second sub-category: other financial management applications. The financial management papers would not fit well in other categories, so we will not provide any examples of this.

5.1.8.1. Portfolio and investment management. Problems considered in this sub-category are the assessment of stock performance and the selection of stocks for portfolios.

Martel, Khoury, and Bergeron (1988) used ELECTRE I and II for portfolio selection problems. Both methods were applied in an analysis of two previous decision problems, where portfolios were selected by an institutional portfolio manager. In each of the two problems, 51 portfolios were compared on four criteria. Also Hurson and Zopounidis (1995) considered a problem of portfolio selection. The specific task, for which ELECTRE TRI was applied, was to sort a sample of stocks from the Athens Stock Exchange into three categories: attractive, to be studied further, and non-attractive. Seven performance criteria were considered in the assessments.

In order to select stocks for pairs trading, Huck (2009) used an integrated approach combining forecasting and MCDA methods to identify potentially under- and overvalued stocks for a selection of 90 stocks from the S&P 100 index. Artificial neural networks were used to forecast the performance of the stocks, and ELECTRE III was applied, in order to obtain a ranking of the stocks, such that pairs could be made of the first and the last assets of the ranking. Huck (2010) extended the approach to use multi-step forecasts.

Xidonas, Askounis, and Psarras (2009) developed an integrated multiple-criteria methodology for the selection of common stock portfolios and applied it to a set of stocks within the Athens Stock Exchange. The method proceeds in four phases, where the first two relate to the selection of securities. For this purpose, ELECTRE TRI and ELECTRE III were used to classify and rank the stocks. The third phase involves an optimization procedure, from which a set of efficient portfolios was obtained. Finally in the last phase, the portfolios were ranked through an ELECTRE III analysis. Table A-23 in Appendix A shows a summary of papers on portfolio and investment management.

5.1.8.2. Other financial management applications. Some issues considered in papers in this category are: bankruptcy and financial distress predictions, credit rating, risk classification of loan applications, credit card assessments and prediction of share repurchase announcements.

Bergeron, Martel, and Twarabimenye (1996) proposed a procedure based on ELECTRE TRI to classify corporate loan applications in appropriate risk categories. To test the method, a set of bound profiles for the categories were initially inferred from 150 loan applications previously categorized by a loan officer. Then the method was applied to another sample of 100 applications. Results indicated that ELECTRE TRI can outperform the loan officer.

Credit card evaluation was considered by Matsatsinis (2002), who applied ELECTRE TRI as well as a proposed DSS for credit card evaluation to a case study involving 60 credit card applications, which should be accepted or rejected. The results were compared to decisions made by a loan officer.

Two applications of a proposed sorting algorithm, based on ELECTRE were presented by Rocha and Dias (2008). One relates to the sorting of stocks listed in the Athens Stock Exchange and the other to business risk classification. Similarities and differences between the proposed method and ELECTRE TRI are discussed throughout the paper. A financial distress prediction problem was studied by Li and Sun (2009), who applied two hybrid data mining models, named ELECTRE-CBR-I and II, based on principles of ELECTRE III and case based reasoning to data from 81 healthy companies and 81 companies in distress from the Shenzhen and Shanghai Stock Exchanges. Doumpos and Zopounidis (2011b) performed credit rating of a large sample of Greek firms, using a proposed methodology, combining the approach from Doumpos, Marinakis, Marinaki, and Zopounidis (2009) for eliciting the parameters of an ELECTRE TRI model with an application of ELECTRE TRI. Three models were created: two based on the optimistic respectively the pessimistic assignment procedure and one based on a minimization of the distance between the procedures. Papers assigned to the other financial management applications category are listed in Table A-24 in Appendix A.

5.1.9. Policy, social and education

Public planning and policy decision papers that do not fit some of the other categories were assigned to this category. We decided to also include the 'education' papers, because education does at least conceptually share some similarities with concepts such as quality of life that are studied in some of the 'social' papers. Because the category mainly was created for papers that do not fit other categories, it would not make sense to attempt to find examples of alternative categorizations for them.

ELECTRE II was used by Bona, Merighi, and Ostanello (1979) within a larger framework for public resources allocation in an Italian metropolitan area. The specific task for ELECTRE II was to compare a number of regional zones on a set of indicators of social demand. Can (1992) combined a GIS with ELECTRE I based net concordance/discordance analysis for the assessment of residential quality in relation to neighborhood planning in the city of Syracuse in USA. An MCDA software package, DEFINITE, which includes ELECTRE II and three other methods, was presented by Massam and Wang (2002) through an application aimed at ranking four Chinese districts in Toronto, according to a set of quality of life indicators.

Floc'hlay and Plottu (1998) proposed the use of ELECTRE I to help rural communities decide if they have anything to gain by cooperation. In a numerical example, three strategies were considered:

cooperate and stay independent, merge, keep status quo. The alternatives were evaluated on three criteria and three stakeholder groups were assumed to be involved in the weighting of the criteria.

A decision support model to assist in formulating a strategy for a city wishing to be developed to, or enhance their status as, a knowledge city was presented by Ergazakis, Metaxiotis, Psarras, and Askounis (2007). ELECTRE III was incorporated in the last step of the model, which involves the prioritization of a number of actions defined earlier in the process. In a presented case study, the results of an application to the Greek municipality of Maroussi was compared to results based on the experience of the working group Petrovic, Bojkovic, Anic, and Petrovic (2012) proposed an iterative procedure based on consecutive applications of ELECTRE I, where the core subset of alternatives selected in any iteration were assigned to a corresponding level and then removed from the set of alternatives. The method was named ELECTRE MLO (Multi Level Outranking) and applied to a case study, where 29 countries were compared on 11 indicators representing measures of digital divide within a country.

A student selection problem for a postgraduate program in a Mexican university was considered by Leyva-Lopez (2005). For this purpose a methodology implemented in a DSS named SADAGE was used. Initially, an outranking relation was created using the first phase of ELECTRE III, by comparing the applicants on five criteria. Then a ranking of the students was obtained by exploiting the relation, using a genetic algorithm proposed in Leyva-Lopez and Fernandez-Gonzales (1999). A similar study was presented in Leyva-Lopez and Sanchez (2005). A summary of papers in the policy, social and education category is given in Table A-25 in Appendix A.

5.1.10. Chemical and biochemical engineering

In chemical and biochemical engineering, ELECTRE methods have been used for various problems related to the assessment and design of chemical processes and substances as well as identification of bacteria. Other categories, which could have been considered for some papers are: product design, e.g. Keller, Massart, and Brans (1991) and safety management, e.g. Opperhuizen and Hutzinger (1982).

Fichefet, Leclercq, Beyne, and Piette (1984) tested ELECTRE II and a maximum likelihood (ML) model for identifying bacteria from a specific family. Based on the test results, they suggested to obtain results from both the ML model and ELECTRE II and if they coincide, then accept the result.

Hazard evaluation and risk assessment of chemical substances was performed by Opperhuizen and Hutzinger (1982), using an ELECTRE I based concordance analysis similar to the 'satisfying norm' approach from Nijkamp and Vos (1977).

Kiss, Zaras, Fonteix, and Dominique (2002) proposed an ELECTRE III based method, where the outranking relation is exploited using net flows as in PROMETHEE II. An example application was provided to a set of Pareto solutions for a chemical manufacturing process. The method was later referred to as the Net Flow Method (NFM), by Renaud et al. (2007) and Fettaka, Gupta, and Thibault (2012). Also, Fonteix, Massebeuf, Pla, and Kiss (2004), Halsall-Whitney, Taylor, and Thibault (2003), Massebeuf, Fonteix, Hoppe, and Pla (2003), Thibault, Lanouette, Fonteix, and Kiss (2002) and Vandervoort, Thibault, and Gupta (2011) used NFM for various problems related to chemical processes. Massebeuf et al. (2003) and Fonteix et al. (2004), for example, used a methodology based on a genetic algorithm and the NFM to assist in the optimization of styrene emulsion polymerization processes. The method was illustrated using a combination of experimental and simulation data.

ELECTRE IS was employed by Galzim et al. (2011) for the assessment of 14 processes for use in hydrogen production, based on eight criteria related to economic, technological and environmental aspects. Gurmeric, Dogan, Toker, Senyigit, and Ersoz (2012) applied ELECTRE I and three other MCDA methods, in order to determine the optimum flavor of prebiotic pudding, based on sensory analyses. Three flavors, strawberry, vanilla and cacao were compared on six sensory scores. Chemical and biochemical engineering papers are listed in Table A-26 in Appendix A.

5.1.11. Agriculture and horticulture

Applications in agriculture include assessment of agricultural land-use types, crops, cropping systems, management practices, investments and animal production. A few papers study problems related to sustainable practices in horticulture. Examples of other categories that could have been considered are: investment decisions, e.g. Van Huylenbroeck (1995), land management, e.g. Ahrens and Kantelhardt (2009) and environmental management, e.g. Arondel and
Girardin (2000) and Blanquart (2006).

The conflict analysis method (CAM), which is a combination of ELECTRE, PROMETHEE and ORESTE, was developed by Van Huylenbroeck (1995), who illustrated the method using an investment decision example in farm management, related to the purchase of a tractor. Later, Van Huylenbroeck and Tagarino (1998) used CAM in an attempt to reconstruct a real crop choice process previously made by a large group of farmers in the Philippines.

Arondel and Girardin (2000) described an MCDA analysis of a problem in agriculture on how to differentiate cropping systems according to their environmental impact. ELECTRE TRI was selected as an appropriate tool for the problem, and applied to the case study, where 33 cropping systems were sorted into four impact categories, using three groups of criteria.

ELECTRE III was used by Diaby, Ferrer, Valognes, and Demange (2011) for the selection of rubber tree clones to be planted in Africa. They considered 11 criteria related to growth, production, tolerance and quality as well as a number of different weights and thresholds scenarios based on ecological constraints and opinions of DMs, in order to rank the 30 clones considered in the study. In order to assist in land suitability assessment for agriculture, Mendas et al. (2014) combined each of the two methods, ELECTRE TRI and Simple Additive Weighting, with a GIS. Both methods were applied in a case study for the area of Mleta in Algeria concerning land suitability for durum wheat cultivation.

Blanquart (2009) applied ELECTRE TRI, in order to check the opportunity of implementing an IPM (integrated pest management) system for sustainable practice (SP) in horticultural farms in France. Two analyses were carried out. In the first analysis, the farms were sorted into three categories according to the feasibility of adopting an SP, whereas in the second analysis, the categories represented how favorable the horticulturists' behavior was with regard to the implementation of an SP. A similar analysis was performed in Blanquart (2006). A list of papers on agriculture and horticulture can be found in Table A-27 in Appendix A.

5.1.12. Health, safety and medicine

Various problems related to the health sector as well as safety management in other areas are considered by papers in this category. One alternative categorization can be mentioned, namely Marbini, Tavana, Moradi, and Kangi (2013), which could have been assigned to waste management.

Martel and D'Avignon (1982) developed an MCDA method using probabilistic evaluations to create an outranking relation, which was subsequently exploited using the second phase of ELECTRE III. The method was used to rank a number of development projects within the hospital sector. The same case study was used in Martel, D'Avignon, and Couillard (1986), who extended the method to include fuzziness in the data.

ELECTRE TRI-C was presented in Almeida-Dias et al. (2010), who used two example applications, one of which included real data from a private infertility center in Lisbon, where 25 couples had to be sorted according to the number of embryos to transfer to the uterus

of the women. ELECTRE TRI-C was later used by Figueira et al. (2011), who considered a similar, yet more elaborate case study, where 51 couples were assigned to one of four categories, based on evaluations on seven criteria. The revised Simos' procedure was used to determine the criteria weights.

Chen, Chang, and Lu (2013) developed extensions of QUALIFLEX and ELECTRE I methods using interval type-2 trapezoidal fuzzy numbers. The two methods were compared through applications to a case study, where three possible treatments for a disease were evaluated on seven criteria. The authors concluded that the computation in the ELECTRE I based method were more complex and in contrast to the other method, some alternatives were incomparable.

ELECTRE I was applied by Pires, de Almeida, and Duarte (2005) in a fire risk analysis for the first floor of a university building in Brazil. The problem was to carry out a room of origin selection, using six rooms and four criteria. Health, safety and medicine papers are summarized in Table A-28 in Appendix A.

5.1.13. Other areas and non-specific applications

Applications that do not fit any of the other 12 categories are assigned to this last category. Some examples other than the non-specific applications include architectural design, military operations planning, tourism destination assessments, movie evaluation, car selection, aquaculture development, referee assignment and problems related to fishing.

Despontin, Lehert, and Roubens (1986) used ELECTRE I and II to compare consumer products, using data sets from previously published tests of consumer products performed with the Fishbein–Rosenberg's model (FRM). They concluded that both ELECTRE methods provided results similar to FRM.

Two MCDA methods, SMAA and SMAA-3 were compared on randomly generated test problems by Lahdelma and Salminen (2002). SMAA is based on the use of utility functions, whereas SMAA-3 uses pseudo-criteria and concordance indices as in ELECTRE III.

ELECTRE III was used by Quéméner, Suquet, Mero, and Gaignon (2002) to rank 27 finfish species in order to select candidates for aquaculture development on the French Atlantic. The evaluation was carried out using four sets of weights, which represented the involved parties within the production, transformation, distribution and consumption areas. The 22 criteria involved biological, fishery and economic considerations.

Scarelli and Narula (2002) used an example for the assignment of a best referee for the matches in an Italian football championship, in order to illustrate an assignment procedure based on ELECTRE III. The method uses concordance and discordance to indicate compatibility and incompatibility between a referee and a match. To account for priorities of a match to be covered, and a referee to be assigned, partial priorities were used to strengthen or weaken the credibility indices. A specialized distillation procedure was used to obtain the final assignments.

A numerical example on project selection was used by Almeida-Dias et al. (2012) to illustrate an extension of ELECTRE TRI-C, called ELECTRE TRI-nC, where the categories can be defined using more than one reference profile per category. The method was compared to a number of other sorting methods.

Bélanger and Martel (2006) proposed an MCDA approach for decision-aiding in military planning operations. The suggested method was called PAMSSEM and is largely based on ELECTRE III and PROMETHEE II, but with support for distributional evaluations. A DSS based on PAMSSEM to support the military operations planning process for counter-drug events and related courses of action (COAs) was presented in Guitouni, Martel, Bélanger, and Hunter (2008). The methodology was illustrated in an example, considering three COAs on 14 criteria related to flexibility, complexity, sustainability, cost and risk.

As a part of a study aimed at analyzing the destination image perceived by visitors of Andalusia and its provinces, Andrades-Caldito, Sanchez-Rivero, and Pulido-Fernandez (2013) applied ELECTRE II to obtain a ranking of the provinces according to their level of attractiveness, measured through four criteria, which were the results of an aggregation procedure of a larger set of indicators. Paper assigned to the other areas and non-specific applications category are listed in Table A-29 in Appendix A.

5.2. Group b: Survey, review and overview (SRO) papers

For this group, 57 relevant papers were identified. In this group, we define a review as a paper, in which a larger literature review is conducted for a specific application area or for a specific methodology. A survey is defined as a paper investigating or discussing the possible use or behavior of one or more methods within an application area. Some of the overview papers are specifically dedicated to concepts from ELECTRE or outranking methods in general, and some also include other methods such as MAUT-based methods. Except for the SMAA methods and preference disaggregation approaches, review papers focusing on MCDA methods other than ELECTRE are not included in this study.

In general we will let Table 1 speak for itself and only comment briefly on a few of the papers.

Lootsma (1990) elaborated on some of the differences and similarities between the French and the American school (represented by ELECTRE and AHP) in MCDA. Roy and Vanderpooten (1996b) used the term 'The European School of MCDA' for a range of methodologies, to which the outranking approaches belong, and discussed the developments within the school. This grouping includes, in particular, the history and the advances of the outranking approach and the birth of the ELECTRE methods.

One of the main concerns with respect to ELECTRE methods is how the parameters should be determined in order to define a model. Jacquet-Lagreze and Siskos (2001) as well as Doumpos and Zopounidis (2011a) provided a review of preference disaggregation approaches (PDAs) to elicit the parameters of MCDA models. Some of these PDAs were specifically designed for ELECTRE (see Section 5.4).

In a recent paper, Figueira et al. (2013) provided a comprehensive overview of ELECTRE methods and some of their latest extensions and developments. This includes works on PDA, robustness analysis and axiomatic analysis of ELECTRE.

5.3. Group c: Papers on MCDA method and model selection (MMS)

Only 20 papers have been assigned to group *c*, which contains papers considering the problem of selecting a specific MCDA method or model. This problem is in itself a multi-criteria problem, since a large number of methods are available, whether they are based on outranking, utility theory, mathematical programming or some other principle. Some papers propose a framework, based on various decision rules to assist in the selection of a method or construction of a model. Others merely discuss some of the pros and cons of different methods. They do, however, all consider ELECTRE in some way as an alternative within a range of methods.

An interactive decision support system based on an ordered series of questions was developed by Teghem, Delhaye, and Kunsch (1989) to assist a DM in the selection of an appropriate MCDA method. The included methods were considered representative for the methods available at the time of writing. It is, however, possible to include additional methods by extending the induced decision tree.

Hobbs, Chankong, Hamadeh, and Stakhiv (1992) addressed the issue of how the MCDA methods differ on several different aspects, using a water resources planning example. Some issues discussed are whether or not there is a difference in the users' perception of appropriateness or ease of use of a given method or the users' expectation

Table 1
Surveys, reviews and overview papers.

Author(s)	Focus	Area	Type
Achillas, Moussiopoulos, Karagiannidis, Banias, and Perkoulidis (2013)	MCDA in waste management problems	Waste	Review
Ananda and Herath (2009)	MCDA in forest management and planning	Forestry	Review
Andalecio (2010)	MCDA for management of tropical coastal fisheries	Fishery	Review
Bakus, Stillwell, Latter, and Wallerstein (1982)	Decision-aiding methods for use in environmental management	Environment	Survey
Balasubramaniam and Voulvoulis (2005)	The appropriateness of multi-criteria analysis in environmental decision-making problems	Environment	Survey
Benedini (1988)	The possible use of decision-aiding methods in relation to water resource systems	Water	Survey
Bezdrob, Bico-Car, and Pasic (2011)	Overview of ELECTRE methods	–	Overview
Brunner and Starkl (2004)	Decision-aiding methods in the context of sustainability evaluation	Water	Survey
Chai, Liu, and Ngai (2013)	Applications of MCDA techniques in supplier selection	Logistics and supply chain	Review
Cohon and Marks (1975)[a]	Applicability of multi-objective approaches to water resource problems	Water	Survey
Diaz-Balteiro and Romero (2008)	MCDA applications to forestry problems	Forestry	Review
Dimitras, Zanakis, and Zopounidis (1996)	Literature on the prediction of business failures	Business	Review
Doukas (2013)	MCDA applications, using linguistic variables for energy policy support	Energy	Review
Doumpos and Zopounidis (2011a)	PDA and statistical learning methods for eliciting the parameters of MCDA models	–	Review
Farahani, SteadieSeifi, and Asgari (2010)	Solution methods and applications to multi-criteria location problems	Location problems	Review
Figueira et al. (2013)	Overview of ELECTRE methods as well as works on PDA, robustness analysis and axiomatic analysis of ELECTRE	–	Overview
Ganoulis (2003)	MCDA for evaluating wastewater treatment and storage technologies	Water	Survey
Guigou (1971b)	Overview of EI (referred to as ELECTRA) and some unicriterion methods	Location problems	Overview
Guigou (1971a)	Comparing EI and some unicriterion methods	Location problems	Survey
Hajkowicz and Collins (2007)	MCDA applications in water management	Water	Review
Herva and Roca (2013)	Combined approaches and MCDA used in corporate environmental evaluation	Environment	Review
Huang, Keisler, and Linkov (2011)	Trends and applications of MCDA in environmental sciences	Environment	Review
Jacquet-Lagreze and Siskos (2001)	PDA in MCDA	–	Review
Jahan, Ismail, Sapuan, and Mustapha (2010)	MCDA applications to material selection problems	Design	Review
Kabir, Sadiq, and Tesfamariam (2013)	MCDA for infrastructure management	Structural	Review
Kiker, Bridges, Varghese, Seager, and Linkov (2005)	MCDA applications for environmental decision making	Environment	Review
Lahdelma et al. (2000)	MCDA in public environmental planning	Environment	Survey
Lai, Lundie, and Ashbolt (2008)	MCDA for sustainability assessment of urban water systems	Water	Review
Lendaris (1980)	Tools for structural modeling	–	Survey
Lootsma (1990)	The French and the American school of MCDA	–	Overview
Løken (2007)	MCDA methods for energy planning purposes	Energy	Survey
Malczewski (2006)	Integrations of GIS and MCDA	Various	Review
Mendoza and Martins (2006)	MCDA applications in natural resource management	Environment	Review
Moffett and Sarkar (2006)	MCDA for the design of conservation area networks	Environment	Review
Morrissey and Browne (2004)	Models used in the area of municipal waste management	Waste	Review
Mysiak (2006)	Consistency of results of different MCDA methods	Environment	Survey
Parsaei, Wilhelm, and Kolli (1993)	Discussion of MCDA for evaluation of CIM systems	Manufacturing	Survey
Pohekar and Ramachandran (2004)	MCDA applications for sustainable energy planning	Energy	Review
Rehman and Romero (1993)	MCDA in the analysis of agricultural systems	Agriculture	Survey
Roy (1971)	Decision making based on multiple objectives	–	Overview
Roy and Vincke (1981)	Outranking, MAUT-based and interactive MCDA methods	–	Overview
Roy (1991)	The outranking approach and ELECTRE methods	–	Overview
Roy and Vanderpooten (1996b)[b]	The European School of MCDA	–	Overview
Sadok et al. (2008)	MCDA for the assessment of sustainability of alternative cropping systems	Agriculture	Survey
Scott, Ho, and Dey (2012)	MCDA for bioenergy systems	Energy/Environment	Review
Siskos, Wäscher, and Winkels (1984)	Outranking and MAUT approaches	–	Overview
Stewart (1992)	The status of MCDA methods	–	Overview
Tervonen and Figueira (2008)	The SMAA family of stochastic MCDA methods, including those based on ELECTRE	–	Overview
Vincke (1986)	Outranking, MAUT and mathematical programming	–	Overview
Wang, Jing, Zhang, and Zhao (2009)	MCDA for sustainable energy decision-aiding	Energy	Review
Xidonas and Psarras (2009)	MCDA for portfolio management	Finance	Review
Zavadskas, Ustinovichius, and Stasiulionis (2004)	MCDA in the evaluation of the effectiveness of investments to commercial construction projects	Construction/Business	Survey
Zavadskas and Turskis (2011)[c]	MCDA methods used in economics	Various	Review
Zhou, Ang, and Poh (2006)	MCDA in energy and environmental modeling	Energy/Environment	Review
Zopounidis (1999)	MCDA for financial decision problems	Finance	Review
Zopounidis and Doumpos (2002b)	MCDA methods of the classification and sorting types, including ETRI	Various	Review
Zopounidis and Doumpos (2002a)	MCDA methodologies and applications in the field of finance	Finance	Review

[a] See also the comment paper by Krzysztofowicz, Castano, and Fike (1977), regarding the applicability of ELECTRE.
[b] The article has a comment attached by Freerk A. Lootsma. See also a response paper to this comment by Roy and Vanderpooten (1996a).
[c] See also the comment and extension paper by Liou and Tzeng (2012).

Table 2
Papers on MCDA method and model selection.

Author(s)	Focus	Area
Al-Shemmeri et al. (1997)	Model selection for water development projects	Water
Bell, Hobbs, Elliott, Ellis, and Robinson (2001)	Testing hypotheses related to the use and perception of a number of MCDA methods	Environment
Benoit and Rousseaux (2003)	Select an appropriate MCDA method for LCA	Environment
Celik and Er (2009)	Model selection, using an interface based on fuzzy axiomatic design principles	–
Cicek, Celik, and Topcu (2010)	Integrated decision aid for selecting an appropriate MCDA method for material selection problems	Design
Cicek and Celik (2010)	A fuzzy axiomatic design model for selecting an MCDA method for material selection problems	Design
Deng and Wibowo (2008)	A DSS to assist in selecting an MCDA method for solving the information systems project evaluation and selection problem	Information technology
Gershon and Duckstein (1984b)	Selecting an MCDA tool for water resources and mineral resources management problems	Environment
Guitouni and Martel (1998)	A conceptual framework to help choosing an MCDA method	–
Hajkowicz (2007)	A study of MCDA vs. unaided decisions in an environmental management context	Environment
Hobbs (1986)	Discussing questions related to the choice of an MCDA method	–
Hobbs et al. (1992)	Testing trade-off hypotheses on the use of different MCDA methods and discussing how methods differ	–
Li (1987)	A DSS to assist in building a multi-criteria model	–
Linstone, Lendaris, Rogers, Wakeland, and Williams (1979)	Developing guidelines for selecting a structural model technique	–
Poh (1998)	An intelligent system to guide a user towards the selection of an appropriate MCDA tool	–
Polatidis, Haralambopoulos, Munda, and Vreeker (2006)	A framework to assist in determining an appropriate MCDA method for renewable energy planning	Energy
Roy and Słowiński (2013)	A set of questions to guide an analyst in the selection of an appropriate MCDA method for a given problem	–
Simpson (1996)	Discussing the connection between choice of method and the view of the decision maker. Focus is on MAVT and ELECTRE II	–
Tecle (1992)	An algorithm for selecting an MCDA technique for watershed resources management	Watershed
Teghem et al. (1989)	An interactive DSS to assist in the selection of an MCDA method	–
Zavadskas et al. (2004)	MCDA in the evaluation of the effectiveness of investments to commercial construction projects	Construction

of the result. There are also some trade-off hypotheses being tested, such as whether or not the type of method matters more than user error or user type matters more than type of method. Hajkowicz (2007) conducted a study of MCDA vs. unaided decisions in an environmental management context. Four different MCDA methods, including a modified ELECTRE I (net concordance/discordance) and five different criteria weighting methods were considered. A total of 55 DMs were involved in the study and the overall conclusion was that although the MCDA methods often did not agree with the unaided decisions, they can provide useful input to the decision process.

Three selection models for choosing an appropriate MCDA method for ranking water development projects were implemented by Al-Shemmeri, Al-Kloub, and Pearman (1997). The models were tested using a number of different MCDA methods, including ELECTRE. Guitouni and Martel (1998) provided a conceptual framework to help choosing an appropriate MCDA method. They felt that the use of an MCDA tool to select an MCDA method created a vicious circle and provided instead seven tentative guidelines to help in selecting a tool. A typological tree based on these guidelines was suggested as one possible approach to solve the problem. Using the guidelines, the authors also compared 29 discrete MCDA methods including the ELECTRE methods. An integrated decision aid (IDEA) was presented by Cicek and Celik (2010) to assist in the selection of an appropriate MCDA method for material selection problems. The IDEA considers a large number of different methods from four different categories: elementary methods, value based methods, interactive methods and outranking methods, including some ELECTRE versions. Recently, Roy and Słowiński (2013) formulated a series of questions that can help an analyst in selecting an appropriate MCDA method for a given decision aiding context. This includes questions related to the type of results required, properties of the performance scales, how hard it is to get the required information, whether uncertainty is an issue, and if compensation and interaction between criteria should be considered. Table 2 summarizes papers in the MCDA method and model selection group.

5.4. Group d: Preference disaggregation and theoretical and non-application (PTN) papers

Several of the most proficient authors on outranking methods and ELECTRE have contributed to papers in this final group, which contains 65 papers. Many papers assigned here contain various preference disaggregation approaches for eliciting the parameters of an ELECTRE model. But axiomatic and robustness analysis of ELECTRE methods are also popular topics. Others consider theoretical developments or analyses of concepts used in the ELECTRE methods. Finally, non-application papers are also assigned here.

Axiomatic analyses of concepts used in ELECTRE have been considered by a number of authors. Bouyssou (1986) and Bouyssou and Vansnick (1986) investigated the non-compensation property of outranking methods and provided axiomatizations for some special as well as general cases. Pirlot (1997) presented a framework aimed at providing a foundation for axiomatizations of outranking procedures used in ELECTRE I and II. A generalization and an axiomatic framework of additive concordance rules, as used in ELECTRE methods, were presented by Dubois, Fargier, Perny, and Prade (2003). Conjoint measurement analysis of ELECTRE methods has also been considered in several articles during the last decade, e.g. Bouyssou and Marchant (2007a,b) and Bouyssou and Pirlot (2007, 2009). A thorough review of these can be found in Figueira et al. (2013).

How to determine the parameter values in an ELECTRE model has been the focus of many authors. Typically, these papers include an inference procedure based on either decision examples obtained from a DM, a parameter constraints analysis, or a combination of the

two. Some papers that focus on the second approach also include robustness concerns. For both types of approaches, ELECTRE TRI has been targeted the most among all ELECTRE methods.

With respect to the first type, Mousseau and Slowinski (1998b) developed a non-linear optimization procedure to infer all parameter values of an ELECTRE TRI model based on assignment examples provided by a DM. By considering one of the possible decompositions of this procedure into smaller linear ones, Mousseau et al. (2000) and Mousseau, Figueira, and Naux (2001) developed and tested the ELECTRE TRI Assistant (see also Section 2) used for obtaining the criteria weights and the cutting level of a particular model. Complementing the works of Mousseau and Dias (2004), who presented a small modification of the valued outranking relation in ELECTRE TRI and ELECTRE III, Dias and Mousseau (2006) developed mathematical programming models to elicit the veto thresholds in models based on these two methods. With respect to the category bounds and the discrimination thresholds in ELECTRE TRI, an inference procedure that can be used to elicit these parameters was developed by Ngo-The and Mousseau (2002). Doumpos and Zopounidis (2002) used linear programming techniques to sequentially estimate all parameters of an ELECTRE TRI model using assignment examples. Later, Doumpos et al. (2009) presented an evolutionary preference disaggregation methodology for determining ELECTRE TRI parameters. Greco, Predki, and Slowinski (2002) showed an equivalence between the decision rule model and the concordance-discordance model used in ELECTRE methods. The result was used to develop a procedure that can be used to infer weights and veto thresholds of ELECTRE methods. Procedures targeted at group decisions have also been developed, e.g. Cailloux, Meyer, and Mousseau (2012) who proposed algorithms to elicit ELECTRE TRI category bounds with and without veto thresholds based on assignment examples from a group of DMs.

The second type of approach was considered by Dias and Clímaco (1999), who studied the problem of finding the maximum and minimum credibility of an outranking, based on a set of linear constraints on the parameter values. A similar approach in a group decision framework for ELECTRE TRI was developed by Dias and Clímaco (2000). Robustness analysis is an integrated part of the approaches in these two papers. ELECTRE TRI was also targeted by Dias, Mousseau, Figueira, and Clímaco (2002), who presented an approach combining preference disaggregation and parameter robustness analysis, based on the works of Dias and Clímaco (1999), Mousseau and Slowinski (1998a) and Dias and Clímaco (2000). The software IRIS (Dias & Mousseau, 2003) (see also Section 2) is an implementation combining concepts and approaches from Dias, Mousseau, Figueira, and Clímaco (2002), Mousseau, Figueira, Dias, Gomes da Silva, and Clímaco (2003), and Mousseau and Dias (2004). Damart, Dias, and Mousseau (2007) proposed a methodology aimed at assisting a group of DMs in determining the weights and the cutting level of an ELECTRE TRI model. The approach was based on the use of IRIS.

Some authors have considered preference disaggregation in other ELECTRE or ELECTRE based methods, e.g. Fernandez, Navarro, and Mazcorro (2012) who used evolutionary multi-objective optimization for obtaining the whole set of parameters compatible with a DM's preferences in an ELECTRE III model and Kiss et al. (1994), who developed ELECCALC for determining the parameters of an ELECTRE II model. Greco, Kadzinski, Mousseau, and Slowinski (2011) developed ELECTRE^{GKMS}, a method that has an inference procedure, which takes into account all sets of parameters obtained from the elicitation procedure by using robust ordinal regression and the concepts of necessary and possible outranking relations. Finally, let us mention the method SMAA-TRI, presented by Tervonen, Figueira, Lahdelma, Almeida-Dias, and Salminen (2009a). The method is based on Monte Carlo simulation and can be used to analyze the stability of some parameters (profiles, cutting level, and weights) in an ELECTRE TRI model.

Criteria weights are sometimes considered outside of the remaining parameters. Rogers and Bruen (1998b) proposed to use a technique called the "resistance to change grid," which is based on concepts from psychology for weighting environmental criteria in an ELECTRE III analysis. Another example is the technique developed by Figueira and Roy (2002) called the "revised Simos' procedure." The method, which is sometimes referred to as the card method, does not require too much effort from the DM and is rather intuitive. The SRF software (see also Section 2) is an implementation of the procedure. Note also that some papers in Section 5.1 contain inference procedures for criteria weights, e.g. Fernandez, Navarro, and Duarte (2008) and Fernandez, Navarro, and Bernal (2009).

Before concluding this section, let us first mention the works of Roy and Slowinski (2008) and Figueira, Greco, and Roy (2009). The former introduces two new thresholds called the reinforced preference threshold and the counter-veto threshold, both related to comparisons where one alternative is very strongly preferred to another. The latter presents an extension of the comprehensive concordance index, which takes into account the interaction between criteria. Finally, we should mention the paper by Corrente, Greco, and Slowinski (2013), in which ELECTRE^{GKMS} was extended to handle a hierarchy of criteria. They also point out that their specific use of a hierarchy of criteria can be applied to any MCDA methodology.

Table 3 shows a summary of all papers assigned to group *d*. For a more detailed review of most papers in this group, please refer to Figueira et al. (2013).

6. Other classifications

Besides the main classification presented in Section 5, we have considered a number of other classifications that may be of interest in studies on ELECTRE. In Section 6.1, the distribution of frequency (DOF) of country of author affiliation is presented. First, using all papers included in the study, and then the DOFs of the top eight countries for the two largest groups of papers, group *a* and *d*, are presented. Section 6.2 contains a presentation of the DOF of all papers according to journals. Here the top five journals for group *a* papers and group *d* papers are also presented. In Section 6.3, the DOF of all papers by year of publication is shown. For applied papers, Section 6.4 shows the DOF of ELECTRE version according to application area. Finally, in Section 6.5, we show the DOF of ELECTRE version according to year of publication.

6.1. Distribution by country of author affiliation (CAA)

We have chosen to use the CAA, rather than nationality of the authors because it is more convenient to record. For the remainder of the text, when we say that an author is from a given country, we refer to the CAA. Authors from 54 countries have contributed to the 686 papers included in this study. In Table 4, we can see that most authors are from Europe and North America, but all populated continents are represented.

Table 5 shows the top eight CAA for applied papers. A few countries have changed place, compared to the top eight for all papers, but overall they are relatively similar. Of course this shift is to be expected, since the applied papers make up 79 percent of all papers included in the study. Authors from 50 countries have contributed to the applied papers.

In Table 6, however, the picture is quite different. France is still in the first place, but Portugal, Belgium and Poland have moved up several places in the list. Authors from these four countries have contributed to as many as 68 percent of the PTN papers. Apart from the eight shown in Table 6, 12 other countries have contributed to the PTN papers.

Table 3
Parameter inference and theoretical and non-application papers.

Author(s)	Focus	Example used
Bisdorff (2000)	A logical framework for handling fuzzy preferential information illustrated in relation to ELECTRE	Choose R&D projects
Bisdorff (2004)	The concept of ordinal concordance related to the problem of having to define the criteria weights as in ELECTRE	Car selection
Bisdorff, Meyer, and Roubens (2008)	A bipolar-valued outranking method called RUBIS, sharing some similarities with ELECTRE, compared to the classical ELECTRE methods	Various
Bouyssou (1986)	Definitions of compensation and non-compensation in MCDA	–
Bouyssou and Vansnick (1986)	A study of non-compensatory preference structures	–
Bouyssou (1996)	Properties of outranking relations as in ELECTRE and PRM	–
Bouyssou and Vincke (1997)	Theoretical analysis of ranking rules for exploiting crisp and valued outranking relation, including some used in ELECTRE	–
Bouyssou and Pirlot (2005)	Axiomatic analysis of concordance relations	–
Bouyssou and Marchant (2007a)	Axiomatic analysis of non-compensatory sorting models similar to ETRI without discordance effect	Various
Bouyssou and Marchant (2007b)	Extension of Bouyssou and Marchant (2007a)	Various
Bouyssou and Pirlot (2007)	Extension of Bouyssou and Pirlot (2005)	–
Bouyssou and Pirlot (2009)	Axiomatic characterizations of outranking relations as in EI & EII	–
Bregar, Gyorkos, and Juric (2008)	An interactive aggregation/disaggregation dichotomic sorting procedure based on a modified ETRI	–
Bregar, Gyorkos, and Juric (2009)	Techniques for measuring robustness and for visualizing MCDA models	Toll systems evaluation
Cailloux et al. (2012)	Procedures for eliciting category limits and possibly veto thresholds from assignment examples for a simplified ETRI model applied in a group setting	Select project to finance
Choo, Schoner, and Wedley (1999)	How criteria weights are used in different MCDA methods	Car selection
Corrente et al. (2013)	Introduce the concept of a hierarchy of criteria in different ELECTRE and PRM methods	Select student for scholarship
Damart et al. (2007)	A group decision aggregation/disaggregation approach for ETRI to assist in determining weights and cutting level	Sorting loan applications
Dias, Costa, and Clímaco (1997)	Parallel implementation of EIII on a computer	–
Dias and Clímaco (1999)	The use of optimization in robustness analysis for ELECTRE methods with fuzzy outranking relations	Stock evaluation
Dias and Clímaco (2000)	Procedure to assist in group decisions, allowing bounds instead of exact values in order to obtain robust conclusions about the values of the parameters in ETRI	Risk classify companies
Dias et al. (2002)	Using assignment examples in ETRI to obtain robust conclusions through a preference aggregation/disaggregation approach	Bankruptcy prediction
Dias and Mousseau (2003)	A DSS called IRIS, incorporating several approaches for robustness analysis and preference aggregation/disaggregation in ETRI	Bankruptcy prediction
Dias and Mousseau (2006)	Procedure for eliciting veto thresholds from assignment examples in an ETRI model	Risk classify companies
Doumpos and Zopounidis (2002)	A heuristic procedure to sequentially estimate all parameters of an ETRI model using assignment examples	Not specified
Doumpos et al. (2009)	An evolutionary methodology to infer the parameters of an ETRI model using assignment examples	Various
Dubois et al. (2003)	Axiomatic analysis of generalized concordance rules	–
Fernandez, Lopez, Bernal, Coello, and Navarro (2010)	An evolutionary procedure to infer the parameters of an EIII model from assignment examples	R&D project evaluation
Figueira and Roy (2002)	A modification of the Simos' card procedure for determining criteria weights in ELECTRE type methods	Not specified
Figueira et al. (2009)	An extension of the overall concordance index of ELECTRE methods taking into account interaction between criteria	Various
Gershon (1984)	How criteria weights are used in different MCDA methods	Water resources
Greco et al. (2002)	To infer weights and veto thresholds of ELECTRE methods using decision rules obtained by a dominance-based rough set approach	Water resources
Greco et al. (2011)	ELECTRE^{GKMS}, a robust ordinal regression approach to construct a set of outranking models compatible with the preferences of a DM	Selecting a bus model
Jacquet-Lagreze (1982)	Binary preference indices as a link between additive utility functions and EI & EII	–
Kadzinski, Greco, and Slowinski (2012)	The concept of a representative set of parameters for ELECTRE^{GKMS}	Various
Kiss et al. (1994)	The ELECCALC procedure, which can be used to estimate the parameters of an EII model	–
Lourenco and Costa (2004)	An ETRI based approach to sort multi-objective MILP non-dominated solutions. Includes a procedure to infer weights and category limits	–
Marchant (2007)	An axiomatic characterization of different majority concepts, including the one used in EI	–
Meier (1997)	A fuzzy ranking approach connecting ELECTRE and PROMETHEE to the concept of linguistic variables	–
Miettinen and Salminen (1999)	A method that allows weights to be partially ranked, specified as ranges or not specified at all in a modified EIII	Waste management
Mousseau and Slowinski (1998a)	An interactive procedure to infer the parameters of an ETRI model from assignment examples. Requires non-linear optimization	Not specified
Mousseau et al. (2000)	A implementation of a procedure for eliciting criteria weights and cutting level of an ETRI model from assignment examples	Not specified
Mousseau et al. (2001)	Test of a procedure for eliciting criteria weights and cutting level of an ETRI model from assignment examples	Not specified

(*continued on next page*)

Table 3 (*continued*)

Author(s)	Focus	Example used
Mousseau et al. (2003)	Two algorithms for solving inconsistencies among constraints on the parameters of an MCDA model illustrated using ETRI	Bankruptcy prediction
Mousseau and Dias (2004)	Modifications of the valued outranking relation in EIII & ETRI	–
Mousseau, Dias, and Figueira (2006)	Extensions of the algorithms from Mousseau et al. (2003)	Not specified
Ngo-The and Mousseau (2002)	A procedure to determine category bounds, thresholds and cutting level in an ETRI model from assignment examples	Not specified
Pavlicic (2000)	Effects of normalization techniques for decision matrices on MCDA results. Includes vector normalization illustrated on EI	Various
Pavlicic (2001)	As in Pavlicic (2000)	Various
Perny and Roy (1992)	Technicalities of fuzzy outranking relations, including EIII types	–
Pirlot (1995)	The 'min'-procedure, sometimes used to exploit EIII valued outranking relations, e.g. in Kangas et al. (2001b)	–
Pirlot (1997)	A common framework for EI & EII to support future axiomatizations	
Rogers and Bruen (1998a)	Interpretations of thresholds in EIII, in an environmental context	Highway noise
Rogers and Bruen (1998b)	The 'resistance to change' grid method, based on concepts from psychology, to determine criteria weights in EIII	Waste management
Roy and Vincke (1984)	Fundamental concepts of pseudo-criteria as used in EIS, EIII & ETRI	–
Roy and Mousseau (1996)	An analysis of the relative importance of criteria under very general conditions	–
Roy and Slowinski (2008)	A new formula for the credibility index in EIII & ETRI taking into account the effects of reinforced preference and counter-veto	–
Slowinski (1989)	EIII incorporated into an interactive procedure for solving multi-objective optimization problems	–
Tavares (2012)	A consensus relation, allowing EI to be reformulated without elementary cycles occurring	Not specified
Tervonen et al. (2009a)	A stochastic method, SMAA-TRI., for parameter stability analysis of ETRI	Risk zoning of land
Thiel (2008)	Confidence intervals for the criteria weights in EIII for use in group decision-aiding	Assess public transportation
Vetschera (1986)	Sensitivity ranges for thresholds and weights in EI, within which the solution will remain unchanged	Purchasing aircrafts
Vetschera (1988)	An interactive DSS based on EI, in which alternatives are successively eliminated by threshold modifications	Hydroelectric power plants
Vincke (1992)	Theoretical analysis of exploitation methods for crisp outranking relations, including variants of the one used in EII	–
Wang and Triantaphyllou (2008)[a]	An empirical study on the occurrence of rank reversals in EII & EIII	Various

[a] See also the comment paper by Figueira and Roy (2009).

Table 4
Distribution of CAA for all papers.

Country	Numbers	Percentage	Country	Numbers	Percentage	Country	Numbers	Percentage
France	124	14.8	Finland	13	1.6	Serbia	3	0.4
USA	76	9.1	Australia	12	1.4	South Africa	3	0.4
Greece	71	8.5	Switzerland	12	1.4	Denmark	2	0.2
Canada	58	6.9	Germany	11	1.3	Egypt	2	0.2
Portugal	43	5.1	South Korea	9	1.1	Israel	2	0.2
Italy	42	5.0	Ireland	7	0.8	Philippines	2	0.2
Belgium	31	3.7	Tunisia	7	0.8	Slovenia	2	0.2
Poland	31	3.7	Romania	6	0.7	Thailand	2	0.2
Turkey	31	3.7	Yugoslavia	6	0.7	Argentina	1	0.1
Brazil	29	3.5	Algeria	5	0.6	Bosnia & Herzegovina	1	0.1
Iran	24	2.9	Luxembourg	4	0.5	Cameroun	1	0.1
Mexico	24	2.9	Malaysia	4	0.5	Colombia	1	0.1
India	22	2.6	Singapore	4	0.5	Croatia	1	0.1
Spain	21	2.5	Austria	3	0.4	Cyprus	1	0.1
China	18	2.2	Hong Kong	3	0.4	New Zealand	1	0.1
United Kingdom	18	2.2	Hungary	3	0.4	Norway	1	0.1
Taiwan	17	2.0	Japan	3	0.4	Serbia & Montenegro	1	0.1
The Netherlands	14	1.7	Lithuania	3	0.4	Yemen	1	0.1
						Total	816	100

Table 5
Top eight CAA for applied papers.

Country	Numbers	Percentage
France	84	13.0
Greece	58	9.0
USA	54	8.3
Canada	52	8.0
Italy	35	5.4
Brazil	29	4.5
Turkey	28	4.3
Portugal	24	3.7

Table 6
Top eight CAA for PTN papers.

Country	Numbers	Percentage
France	29	29.9
Portugal	16	16.5
Belgium	12	12.4
Poland	9	9.3
USA	6	6.2
Italy	5	5.2
Canada	3	3.1
Luxembourg	3	3.1

Table 7
Distribution by journals for all papers.

Journal	Numbers	Percentage
European Journal of Operational Research	87	12.7
Journal of Multi-Criteria Decision Analysis	25	3.6
Computers & Operations Research	16	2.3
Expert Systems with Applications	15	2.2
Decision Support Systems	12	1.7
Omega	11	1.6
Foundations of Computing and Decision Sciences	8	1.2
Water Resources Bulletin	8	1.2
Journal of the Operational Research Society	7	1.0
Annals of Operations Research	6	0.9
International Transactions in Operational Research	6	0.9
Materials & Design	6	0.9
Operational Research—An International Journal	6	0.9
Pesquisa Operacional	6	0.9
Water Resources Research	6	0.9
Fuzzy Sets and Systems	5	0.7
Informatica	5	0.7
Information Sciences	5	0.7
International Journal of Production Research	5	0.7
Renewable and Sustainable Energy Reviews	5	0.7
Technological and Economic Development of Economy	5	0.7
Theory and Decision	5	0.7
Waste Management	5	0.7
Water Science and Technology	5	0.7
Building and Environment	4	0.6
Energy Policy	4	0.6
Environmental Management	4	0.6
International Journal of Multicriteria Decision Making	4	0.6
Journal of Applied Sciences	4	0.6
Journal of Cleaner Production	4	0.6
Journal of Environmental Management	4	0.6
Journal of Water Resources Planning and Management	4	0.6
IEEE Transactions on Systems, Man and Cybernetics	4	0.6
Waste Management & Research	4	0.6
4OR	3	0.4
Agricultural Water Management	3	0.4
Agronomy for Sustainable Development	3	0.4
Applied Mathematical Modelling	3	0.4
Applied Mathematics and Computation	3	0.4
Computers & Industrial Engineering	3	0.4
Energy	3	0.4
Environmental Impact Assessment Review	3	0.4
International Journal of Geographical Information Science	3	0.4
International Journal of Information Technology & Decision Making	3	0.4
Journal of Advanced Transportation	3	0.4
Journal of Civil Engineering and Management	3	0.4
Journal of Decision Systems	3	0.4
Journal of Global Optimization	3	0.4
Journal of Hydroinformatics	3	0.4
Mathematical and Computer Modelling	3	0.4
Papers of the Regional Science Association	3	0.4
Regional and Urban Economics	3	0.4
Water Resources Management	3	0.4
Yugoslav Journal of Operations Research	3	0.4
2 articles from each of 44 journals	88	12.8
1 article from each of 228 journals	228	33.2
Total	686	100

6.2. Distribution by journals

A total of 326 journals have published papers related to the ELECTRE methods. Table 7 shows the journals in descending order with respect to the number of published articles. The journal with most publications is *European Journal of Operational Research*. They have published more than three times as many articles than the second in the list, which is *Journal of Multi-Criteria Decision Analysis*, and more than five times more than each of the next two: *Computers & Operations Research*, and *Expert Systems with Applications*. Most journals have only published one or two articles.

Table 8
Top four journals for applied papers.

Journal	Numbers	Percentage
European Journal of Operational Research	51	9.4
Expert Systems with Applications	13	2.4
Journal of Multi-Criteria Decision Analysis	12	2.2
Computers & Operations Research	11	2.0

Table 9
Top four journals for PTN papers.

Journal	Numbers	Percentage
European Journal of Operational Research	25	38.5
Journal of Multi-Criteria Decision Analysis	8	12.3
Computers & Operations Research	5	7.7
4OR	3	4.6
Omega	3	4.6

In Table 8, we can see that for the applied papers, the first four journals are the same as for all papers, but *Expert Systems with Applications* has moved from a fourth to a second place. A total of 304 journals have published at least one paper from the group of applied papers.

In the top four of the PTN papers, shown in Table 9, the first three journals are unchanged compared to Table 7. In a shared fourth place we find *4OR* and *Omega*. Only a total of 21 journals have published papers from the PTN group.

6.3. Distribution by year of publication

The frequency distribution and percentage of published articles with respect to year of publication is shown in Table 10 for all papers as well as for each of the group categorizations from Sections 5.1–5.4. The starting year in the table is 1968, which was chosen for this paper. In general three year intervals are used, but since only a few articles were found for the earliest years, we allow the first interval to cover six years. If we look at the columns for all papers and for applied papers, we see an increase in the amount of published papers for almost every interval, with only a few exceptions showing a decrease close to status quo. The column for SRO papers shows almost a status quo with 0–4 (0–7 percent) published papers per interval until 2004–2006, when 11 (19.3 percent) were published. The next intervals show a slight decrease. Looking at the MMS papers, we see that 0–3 (0–15.0 percent) papers have been published in each interval. The number of publications in the final group of papers, PTN, varies over the years, but the underlying trend seems to be increasing until 2009. Since then, only six papers have been published in the PTN group.

6.4. Distribution by ELECTRE version vs. application area

In order to determine the most used ELECTRE version in various areas as well as in general, we show the distribution by ELECTRE version vs. application area in Table 11. As the application areas, we use the main categorizations from Sections 5.1.1–5.1.13, but because the NRE category is very large, we also provide the sub-categories of NRE.

Overall, the most used ELECTRE version is ELECTRE III, with 212 applications in total, followed by ELECTRE I with 189 applications and ELECTRE II and TRI, with 81 and 82 applications, respectively. Only 21 applications of ELECTRE IV were found and 11 of ELECTRE IS. The two latest versions, ELECTRE TRI-C and TRI-nC, are relatively new and have not been applied much yet.

For the application areas, we will mainly comment on a few of the notable differences with respect to the most popular version. In financial management ELECTRE TRI is most popular with almost half

Table 10
Distribution by year for all papers.

Years	All	Percentage	Applied	Percentage	SRO	Percentage	MMS	Percentage	PTN	Percentage
1968–1973	5	0.7	2	0.4	3	5.3	0	0.0	0	0.0
1974–1976	6	0.9	5	0.9	1	1.8	0	0.0	0	0.0
1977–1979	5	0.7	4	0.7	0	0.0	1	5.0	0	0.0
1980–1982	11	1.6	7	1.3	3	5.3	0	0.0	1	1.5
1983–1985	12	1.7	8	1.5	1	1.8	1	5.0	2	3.1
1986–1988	23	3.4	15	2.8	2	3.5	2	10.0	4	6.2
1989–1991	18	2.6	14	2.6	2	3.5	1	5.0	1	1.5
1992–1994	26	3.8	18	3.3	3	5.3	2	10.0	3	4.6
1995–1997	38	5.5	27	5.0	2	3.5	2	10.0	7	10.8
1998–2000	45	6.6	31	5.7	2	3.5	2	10.0	10	15.4
2001–2003	70	10.2	54	9.9	4	7.0	2	10.0	10	15.4
2004–2006	70	10.2	52	9.6	11	19.3	1	5.0	6	9.2
2007–2009	141	20.6	114	21.0	9	15.8	3	15.0	15	23.1
2010–2012	177	25.8	162	29.8	8	14.0	2	10.0	5	7.7
2013–	39	5.7	31	5.7	6	10.5	1	5.0	1	1.5
Total	686	100	544	100	57	100.0	20	100	65	100

Table 11
Distribution by ELECTRE version vs. application area for applied papers.

	EI	EIS	EII	EIII	EIV	ETRI	ETRI-C	ETRI-nC	Total
Water management	27	0	30	24	3	6	0	0	90
Waste management	7	2	3	24	2	0	0	0	38
LGC[a]	7	0	0	8	0	8	0	0	23
FNE[b]	3	0	1	6	0	2	0	0	12
Other papers on NRE[c]	2	0	1	5	0	2	0	0	10
NRE total	46	2	35	67	5	18	0	0	173
Business management	27	1	4	22	3	15	0	0	72
Energy management	7	2	4	30	3	11	0	0	57
DMM[d]	23	2	7	14	3	1	0	0	50
SCT[e]	16	0	5	16	3	6	1	0	47
LSC[f]	18	1	6	9	2	3	0	0	39
Information technology	16	1	5	8	1	3	0	0	34
Financial management	5	1	3	7	0	15	0	0	31
CBE[g]	5	1	1	8	0	0	0	0	15
Policy, social and education	7	0	4	11	1	2	0	0	25
Agriculture and horticulture	4	0	2	2	0	5	0	0	13
Health, safety and medicine	6	0	1	3	0	0	2	0	12
OAN[h]	9	0	4	15	0	3	0	1	31
Total	189	11	81	212	21	82	3	1	599

[a] LGC: Land management, geology and cartography.
[b] FNE: Forestry, natural reserves and ecotourism.
[c] NRE: Natural resources and environmental management.
[d] DMM: Design, mechanical engineering and manufacturing systems.
[e] SCT: Structural, construction and transportation engineering.
[f] LSC: Logistics and supply chain.
[g] CBE: Chemical and biochemical engineering.
[h] OAN: Other areas and non-specific applications.

Table 12
Distribution by ELECTRE version vs. year of publication for applied papers.

	EI	EIS	EII	EIII	EIV	ETRI	ETRI-C	ETRI-nC	Total
1968–1973	2	0	0	–	–	–	–	–	2
1974–1976	4	0	1	–	–	–	–	–	5
1977–1979	3	0	1	0	–	–	–	–	4
1980–1982	5	0	2	1	1	–	–	–	9
1983–1985	5	0	3	1	0	–	–	–	9
1986–1988	8	0	5	7	0	–	–	–	20
1989–1991	11	0	2	1	1	–	–	–	15
1992–1994	10	1	7	5	1	0	–	–	24
1995–1997	8	0	9	11	2	3	–	–	33
1998–2000	9	0	8	13	4	4	–	–	38
2001–2003	12	3	7	24	1	11	–	–	58
2004–2006	15	1	5	27	2	5	–	–	54
2007–2009	27	2	8	51	6	28	–	–	122
2010–2012	61	3	22	57	3	25	3	1	175
2013–	9	1	1	14	0	6	0	0	31
Total	189	11	81	212	21	82	3	1	599

of the applications in this area. The information technology and the land management, geology and cartography areas have most applications of ELECTRE I, once again almost half of the total applications in each of two areas. In the sub-category water management under NRE, ELECTRE II is most popular followed by ELECTRE I.

6.5. Distribution by ELECTRE version vs. year for applied papers

Table 12 gives the distribution of ELECTRE applications with respect to the year of publication, in which the applications were presented.

ELECTRE I has had an increase in the number of applications until the early 1990s, followed by 10 years of almost status quo. Then starting from 2001, the number started to increase again. ELECTRE III had a small peak in the number of applications in the late 1980s, and then from the mid-1990s it has had a steady increase. It is interesting to see that ELECTRE I has been used almost as much ELECTRE III. ELECTRE I is, of course, an older method, but even in recent years there have been an almost equal number of applications of ELECTRE I and ELECTRE III. The number of ELECTRE TRI applications varies over the years, but had a large jump in the late 2000s. Also ELECTRE II has had a sudden increase in the number of applications recently, even though it is one of the early ELECTRE versions. The remaining ELECTRE versions have had few applications, and are therefore harder to comment on, but in general the most applications fall within the last 10 years.

7. Conclusions and research directions

In this paper we have performed a comprehensive review of 686 journal articles dealing with ELECTRE or concepts from ELECTRE. Each paper has been carefully studied in order to place it into one of four groups that represent the contexts in which ELECTRE or the related concepts are used. The largest of these groups, the applied papers, include 544 papers that were further categorized according to 13 main application areas and a number of sub-areas. In addition, all papers were classified according to country of author affiliation, journal of publication, and year of publication. For the group of applied papers, the distribution by ELECTRE version vs. application area and ELECTRE version vs. year were also provided.

Limitations of the review:

One of the limitations of the review is that although an attempt has been made to include all relevant journal articles, some may neither be listed in the databases or database hosts available to us, nor in the cross-references of the reviewed papers. In addition it is sometimes hard to determine if a paper presenting a hybrid approach should be included or not. It may use some amount of concepts from ELECTRE, but it is not easy to define a clear line for when this amount is too small. Therefore some papers excluded from the review may still use some concepts from ELECTRE. Finally, there may be papers dealing specifically with outranking concepts used in ELECTRE, but without actually considering ELECTRE. Another limitation of our research is the fact that conference proceedings, books, book chapters, dissertations and literature in languages other than English are not included in the review. Nevertheless, we do believe that the majority of English journal articles on ELECTRE and ELECTRE-based methods are included in the review, and secondly that they represent state-of-the-art research with respect to ELECTRE. Therefore, it is our belief that this review can be a valuable source of information for researchers and practitioners in the field of MCDA and on ELECTRE in particular.

Findings:

The review enables us to make a number of observations with respect to applications of ELECTRE:

(1) Overall, ELECTRE III is the most popular of the ELECTRE methods, but it is actually only the most popular in five of the 13 main categories (see Table 11). Almost half of all ELECTRE III applications are in the areas of energy management and natural resources and environmental management. This finding indicates that ELECTRE III may be overlooked in some areas. Although ELECTRE III may be considered relatively complicated, official software does exist, which can ease the use for researchers.
(2) ELECTRE I is more than 40 years old, but it continues to be a popular method in several application areas. This can probably be contributed to the fact that it is less involved than the other methods, which makes it easier to combine with other MCDA methods or to integrate into a larger methodology.
(3) In relation to the points above, the review has identified several applications of modified ELECTRE versions. ELECTRE I and ELECTRE III, especially, have been modified in various ways. The ELECTRE III modifications mostly involve replacing the entire aggregation or exploitation phase. In the case of ELECTRE I, the modifications are more targeted against smaller or larger modifications within the original algorithm, such as the use of interval data or fuzzy numbers.
(4) ELECTRE IV has had few applications overall. It clearly has less flexibility than the other methods, but one should think that the fact that no criteria weights have to be defined would make it more suitable than other methods in some cases. For example, it may be used as a decision module within a larger algorithm.
(5) ELECTRE IS has also not been used much, despite the fact that it is more flexible than ELECTRE I and that an official software exists. Similar to ELECTRE I, it can select a subset of best alternatives, which means that it can be used to reduce a large set of alternatives, before possibly applying another method.
(6) ELECTRE TRI has been successfully applied to a number of risk-related problems in financial management and land use management as well as for performance evaluations in various areas, such as business management and energy management. This usage indicates that it may be particularly well suited for risk and performance assessment problems.
(7) The two latest ELECTRE methods, ELECTRE TRI-C and ELECTRE TRI-nC have only seen very few applications.

The group of survey, review, and overview papers mainly contains literature reviews of MCDA applications. In fact, 42 of the 57 papers in this group are directly related to an application area. Most of the 13 application areas or sub-areas defined in the present paper are represented. This paper can, on one hand, be seen as an extension of these papers, because it provides additional literature references to ELECTRE applications, which may be relevant in the specific area. On the other hand, some of the applied papers reviewed here are reviewed in more detail in the application specific review papers.

In general, the papers focusing on the problem of selecting an appropriate MCDA method agree that it is in itself a multi-criteria problem. As with most other MCDA problems, there is generally no single best solution to the problem (see for instance Roy and Słowiński, 2013). Every MCDA method, including each of the members of the ELECTRE family, has its strengths and weaknesses. Any DM who considers using an MCDA method will have to carefully weigh these factors against each other. A discussion of strengths and weaknesses of ELECTRE methods can be found in Figueira et al. (2010) and Figueira and Roy (2009).

A popular topic in the last group of papers is the problem of assisting a DM in selecting appropriate parameter values, mostly in the form of preference disaggregation approaches. ELECTRE TRI has been especially targeted in these papers, since it requires relatively many parameters which are not easily determined. The more general prob-

lem of determining criteria weights in an MCDA or ELECTRE model is also the focus in a number of papers. Other popular areas are robustness analysis and axiomatic analysis of ELECTRE and ELECTRE-based methods. As mentioned previously, most papers in the final group are reviewed in more detail in Figueira et al. (2013). Another good source providing an overview of many of the approaches is Figueira et al. (2010). Preference disaggregation approaches are also reviewed in Doumpos and Zopounidis (2011a).

Future research directions:

Future research can be targeted against application of some of the new ELECTRE methods or application of ELECTRE methods, which are overlooked, either in a specific area or in general. Examples include ELECTRE III and TRI, which have been applied less often than some of the simpler ELECTRE methods in some areas, especially in design, mechanical engineering and manufacturing systems and logistics and supply chain. Since it does not require criteria weights, ELECTRE IV may be a good choice as a decision module in, for example, computer algorithms or other problems where user interaction may not be desirable. In light of the recent increasing popularity of ELECTRE I, ELECTRE IS may be a better choice of method, provided that simplicity is not a concern. ELECTRE TRI and the related software, which can assist in determining the parameters, could be a good choice for risk assessments, for example in health and safety management or logistics and supply chain management. The same can be said for ELECTRE TRI-C and TRI-nC, which generally have not been used much yet.

With respect to the ELECTRE methods themselves, much work has been done in order to assist a DM in determining the necessary parameters. But the parameters remain a problematic issue. Also the evaluations of the alternatives can be problematic, although the use of pseudo-criteria has diminished this problem, because the evaluations then can be fuzzy. In an attempt to reduce the strain on the DM, in terms of the exactness of evaluations and parameter values, some ELECTRE methods have been combined with (intuitionistic) fuzzy set theory or evolutionary approaches. Especially ELECTRE I has been targeted for this purpose, but also ELECTRE III has been considered and to a lesser extent ELECTRE II. It may be worthwhile in future research to consider other combinations of ELECTRE methods with such approaches.

Concluding comments:

To conclude this paper, we can summarize our findings, by quoting Figueira et al. (2013): *…research on ELECTRE methods is not a dead field. Rather the opposite, it is still evolving and gains acceptance thanks to new application areas, new methodological and theoretical developments, as well as user-friendly software implementations.*

Acknowledgments

The authors sincerely thank Professor Bernard Roy, Professor Roman Slowinski and Professor José Rui Figueira for their valuable suggestions to improve the initial version of the paper. Also, the authors thank the editor and three anonymous reviewers for their valuable comments which improved this paper, significantly.

Supplementary Materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ejor.2015.07.019.

References

Abedi, M., Torabi, S. A., Norouzi, G. H., & Hamzeh, M. (2012). ELECTRE III: A knowledge-driven method for integration of geophysical data with geological and geochemical data in mineral prospectivity mapping. *Journal of Applied Geophysics, 87*, 9–18.

Achillas, C., Moussiopoulos, N., Karagiannidis, A., Banias, G., & Perkoulidis, G. (2013). The use of multi-criteria decision analysis to tackle waste management problems: A literature review. *Waste Management & Research, 31*(2), 115–129.

Achillas, C., Vlachokostas, C., Moussiopoulos, N., & Banias, G. (2010). Decision support system for the optimal location of electrical and electronic waste treatment plants: A case study in Greece. *Waste Management, 30*(5), 870–879.

Achillas, C., Vlachokostas, C., Moussiopoulos, N., & Banias, G. (2011). Prioritize strategies to confront environmental deterioration in urban areas: Multicriteria assessment of public opinion and experts' views. *Cities, 28*(5), 414–423.

Ahrens, H., & Kantelhardt, J. (2009). Accounting for farmers' production responses to environmental restrictions within landscape planning. *Land Use Policy, 26*(4), 925–934.

Aiello, G., Enea, M., & Galante, G. (2006). A multi-objective approach to facility layout problem by genetic search algorithm and Electre method. *Robotics and Computer-Integrated Manufacturing, 22*(5–6), 447–455.

Alencar, L. H., & de Almeida, A. T. (2008). Multicriteria decision group model for the selection of suppliers. *Pesquisa Operacional, 28*(2), 321–337.

Alencar, L. H., de Almeida, A. T., & Morais, D. C. (2010). A multicriteria group decision model aggregating the preferences of decision-makers based on electre methods. *Pesquisa Operacional, 30*(3), 687–702.

Alexopoulos, S., Siskos, Y., Tsotsolas, N., & Hristodoulakis, N. (2012). Evaluating strategic actions for a Greek publishing company. *Operational Research—An International Journal, 12*(2), 253–269.

Alkhawlani, M. M. (2011). Intelligent vertical handover for heterogonous networks using FL and ELECTRE. *International Journal of Computer Networks & Communications, 3*(4), 118–135.

Almeida-Dias, J., Figueira, J. R., & Roy, B. (2010). Electre Tri-C: A multiple criteria sorting method based on characteristic reference actions. *European Journal of Operational Research, 204*(3), 565–580.

Almeida-Dias, J., Figueira, J. R., & Roy, B. (2012). A multiple criteria sorting method where each category is characterized by several reference actions: The Electre Tri-nC method. *European Journal of Operational Research, 217*(3), 567–579.

Al-Shemmeri, T., Al-Kloub, B., & Pearman, A. (1997). Model choice in multicriteria decision aid. *European Journal of Operational Research, 97*(3), 550–560.

Amiri, M., Nosratian, N. E., Jamshidi, A., & Kazemi, A. (2008). Developing a new ELECTRE method with interval data in multiple attribute decision making problems. *Journal of Applied Sciences, 8*(22), 4017–4028.

Ananda, J., & Herath, G. (2009). A critical review of multi-criteria decision making methods with special reference to forest management and planning. *Ecological Economics, 68*(10), 2535–2548.

Andalecio, M. N. (2010). Multi-criteria decision models for management of tropical coastal fisheries. A review. *Agronomy for Sustainable Development, 30*(3), 557–580.

Andrades-Caldito, L., Sanchez-Rivero, M., & Pulido-Fernandez, J. I. (2013). Differentiating competitiveness through tourism image assessment: An application to Andalusia (Spain). *Journal of Travel Research, 52*(1), 68–81.

Anestis, G., Grigoroudis, E., Krassadaki, E., Matsatsinis, N. F., & Siskos, Y. (2006). Skills evaluator: A multicriteria decision support system for the evaluation of qualifications and skills in Information and Communication Technologies. *Journal of Multi-Criteria Decision Analysis, 14*(1–3), 21–34.

Armaghan, N., & Renaud, J. (2012). An application of multi-criteria decision aids models for case-based reasoning. *Information Sciences, 210*, 55–66.

Arondel, C., & Girardin, P. (2000). Sorting cropping systems on the basis of their impact on groundwater quality. *European Journal of Operational Research, 127*(3), 467–482.

Ashayeri, J., & Rongen, J. M. J. (1997). Central distribution in Europe: A multi-criteria approach to location selection. *The International Journal of Logistics Management, 8*(1), 97–109.

Atici, K. B., & Ulucan, A. (2011). A multiple criteria energy decision support system. *Technological and Economic Development of Economy, 17*(2), 219–245.

Augusto, M., Lisboa, J., Yasin, M., & Figueira, J. R. (2008). Benchmarking in a multiple criteria performance context: An application and a conceptual framework. *European Journal of Operational Research, 184*(1), 244–254.

Avgelis, A., & Papadopoulos, A. M. (2009). Application of multicriteria analysis in designing HVAC systems. *Energy and Buildings, 41*(7), 774–780.

Azmi, M., Araghinejad, S., & Sarmadi, F. (2011). A National-scale assessment of agricultural development feasibility using multi-criteria decision making (MCDM) approaches. *Advances in Natural & Applied Sciences, 5*(4), 379–391.

Bakus, G. J., Stillwell, W. G., Latter, S. M., & Wallerstein, M. C. (1982). Decision making: With applications for environmental management. *Environmental Management, 6*(6), 493–504.

Balali, V. B., Zahraie, B., & Roozbahani, A. (2014). Integration of ELECTRE III and PROMETHEE II decision making methods with interval approach: Application in selection of appropriate structural systems. *Journal of Computing in Civil Engineering, 28*(2), 297–314.

Balasubramaniam, A., & Voulvoulis, N. (2005). The appropriateness of multicriteria analysis in environmental decision-making problems. *Environmental Technology, 26*(9), 951–962.

Banias, G., Achillas, C., Vlachokostas, C., Moussiopoulos, N., & Tarsenis, S. (2010). Assessing multiple criteria for the optimal location of a construction and demolition waste management facility. *Building and Environment, 45*(10), 2317–2326.

Barda, O. H., Dupuis, J., & Lencioni, P. (1990). Multicriteria location of thermal power plants. *European Journal of Operational Research, 45*(2–3), 332–346.

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*(1), 198–215.

Behzadian, M., Otaghsara, S. K., Yazdani, M., & Ignatius, J. (2012). A state-of the-art survey of TOPSIS applications. *Expert Systems with Applications, 39*(17), 13051–13069.
Bélanger, M., & Martel, J. M. (2006). Explanations for a decision support system based on MCDA. *Computing and Informatics, 25*(2–3), 195–221.
Bell, M. L., Hobbs, B. F., Elliott, E. M., Ellis, H., & Robinson, Z. (2001). An evaluation of multi-criteria methods in integrated assessment of climate policy. *Journal of Multi-Criteria Decision Analysis, 10*(5), 229–256.
Belton, V., & Stewart, T. (2002). *Multiple criteria decision analysis: An integrated approach*. Boston , MA: Kluwer Academic Publishers.
Benayoun, R., Roy, B., & Sussman, B. (1966). Une méthode pour guider le choix en présence de points de vue multiples. Note de travail 49. SEMA-METRA. Direction-Scientifique
Bender, M. J., & Simonovic, S. P. (2000). A fuzzy compromise approach to water resource systems planning under uncertainty. *Fuzzy Sets and Systems, 115*(1), 35–44.
Benedini, M. (1988). Developments and possibilities of optimization models. *Agricultural Water Management, 13*(2–4), 329–358.
Benoit, V., & Rousseaux, P. (2003). Aid for aggregating the impacts in Life Cycle assessment. *International Journal of Life Cycle Assessment, 8*(2), 74–82.
Bergeron, M., Martel, J. M., & Twarabimenye, P. (1996). The evaluation of corporate loan applications based on the MCDA. *Journal of Euro-Asian Management, 2*(2), 16–46.
Bezdrob, M., Bico-Car, M., & Pasic, F. (2011). Managerial decision making tools—Electre methods brief overview of methods with practical examples. *Sarajevo Business & Economics Review (Zbornik Radova), 31*, 237–262.
Bilich, F., & da Silva, R. (2008). Valuation and optimization of the impact of intellectual capital on organizational performance. *Portuguese Journal of Management Studies, 13*(3), 341–359.
Bisdorff, R. (2000). Logical foundation of fuzzy preferential systems with application to the electre decision aid methods. *Computers & Operations Research, 27*(7–8), 673–687.
Bisdorff, R. (2004). Concordant outranking with multiple criteria of ordinal significance. *4OR, 2*(4), 293–308.
Bisdorff, R., Meyer, P., & Roubens, M. (2008). RUBIS: A bipolar-valued outranking method for the choice problem. *4OR, 6*, 143–165.
Blanquart, S. (2006). Multi-criteria decision-aid: Local method for sustainable management of groundwater quality in the agricultural sector. *International Journal of Sustainable Development, 9*(2), 138–160.
Blanquart, S. (2009). Role of multicriteria decision-aid (MCDA) to promote sustainable agriculture: Heterogeneous data and different kinds of actors in a decision process. *International Journal of Agricultural Resources, Governance and Ecology, 8*(2–4), 258–281.
Bojkovic, N., Anic, I., & Tarle, S. P. (2010). One solution for cross-country transport-sustainability evaluation using a modified ELECTRE method. *Ecological Economics, 69*(5), 1176–1186.
Bona, B., Merighi, D., & Ostanello, A. (1979). A model of public resources allocation for social investments on urban districts: The case of a Northern Italian metropolitan area. *IEEE Transactions on Systems, Man and Cybernetics, 9*(9), 459–464.
Borade, A. B., & Bansod, S. V. (2011). Comparison of neural network-based forecasting methods using multi-criteria decision-making tools. *Supply Chain Forum, 12*(4), 4–14.
Bouyssou, D. (1986). Some remarks on the notion of compensation in MCDM. *European Journal of Operational Research, 26*(1), 150–160.
Bouyssou, D. (1996). Outranking relations: Do they have special properties? *Journal of Multi-Criteria Decision Analysis, 5*(2), 99–111.
Bouyssou, D., & Marchant, T. (2007a). An axiomatic approach to noncompensatory sorting methods in MCDM, I: The case of two categories. *European Journal of Operational Research, 178*(1), 217–245.
Bouyssou, D., & Marchant, T. (2007b). An axiomatic approach to noncompensatory sorting methods in MCDM, II: More than two categories. *European Journal of Operational Research, 178*(1), 246–276.
Bouyssou, D., & Pirlot, M. (2005). A characterization of concordance relations. *European Journal of Operational Research, 167*(2), 427–443.
Bouyssou, D., & Pirlot, M. (2007). Further results on concordance relations. *European Journal of Operational Research, 181*(1), 505–514.
Bouyssou, D., & Pirlot, M. (2009). An axiomatic analysis of concordance-discordance relations. *European Journal of Operational Research, 199*(2), 468–477.
Bouyssou, D., & Vansnick, J. C. (1986). Noncompensatory and generalized noncompensatory preference structures. *Theory and Decision, 21*(3), 251–266.
Bouyssou, D., & Vincke, P. (1997). Ranking alternatives on the basis of preference relations: A progress report with special emphasis on outranking relations. *Journal of Multi-Criteria Decision Analysis, 6*(2), 77–85.
Bregar, A., Gyorkos, J., & Juric, M. B. (2008). Interactive aggregation/disaggregation dichotomic sorting procedure for group decision analysis based on the threshold model. *Informatica, 19*(2), 161–190.
Bregar, A., Gyorkos, J., & Juric, M. B. (2009). Robustness and visualization of decision models. *Informatica, 33*(3), 385–395.
Brito, A. J., de Almeida, A. T., & Mota, C. M. 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*(3), 812–821.
Brunner, N., & Starkl, M. (2004). Decision aid systems for evaluating sustainability: A critical survey. *Environmental Impact Assessment Review, 24*(4), 441–469.
Bufardi, A., Sakara, D., Gheorghe, R., Kiritsis, D., & Xirouchakis, P. (2003). Multiple criteria decision aid for selecting the best product end of life scenario. *International Journal of Computer Integrated Manufacturing, 16*(7–8), 526–534.
Cailloux, O., Meyer, P., & Mousseau, V. (2012). Eliciting Electre Tri category limits for a group of decision makers. *European Journal of Operational Research, 223*(1), 133–140.
Can, A. (1992). Residential quality assessment. *The Annals of Regional Science, 26*(1), 97–110.
Capros, P., Papathanassiou, S., & Samouilidis, J. E. (1988). Multicriteria analysis of energy supply decisions in an uncertain future. *Omega, 16*(2), 107–115.
Carrico, N., Covas, D. I. C., Almeida, M. C., Leitao, J. P., & Alegre, H. (2012). Prioritization of rehabilitation interventions for urban water assets using multiple criteria decision-aid methods. *Water Science and Technology, 66*(5), 1007–1014.
Catalina, T., Virgone, J., & Blanco, E. (2010). Multi-criteria decision analysis of multi-source systems and renewable energy integration. *Mathematical Modeling in Civil Engineering, 4*, 18–25.
Catalina, T., Virgone, J., & Blanco, E. (2011). Multi-source energy systems analysis using a multi-criteria decision aid methodology. *Renewable Energy, 36*(8), 2245–2252.
Ceccato, L., Giannini, V., & Giupponi, C. (2011). Participatory assessment of adaptation strategies to flood risk in the Upper Brahmaputra and Danube river basins. *Environmental Science & Policy, 14*(8), 1163–1174.
Celik, M., & Er, I. D. (2009). Fuzzy axiomatic design extension for managing model selection paradigm in decision science. *Expert Systems with Applications, 36*(3, Part 2), 6477–6484.
Certa, A., Enea, M., Galante, G., & La Fata, C. M. (2009). Multi-objective human resources allocation in R&D projects planning. *International Journal of Production Research, 47*(13), 3503–3523.
Certa, A., Enea, M., & Lupo, T. (2013). ELECTRE III to dynamically support the decision maker about the periodic replacements configurations for a multi-component system. *Decision Support Systems, 55*(1), 126–134.
Chai, J., Liu, J. N. K., & Ngai, E. W. T. (2013). Application of decision-making techniques in supplier selection: A systematic review of literature. *Expert Systems with Applications, 40*(10), 3872–3885.
Chakhar, S., & Mousseau, V. (2008). GIS-based multicriteria spatial modeling generic framework. *International Journal of Geographical Information Science, 22*(11–12), 1159–1196.
Charilas, D. E., Panagopoulos, A. D., & Markaki, O. I. (2014). A unified network selection framework using principal component analysis and multi attribute decision making. *Wireless Personal Communications, 74*(1), 147–165.
Chatterjee, P., Athawale, V. M., & Chakraborty, S. (2010). Selection of industrial robots using compromise ranking and outranking methods. *Robotics and Computer-Integrated Manufacturing, 26*(5), 483–489.
Chen, T. Y., Chang, C. H., & Lu, J. R. (2013). The extended QUALIFLEX method for multiple criteria decision analysis based on interval type-2 fuzzy sets and applications to medical decision making. *European Journal of Operational Research, 226*(3), 615–625.
Cheng, S., Chan, C. W., & Huang, G. H. (2002). Using multiple criteria decision analysis for supporting decisions of solid waste management. *Journal of Environmental Science and Health, Part A, 37*(6), 975–990.
Cheng, S., Chan, C. W., & Huang, G. H. (2003). An integrated multi-criteria decision analysis and inexact mixed integer linear programming approach for solid waste management. *Engineering Applications of Artificial Intelligence, 16*(5–6), 543–554.
Chin, C., Duckstein, L., & Wymore, M. L. (1991). Factory automation project selection using multicriterion Q-analysis. *Applied Mathematics and Computation, 46*(2), 107–126.
Choo, E. U., Schoner, B., & Wedley, W. C. (1999). Interpretation of criteria weights in multicriteria decision making. *Computers & Industrial Engineering, 37*(3), 527–541.
Cicek, K., & Celik, M. (2010). Multiple attribute decision-making solution to material selection problem based on modified fuzzy axiomatic design-model selection interface algorithm. *Materials & Design, 31*(4), 2129–2133.
Cicek, K., Celik, M., & Topcu, Y. I. (2010). An integrated decision aid extension to material selection problem. *Materials & Design, 31*(9), 4398–4402.
Clímaco, J., Martins, A. G., & De Almeida, A. (1990). On the use of multicriteria optimisation for electric energy planning. *International Journal of Global Energy Issues, 2*(3), 194–203.
Cloquell-Ballester, V. A., Cloquell-Ballester, V. A., Monterde-Diaz, R., & Siurana, M. C. S. (2006). Indicators validation for the improvement of environmental and social impact quantitative assessment. *Environmental Impact Assessment Review, 26*(1), 79–105.
Cohon, J. L., & Marks, D. H. (1975). A review and evaluation of multiobjective programing techniques. *Water Resources Research, 11*(2), 208–220.
Coronado, M., Dosal, E., Coz, A., Viguri, J. R., & Andres, A. (2011). Estimation of construction and demolition waste (C&DW) Generation and multicriteria analysis of C&DW management alternatives: A case study in Spain. *Waste and Biomass Valorization, 2*(2), 209–225.
Corrente, S., Greco, S., & Slowinski, R. (2013). Multiple criteria hierarchy process with ELECTRE and PROMETHEE. *Omega, 41*(5), 820–846.
Costa, A. P. C. S., de Almeida, A. T., & de Miranda, C. M. G. (2003). Multicriteria support to sort information systems portfolio. *Journal of the Academy of Business and Economics, 2*(1), 237–247.
Covas, M. T., Silva, C. A., & Dias, L. C. (2013). Multicriteria decision analysis for sustainable data centers location. *International Transactions in Operational Research, 20*(3), 269–299.
Czyzak, P., & Slowinski, R. (1996). Possibilistic construction of fuzzy outranking relation for multiple-criteria ranking. *Fuzzy Sets and Systems, 81*(1), 123–131.

Damart, S., Dias, L. C., & Mousseau, V. (2007). Supporting groups in sorting decisions: Methodology and use of a multi-criteria aggregation/disaggregation DSS. *Decision Support Systems, 43*(4), 1464–1475.

David, L., & Duckstein, L. (1976). Multi-criterion ranking of alternative long-range water resource systems. *Water Resources Bulletin, 12*(4), 731–754.

De, M., & Hipel, K. W. (1987). A fuzzy multicriteria model for comparing energy projects. *Energy, 12*(7), 599–613.

de Almeida, A. T. (2007). Multicriteria decision model for outsourcing contracts selection based on utility function and ELECTRE method. *Computers & Operations Research, 34*(12), 3569–3574.

de Miranda Mota, C. M., & de Almeida, A. T. (2012). A multicriteria decision model for assigning priority classes to activities in project management. *Annals of Operations Research, 199*(1), 361–372.

Deng, H., & Wibowo, S. (2008). Intelligent decision support for evaluating and selecting information systems projects. *Engineering Letters, 16*(3), 412–418.

Despontin, M., Lehert, F., & Roubens, M. (1986). Multi-attribute decision making by consumers associations. *European Journal of Operational Research, 23*(2), 194–201.

Devi, K., & Yadav, S. P. (2013). A multicriteria intuitionistic fuzzy group decision making for plant location selection with ELECTRE method. *International Journal of Advanced Manufacturing Technology, 66*(9–12), 1219–1229.

Diaby, M., Ferrer, H., Valognes, F., & Demange, A. C. (2011). A comprehensive decision approach for rubber tree planting management in Africa. *Journal of Multi-Criteria Decision Analysis, 18*(3–4), 187–201.

Dias, L., & Clímaco, J. (2000). ELECTRE TRI for groups with imprecise information on parameter values. *Group Decision and Negotiation, 9*(5), 355–377.

Dias, L., Mousseau, V., Figueira, J., & Clímaco, J. (2002). An aggregation/disaggregation approach to obtain robust conclusions with ELECTRE TRI. *European Journal of Operational Research, 138*(2), 332–348.

Dias, L. C., & Clímaco, J. N. (1999). On computing ELECTRE's credibility indices under partial information. *Journal of Multi-Criteria Decision Analysis, 8*(2), 74–92.

Dias, L. C., Costa, J. P., & Clímaco, J. N. (1997). Conflicting criteria, cooperating processors-Some experiments on implementing a multicriteria decision support method on a parallel computer. *Computers & Operations Research, 24*(9), 805–817.

Dias, L. C., & Mousseau, V. (2003). IRIS: A DSS for multiple criteria sorting problems. *Journal of Multi-Criteria Decision Analysis, 12*(4–5), 285–298.

Dias, L. C., & Mousseau, V. (2006). Inferring Electre's veto-related parameters from outranking examples. *European Journal of Operational Research, 170*(1), 172–191.

Diaz-Balteiro, L., & Romero, C. (2008). Making forestry decisions with multiple criteria: A review and an assessment. *Forest Ecology and Management, 255*(8–9), 3222–3241.

Dimitras, A. I., Zanakis, S. H., & Zopounidis, C. (1996). A survey of business failures with an emphasis on prediction methods and industrial applications. *European Journal of Operational Research, 90*(3), 487–513.

Doukas, H. (2013). Modelling of linguistic variables in multicriteria energy policy support. *European Journal of Operational Research, 227*(2), 227–238.

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*(2), 496–505.

Doumpos, M., & Zopounidis, C. (2002). On the development of an outranking relation for ordinal classification problems: An experimental investigation of a new methodology. *Optimization Methods and Software, 17*(2), 293–317.

Doumpos, M., & Zopounidis, C. (2011a). Preference disaggregation and statistical learning for multicriteria decision support: A review. *European Journal of Operational Research, 209*(3), 203–214.

Doumpos, M., & Zopounidis, C. (2011b). A multicriteria outranking modeling approach for credit rating. *Decision Sciences, 42*(3), 721–742.

Dubois, D., Fargier, H., Perny, P., & Prade, H. (2003). A characterization of generalized concordance rules in multicriteria decision making. *International Journal of Intelligent Systems, 18*(7), 751–774.

Duckstein, L., Gershon, M., & McAniff, R. (1982). Model selection in multiobjective decision making for river basin planning. *Advances in Water Resources, 5*(3), 178–184.

Duckstein, L., & Opricovic, S. (1980). Multiobjective optimization in river basin development. *Water Resources Research, 16*(1), 14–20.

Duckstein, L., Treichel, W., & Elmagnouni, S. (1994). Ranking groundwater-management alternatives by multicriterion analysis. *Journal of Water Resources Planning and Management, 120*(4), 546–565.

El Hanandeh, A., & El-Zein, A. (2010). The development and application of multi-criteria decision-making tool with consideration of uncertainty: The selection of a management strategy for the bio-degradable fraction in the municipal solid waste. *Bioresource Technology, 101*(2), 555–561.

Elshorbagy, A. (2006). Multicriterion decision analysis approach to assess the utility of watershed modeling for management decisions. *Water Resources Research, 42*(9), 1–14.

Ergazakis, K., Metaxiotis, K., Psarras, J., & Askounis, D. (2007). An integrated decision support model for a knowledge city's strategy formulation. *Journal of Knowledge Management, 11*(5), 65–86.

Farahani, R. Z., SteadieSeifi, M., & Asgari, N. (2010). Multiple criteria facility location problems: A survey. *Applied Mathematical Modelling, 34*(7), 1689–1709.

Fernandez, E., Lopez, E., Bernal, S., Coello, C. A. C., & Navarro, J. (2010). Evolutionary multiobjective optimization using an outranking-based dominance generalization. *Computers & Operations Research, 37*(2), 390–395.

Fernandez, E., Navarro, J., & Bernal, S. (2009). Multicriteria sorting using a valued indifference relation under a preference disaggregation paradigm. *European Journal of Operational Research, 198*(2), 602–609.

Fernandez, E., Navarro, J., & Duarte, A. (2008). Multicriteria sorting using a valued preference closeness relation. *European Journal of Operational Research, 185*(2), 673–686.

Fernandez, E., Navarro, J., & Mazcorro, G. (2012). Evolutionary multi-objective optimization for inferring outranking model's parameters under scarce reference information and effects of reinforced preference. *Foundations of Computing and Decision Sciences, 37*(3), 163–167.

Fettaka, S., Gupta, Y. P., & Thibault, J. (2012). Multiobjective optimization of an industrial styrene reactor using the dual population evolutionary algorithm (DPEA). *International Journal of Chemical Reactor Engineering, 10* (1, Article A9).

Fichefet, J., Leclercq, J. P., Beyne, P., & Piette, F. F. R. (1984). Microcomputer-assisted identification of bacteria and multicriteria decision models. *Computers & Operations Research, 11*(4), 361–372.

Figueira, J. R., Almeida-Dias, J., Matias, S., Roy, B., Carvalho, M. J., & Plancha, C. E. (2011). Electre Tri-C, a multiple criteria decision aiding sorting model applied to assisted reproduction. *International Journal of Medical Informatics, 80*(4), 262–273.

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*(2), 478–495.

Figueira, J., Greco, S., Roy, B., & Słowiński, R. (2010). ELECTRE methods: Main features and recent developments. In P. M. Pardalos, D. Hearn, & C. Zopounidis (Eds.), *Handbook of multicriteria analysis. Applied optimization* (pp. 51–89). Berlin: Springer.

Figueira, J. R., Greco, S., Roy, B., & Slowinski, R. (2013). An overview of ELECTRE methods and their recent extensions. *Journal of Multi-Criteria Decision Analysis, 20*(1–2), 61–85.

Figueira, J., Mousseau, V., & Roy, B. (2005). ELECTRE methods. In J. Figueira, S. Greco, & M. Ehrgott (Eds.), *Multiple criteria decision analysis: State of the art surveys* (pp. 133–153). New York: Springer.

Figueira, J. R., & Roy, B. (2002). Determining the weights of criteria in the ELECTRE type methods with a revised Simos' procedure. *European Journal of Operational Research, 139*(2), 317–326.

Figueira, J. R., & Roy, B. (2009). A note on the paper, "Ranking irregularities when evaluating alternatives by using some ELECTRE methods", by Wang and Triantaphyllou, Omega (2008). *Omega, 37*(3), 731–733.

Floc'hlay, B., & Plottu, E. (1998). Democratic evaluation: From empowerment evaluation to public decision-making. *Evaluation, 4*(3), 261–277.

Fonteix, C., Massebeuf, S., Pla, F., & Kiss, L. N. (2004). Multicriteria optimization of an emulsion polymerization process. *European Journal of Operational Research, 153*(2), 350–359.

Frenette, C. D., Beauregard, R., Abi-Zeid, I., Derome, D., & Salenikovich, A. (2010). Multicriteria decision analysis applied to the design of light-frame wood wall assemblies. *Journal of Building Performance Simulation, 3*(1), 33–52.

Galzim, O., Mansilla, C., Giaconia, A., Poitou, S., Hinkley, J., Ebbesen, S. D., et al. (2011). A multicriteria approach for evaluating high temperature hydrogen production processes. *International Journal of Multicriteria Decision Making, 1*(2), 177–204.

Ganoulis, J. (2003). Evaluating alternative strategies for wastewater recycling and reuse in the Mediterranean area. *Water Science Technology: Water Supply, 3*(4), 11–19.

Georgopoulou, E., Lalas, D., & Papagiannakis, L. (1997). A multicriteria decision aid approach for energy planning problems: The case of renewable energy option. *European Journal of Operational Research, 103*(1), 38–54.

Gershon, M. (1984). The role of weights and scales in the application of multiobjective decision making. *European Journal of Operational Research, 15*(2), 244–250.

Gershon, M., & Duckstein, L. (1983). Multiobjective approaches to river basin planning. *Journal of Water Resources Planning and Management, 109*(1), 13–28.

Gershon, M., & Duckstein, L. (1984). A procedure for selection of a multiobjective technique with application to water and mineral resources. *Applied Mathematics and Computation, 14*(3), 245–271.

Gershon, M., Duckstein, L., & McAniff, R. (1982). Multiobjective river basin planning with qualitative criteria. *Water Resources Research, 18*(2), 193–202.

Giuliano, G. (1985). A multicriteria method for transportation investment planning. *Transportation Research Part A: General, 19*(1), 29–41.

Gomes, L. F. A. M., Rangel, L. A. D., & Moreira, R. A. (2009). Using ELECTRE IV in the promotion of social and economic development: A case study in Rio de Janeiro. *Foundations of Computing and Decision Sciences, 34*, 155–172.

Gomez, A., & Carnero, M. C. (2011). Selection of a computerised maintenance management system: A case study in a regional health service. *Production Planning & Control, 22*(4), 426–436.

Govindan, K. (2013). Vendor managed inventory: A review based on dimensions. *International Journal of Production Research, 51*(13), 3808–3835.

Govindan, K., Soleimani, H., & Kannan, D. (2015). Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future. *European Journal of Operational Research, 240*(3), 603–626.

Greco, S., Predki, B., & Slowinski, R. (2002). Searching for an equivalence between decision rules and concordance-discordance preference model in multicriteria choice problems. *Control and Cybernetics, 31*(4), 921–935.

Greco, S., Kadzinski, M., Mousseau, V., & Slowinski, R. (2011). ELECTREGKMS: Robust ordinal regression for outranking methods. *European Journal of Operational Research, 214*(1), 118–135.

Guerra, M. A., Viguri, J. R., & Voulvoulis, N. (2009). A multicriteria-based methodology for site prioritisation in sediment management. *Environment International, 35*(6), 920–930.

Guigou, J. L. (1971a). On French location models for production units—Part 2. *Regional and Urban Economics, 1*(3), 289–316.

Guigou, J. L. (1971b). On French location models for production units. *Regional and Urban Economics, 1*(2), 107–138.

Guitouni, A., & Martel, J. M. (1998). Tentative guidelines to help choosing an appropriate MCDA method. *European Journal of Operational Research, 109*(2), 501–521.
Guitouni, A., Martel, J. M., Bélanger, M., & Hunter, C. (2008). Multiple criteria courses of action selection. *Military Operations Research, 13*(1), 35–50.
Guo, Y. (2010). A decision method for m-commerce partner selection based on AHP/ELECTRE I. *Journal of Computational Information Systems, 6*(9), 3077–3086.
Gurmeric, V. E., Dogan, M., Toker, O. S., Senyigit, E., & Ersoz, N. B. (2012). Application of different multi-criteria decision techniques to determine optimum flavour of prebiotic pudding based on sensory analyses. *Food and Bioprocess Technology, 6*(10), 1–16.
Hajkowicz, S. (2007). A comparison of multiple criteria analysis and unaided approaches to environmental decision making. *Environmental Science & Policy, 10*(3), 177–184.
Hajkowicz, S., & Collins, K. (2007). A review of multiple criteria analysis for water resource planning and management. *Water Resources Management, 21*(9), 1553–1566.
Halsall-Whitney, H., Taylor, D., & Thibault, J. (2003). Multicriteria optimization of gluconic acid production using net flow. *Bioprocess and Biosystems Engineering, 25*(5), 299–307.
Hansen, D. R., & Goicoechea, A. (1979). Management of flooding in a fully-developed low-cost housing neighborhood," by J. I. Novoa and A. H. Halff. *Water Resources Bulletin, 15*(3), 880–883.
Haurant, P., Oberti, P., & Muselli, M. (2011). Multicriteria selection aiding related to photovoltaic plants on farming fields on Corsica island: A real case study using the ELECTRE outranking framework. *Energy Policy, 39*(2), 676–688.
Herva, M., & Roca, E. (2013). Review of combined approaches and multi-criteria analysis for corporate environmental evaluation. *Journal of Cleaner Production, 39*, 355–371.
Hobbs, B. F. (1986). What can we learn from experiments in multiobjective decision analysis? *IEEE Transactions on Systems, Man and Cybernetics, 16*(3), 384–394.
Hobbs, B. F., Chankong, V., Hamadeh, W., & Stakhiv, E. Z. (1992). Does choice of multicriteria method matter? An experiment in water resources planning. *Water Resources Research, 28*(7), 1767–1779.
Hokkanen, J., & Salminen, P. (1997a). ELECTRE III and IV decision aids in an environmental problem. *Journal of Multi-Criteria Decision Analysis, 6*(4), 215–226.
Hokkanen, J., & Salminen, P. (1997b). Choosing a solid waste management system using multicriteria decision analysis. *European Journal of Operational Research, 98*(1), 19–36.
Huang, I. B., Keisler, J., & Linkov, I. (2011). Multi-criteria decision analysis in environmental sciences: Ten years of applications and trends. *Science of the Total Environment, 409*(19), 3578–3594.
Huck, N. (2009). Pairs selection and outranking: An application to the S&P 100 index. *European Journal of Operational Research, 196*(2), 819–825.
Huck, N. (2010). Pairs trading and outranking: The multi-step-ahead forecasting case. *European Journal of Operational Research, 207*(3), 1702–1716.
Hurson, C., & Zopounidis, C. (1995). On the use of multicriteria decision aid methods to portfolio selection. *Journal of Euro-Asian Management, 1*(2), 69–94.
Hwang, C. L., & Yoon, K. (1981). *Multiple attribute decision making: Methods and applications, a state-of-the-art survey*. Berlin/Heidelberg, New York: Springer-Verlag.
Infante, C. E. D. d., Mendonca, F. M. d., Purcidonio, P. M., & Valle, R. (2013). Triple bottom line analysis of oil and gas industry with multicriteria decision making. *Journal of Cleaner Production, 52*, 289–300.
Jacquet-Lagreze, E. (1982). Binary preference indices: A new look on multicriteria aggregation procedures. *European Journal of Operational Research, 10*(1), 26–32.
Jacquet-Lagreze, E., & Siskos, Y. (2001). Preference disaggregation: 20 years of MCDA experience. *European Journal of Operational Research, 130*(2), 233–245.
Jahan, A., Ismail, M. Y., Sapuan, S. M., & Mustapha, F. (2010). Material screening and choosing methods—A review. *Materials & Design, 31*(2), 696–705.
Jeffreys, I. (2004). The use of compensatory and non-compensatory multi-criteria analysis for small-scale forestry. *Small-Scale Forestry, 3*(1), 99–117.
Ka, B. (2011). Application of fuzzy AHP and ELECTRE to China dry port location selection. *Asian Journal of Shipping and Logistics, 27*(2), 331–353.
Kabir, G., Sadiq, R., & Tesfamariam, S. (2013). A review of multi-criteria decision-making methods for infrastructure management. *Structure and Infrastructure Engineering, 10*(9), 1176–1210.
Kadzinski, M., Greco, S., & Slowinski, R. (2012). Selection of a representative set of parameters for robust ordinal regression outranking methods. *Computers & Operations Research, 39*(11), 2500–2519.
Kangas, J., Kangas, A., Leskinen, P., & Pykäläinen, J. (2001a). MCDM methods in strategic planning of forestry on state-owned lands in Finland: Applications and experiences. *Journal of Multi-Criteria Decision Analysis, 10*(5), 257–271.
Kangas, A., Kangas, J., & Pykäläinen, J. (2001b). Outranking methods as tools in strategic natural resources planning. *Silva Fennica, 35*(2), 215–227.
Kaplan, S., Araz, C., & Goktepe, O. (2006). A multicriteria decision aid approach on navel selection problem for rotor spinning. *Textile Research Journal, 76*(12), 896–904.
Karagiannidis, A., & Perkoulidis, G. (2009). A multi-criteria ranking of different technologies for the anaerobic digestion for energy recovery of the organic fraction of municipal solid wastes. *Bioresource Technology, 100*(8), 2355–2360.
Karakosta, C., Doukas, H., & Psarras, J. (2008). A decision support approach for the sustainable transfer of energy technologies under the kyoto protocol. *American Journal of Applied Sciences, 5*(12), 1720–1729.
Karakosta, C., Doukas, H., & Psarras, J. (2009). Directing clean development mechanism towards developing countries' sustainable development priorities. *Energy for Sustainable Development, 13*(2), 77–84.
Keller, H. R., Massart, D. L., & Brans, J. P. (1991). Multicriteria decision making: A case study. *Chemometrics and Intelligent Laboratory Systems, 11*(2), 175–189.
Kiker, G. A., Bridges, T. S., Varghese, A., Seager, P. T., & Linkov, I. (2005). Application of multicriteria decision analysis in environmental decision making. *Integrated Environmental Assessment and Management, 1*(2), 95–108.
Kiss, L. N., Martel, J. M., & Nadeau, R. (1994). ELECCALC: An interactive software for modelling the decision maker's preferences. *Decision Support Systems, 12*(4–5), 311–326.
Kiss, L. N., Zaras, K., Fonteix, C., & Dominique, C. R. (2002). Multicriteria modelling and decision engineering of a chemical extrusion process. *ASOR Bulletin, 21*(2), 2–8.
Köksalan, M., Wallenius, J., & Zionts, S. (2011). *Multiple criteria decision making. From early history to the 21st century*. Singapore: World Scientific Publishing Co. Pte. Ltd.
Krzysztofowicz, R., Castano, E., & Fike, R. L. (1977). Comment on 'A review and evaluation of multiobjective programing techniques' by Jared L. Cohon and David H. Marks. *Water Resources Research, 13*(3), 690–692.
Laforest, V., Raymond, G., & Piatyszek, E. (2013). Choosing cleaner and safer production practices through a multi-criteria approach. *Journal of Cleaner Production, 47*, 490–503.
Lahdelma, R., & Salminen, P. (2002). Pseudo-criteria versus linear utility function in stochastic multi-criteria acceptability analysis. *European Journal of Operational Research, 141*(2), 454–469.
Lahdelma, R., Salminen, P., & Hokkanen, J. (2000). Using multicriteria methods in environmental planning and management. *Environmental Management, 26*(6), 595–605.
Lai, E., Lundie, S., & Ashbolt, N. J. (2008). Review of multi-criteria decision aid for integrated sustainability assessment of urban water systems. *Urban Water Journal, 5*(4), 315–327.
Le Gauffre, P., Haidar, H., Poinard, D., Laffrechine, K., Baur, R., & Schiatti, M. (2007). A multicriteria decision support methodology for annual rehabilitation programs of water networks. *Computer-Aided Civil and Infrastructure Engineering, 22*(7), 478–488.
Lendaris, G. G. (1980). Structural modeling a tutorial guide. *IEEE Transactions on Systems, Man and Cybernetics, 10*(12), 807–840.
Leyva-Lopez, J. C. (2005). Multicriteria decision aid application to a student selection problem. *Pesquisa Operacional, 25*(1), 45–68.
Leyva-Lopez, J. C., & Fernandez-Gonzales, E. (1999). A genetic algorithm for deriving final ranking from a fuzzy outranking relation. *Foundations of Computing and Decision Sciences, 24*(1), 33–47.
Leyva-Lopez, J. C., & Fernandez-Gonzalez, E. (2003). A new method for group decision support based on ELECTRE III methodology. *European Journal of Operational Research, 148*(1), 14–27.
Leyva-Lopez, J. C., & Sanchez, L. D. (2005). A new decision support system for rank a finite set of multicriteria alternatives. *Investigacion Operacional, 26*(3), 1–11.
Leyva-Lopez, J. C., Sanchez, L. D., & Contreras, M. A. A. (2008). A multicriteria decision support system with an evolutionary algorithm for deriving final ranking from a fuzzy outranking relation. *Operational Research—An International Journal, 8*(1), 47–62.
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*(1), 214–224.
Li, H. L. (1987). Solving discrete multicriteria decision problems based on logic-based decision support systems. *Decision Support Systems, 3*(2), 101–119.
Linstone, H. A., Lendaris, G. G., Rogers, S. D., Wakeland, W., & Williams, M. (1979). The use of structural modeling for technology assessment. *Technological Forecasting and Social Change, 14*(4), 291–327.
Liou, J. J. H., & Tzeng, G. H. (2012). Comments on "Multiple criteria decision making (MCDM) methods in economics: An overview". *Technological & Economic Development of Economy, 18*(4), 672–695.
Løken, E. (2007). Use of multicriteria decision analysis methods for energy planning problems. *Renewable and Sustainable Energy Reviews, 11*(7), 1584–1595.
Lootsma, F. A. (1990). The French and the American school in multi-criteria decision analysis. *Revue Française d'Informatique et de Recherche Opérationnelle, 24*(3), 263–285.
Lourenco, R. P., & Costa, J. P. (2004). Using ELECTRE TRI outranking method to sort MOMILP nondominated solutions. *European Journal of Operational Research, 153*(2), 271–289.
Macary, F., Ombredane, D., & Uny, D. (2010). A multicriteria spatial analysis of erosion risk into small watersheds in the low Normandy bocage (France) by ELECTRE III method coupled with a GIS. *International Journal of Multicriteria Decision Making, 1*(1), 25–48.
Madlener, R., Antunes, C. H., & Dias, L. C. (2009). Assessing the performance of biogas plants with multi-criteria and data envelopment analysis. *European Journal of Operational Research, 197*(3), 1084–1094.
Malczewski, J. (2006). GIS-based multicriteria decision analysis: A survey of the literature. *International Journal of Geographical Information Science, 20*(7), 703–726.
Marbini, A. H., & Tavana, M. (2011). An extension of the Electre I method for group decision-making under a fuzzy environment. *Omega, 39*(4), 373–386.
Marbini, A. H., Tavana, M., Moradi, M., & Kangi, F. (2013). A fuzzy group Electre method for safety and health assessment in hazardous waste recycling facilities. *Safety Science, 51*(1), 414–426.
Marchant, T. (2007). An axiomatic characterization of different majority concepts. *European Journal of Operational Research, 179*(1), 160–173.
Martel, J. M., & D'Avignon, G. R. (1982). Projects ordering with multicriteria analysis. *European Journal of Operational Research, 10*(1), 56–69.

Martel, J. M., D'Avignon, G. R., & Couillard, J. (1986). A fuzzy outranking relation in multicriteria decision making. *European Journal of Operational Research, 25*(2), 258–271.

Martel, J. M., Khoury, N. T., & Bergeron, M. (1988). An application of a multicriteria approach to portfolio comparisons. *Journal of the Operational Research Society, 39*(7), 617–628.

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*(1), 338–349.

Massam, B. H., & Wang, B. (2002). An application of DEFINITE: The quality of life of Chinese seniors in four districts of Toronto. *Journal of Geographic Information and Decision Analysis, 6*(1), 57–66.

Massebeuf, S., Fonteix, C., Hoppe, S., & Pla, F. (2003). Development of new concepts for the control of polymerization processes: Multiobjective optimization and decision engineering. I. Application to emulsion homopolymerization of styrene. *Journal of Applied Polymer Science, 87*(14), 2383–2396.

Mastrogiannis, N., Boutsinas, B., & Giannikos, I. (2009). A method for improving the accuracy of data mining classification algorithms. *Computers & Operations Research, 36*(10), 2829–2839.

Matsatsinis, N. F. (2002). An intelligent decision support system for credit card assessment based on a machine learning technique. *Operational Research—An International Journal, 2*(2), 243–260.

Meier, K. (1997). Methods for decision making with cardinal numbers and additive aggregation. *Fuzzy Sets and Systems, 88*(2), 135–159.

Mendas, A., Delali, A., Khalfallah, M., Likou, L., Gacemi, M. A., Boukrentach, H., Djilali, A., & Mahmoudi, R. (2014). Improvement of land suitability assessment for agriculture—application in Algeria. *Arabian Journal of Geosciences, 7*(2), 435–445.

Mendoza, G. A., & Martins, H. (2006). Multi-criteria decision analysis in natural resource management: A critical review of methods and new modelling paradigms. *Forest Ecology and Management, 230*(1–3), 1–22.

Merad, M. M., Verdel, T., Roy, B., & Kouniali, S. (2004). Use of multi-criteria decision-aids for risk zoning and management of large area subjected to mining-induced hazards. *Tunnelling and Underground Space Technology, 19*(2), 125–138.

Miettinen, K., & Salminen, P. (1999). Decision-aid for discrete multiple criteria decision making problems with imprecise data. *European Journal of Operational Research, 119*(1), 50–60.

Moffett, A., & Sarkar, S. (2006). Incorporating multiple criteria into the design of conservation area networks: A minireview with recommendations. *Diversity and Distributions, 12*(2), 125–137.

Montazer, G. A., Saremi, H. Q., & Ramezani, M. (2009). Design a new mixed expert decision aiding system using fuzzy ELECTRE III method for vendor selection. *Expert Systems with Applications, 36*(8), 10837–10847.

Moriki, A., & Karydis, M. (1994). Application of multicriteria choice-methods in assessing eutrophication. *Environmental Monitoring and Assessment, 33*(1), 1–18.

Morrissey, A. J., & Browne, J. (2004). Waste management models and their application to sustainable waste management. *Waste Management, 24*(3), 297–308.

Mousseau, V., & Dias, L. (2004). Valued outranking relations in ELECTRE providing manageable disaggregation procedures. *European Journal of Operational Research, 156*(2), 467–482.

Mousseau, V., Dias, L. C., & Figueira, J. (2006). Dealing with inconsistent judgments in multiple criteria sorting models. *4OR, 4*(2), 145–158.

Mousseau, V., Figueira, J., Dias, L., Gomes da Silva, C., & Clímaco, J. (2003). Resolving inconsistencies among constraints on the parameters of an MCDA model. *European Journal of Operational Research, 147*(1), 72–93.

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*(2), 263–275.

Mousseau, V., & Slowinski, R. (1998a). Inferring an ELECTRE TRI model from assignment examples. *Journal of Global Optimization, 12*(2), 157–174.

Mousseau, V., & Slowinski, R. (1998b). Inferring an ELECTRE TRI model from assignment examples. *Journal of Global Optimization, 12*(2), 157–174.

Mousseau, V., Slowinski, R., & Zielniewicz, P. (2000). A user-oriented implementation of the ELECTRE-TRI method integrating preference elicitation support. *Computers & Operations Research, 27*(7–8), 757–777.

Mröz, T. M., & Thiel, T. (2005). Evaluation of a heating system for buildings using multiple criteria decision analysis. *Archives of Civil Engineering, 51*(2), 281–298.

Mun, D., & Ramani, K. (2011). Knowledge-based part similarity measurement utilizing ontology and multi-criteria decision making technique. *Advanced Engineering Informatics, 25*(2), 119–130.

Mysiak, J. (2006). Consistency of the results of different MCA methods: A critical review. *Environment and Planning C: Government and Policy, 24*(2), 257–277.

Ngo-The, A., & Mousseau, V. (2002). Using assignment examples to infer category limits for the ELECTRE TRI method. *Journal of Multi-Criteria Decision Analysis, 11*(1), 29–43.

Ngo-The, A., & Ruhe, G. (2008). A systematic approach for solving the wicked problem of software release planning. *Soft Computing, 12*(1), 95–108.

Nijkamp, P. (1975). A multicriteria analysis for project evaluation: Economic-ecological evaluation of a land reclamation project. *Papers of the Regional Science Association, 35*(1), 87–111.

Nijkamp, P., & Vos, J. B. (1977). A multicriteria analysis for water resource and land use development. *Water Resources Research, 13*(3), 513–518.

Norese, M. F. (2006). ELECTRE III as a support for participatory decision-making on the localisation of waste-treatment plants. *Land Use Policy, 23*(1), 76–85.

Norese, M. F., & Toso, F. (2004). Group decision and distributed technical support. *International Transactions in Operational Research, 11*(4), 395–417.

Nowak, M. (2004). Preference and veto thresholds in multicriteria analysis based on stochastic dominance. *European Journal of Operational Research, 158*(2), 339–350.

Ok, K., Okan, T., & Yilmaz, E. (2011). A comparative study on activity selection with multicriteria decision-making techniques in ecotourism planning. *Scientific Research and Essays, 6*(6), 1417–1427.

Oktem, R., & Ergul, N. (2012). Testing Electre-III method in stock selection. *Journal of Money, Investment and Banking, 24*, 17–26.

Oliveira, E., Antunes, C. H., & Gomes, A. (2011). Incorporation of preferences in an evolutionary algorithm using an outranking relation: The EvABOR approach. *International Journal of Natural Computing Research, 2*(1), 63–85.

Oliveira, E., Antunes, C. H., & Gomes, A. (2013). A comparative study of different approaches using an outranking relation in a multi-objective evolutionary algorithm. *Computers & Operations Research, 40*(6), 1602–1615.

Ondrus, J., & Pigneur, Y. (2009). Near field communication: An assessment for future payment systems. *Information Systems and e-Business Management, 7*(3), 347–361.

Opperhuizen, A., & Hutzinger, O. (1982). Multi-criteria analysis and risk assessment. *Chemosphere, 11*(7), 675–678.

Opricovic, S., & Tzeng, G. H. (2007). Extended VIKOR method in comparison with outranking methods. *European Journal of Operational Research, 178*(2), 514–529.

Parsaei, H. R., Wilhelm, M. R., & Kolli, S. S. (1993). Application of outranking methods to economic and financial justificaton of CIM systems. *Computers & Industrial Engineering, 25*(1–4), 357–360.

Paschetta, E., & Tsoukias, A. (2000). A real-world MCDA application: Evaluating software. *Journal of Multi-Criteria Decision Analysis, 9*(5), 205–226.

Pauwels, D., Lejeune, P., & Rondeux, J. (2007). A decision support system to simulate and compare silvicultural scenarios for pure even-aged larch stands. *Annals of Forest Science, 64*(3), 345–353.

Pavlicic, D. M. (2000). Normalization of attribute values in MADM violates the conditions of consistent choice IV, DI and α. *Yugoslav Journal of Operations Research, 10*(1), 109–122.

Pavlicic, D. M. (2001). Normalisation affects the results of MADM methods. *Yugoslav Journal of Operations Research, 11*(2), 251–265.

Pedras, C. M. G., & Pereira, L. S. (2009). Multicriteria analysis for design of microirrigation systems. Application and sensitivity analysis. *Agricultural Water Management, 96*(4), 702–710.

Perkoulidis, G., Papageorgiou, A., Karagiannidis, A., & Kalogirou, S. (2010). Integrated assessment of a new Waste-to-Energy facility in Central Greece in the context of regional perspectives. *Waste Management, 30*(7), 1395–1406.

Perny, P., & Roy, B. (1992). The use of fuzzy outranking relations in preference modelling. *Fuzzy Sets and Systems, 49*(1), 33–53.

Petrovic, M., Bojkovic, N., Anic, I., & Petrovic, D. (2012). Benchmarking the digital divide using a multi-level outranking framework: Evidence from EBRD countries of operation. *Government Information Quarterly, 29*(4), 597–607.

Pires, T. T., de Almeida, A. T., & Duarte, D. C. L. (2005). A decision-aided fire risk analysis. *Fire Technology, 41*(1), 25–35.

Pirlot, M. (1995). A characterization of 'min' as a procedure for exploiting valued preference relations and related results. *Journal of Multi-Criteria Decision Analysis, 4*(1), 37–56.

Pirlot, M. (1997). A common framework for describing some outranking methods. *Journal of Multi-Criteria Decision Analysis, 6*(2), 86–92.

Poh, K. L. (1998). A knowledge-based guidance system for multi-attribute decision making. *Artificial Intelligence in Engineering, 12*(3), 315–326.

Pohekar, S. D., & Ramachandran, M. (2004). Application of multi-criteria decision making to sustainable energy planning—A review. *Renewable and Sustainable Energy Reviews, 8*(4), 365–381.

Polatidis, H., Haralambopoulos, D. A., Munda, G., & Vreeker, R. (2006). Selecting an appropriate multi-criteria decision analysis technique for renewable energy planning. *Energy Sources, Part B: Economics, Planning, and Policy, 1*(2), 181–193.

Proulx, F., Rodriguez, M. J., Sérodes, J., & Bouchard, C. (2007). A methodology for identifying vulnerable locations to taste and odour problems in a drinking water system. *Water Science and Technology, 55*(5), 177–183.

Quéméner, L., Suquet, M., Mero, D., & Gaignon, J. L. (2002). Selection method of new candidates for finfish aquaculture: The case of the French Atlantic, the Channel and the North Sea coasts. *Aquatic Living Resources, 15*(5), 293–302.

Raju, K. S., Duckstein, L., & Arondel, C. (2000). Multicriterion analysis for sustainable water resources planning: A case study in Spain. *Water Resources Management, 14*(6), 435–456.

Ramos, J. M. M., Garcia, D. L., Gómez-Bravo, F., & Morón, A. B. (2010). Application of multicriteria decision-making techniques to manoeuvre planning in nonholonomic robots. *Expert Systems with Applications, 37*(5), 3962–3976.

Rangel, L. A. D., Gomes, L. F. A. M., & Moreira, R. A. (2009). Decision theory with multiple criteria: An application of electre iv and todim to Sebrae/RJ. *Pesquisa Operacional, 29*(3), 577–590.

Rehman, T., & Romero, C. (1993). The application of the MCDM paradigm to the management of agricultural systems: Some basic considerations. *Agricultural Systems, 41*(3), 239–255.

Renaud, J., Thibault, J., Lanouette, R., Kiss, L. N., Zaras, K., & Fonteix, C. (2007). Comparison of two multicriteria decision aid methods: Net Flow and Rough Set Methods in a high yield pulping process. *European Journal of Operational Research, 177*(3), 1418–1432.

Rigopoulos, G., & Anagnostopoulos, K. (2010). Fuzzy multicriteria assignment for nominal classification: Methodology and application in evaluation of Greek Bank's electronic payment retailers. *International Journal of Information Technology & Decision Making, 9*(3), 437–454.

Rigopoulos, G., Askounis, D. T., & Metaxiotis, K. (2010). NeXClass: A decision support system for non-ordered multicriteria classification. *International Journal of Information Technology & Decision Making, 9*(1), 53–79.

Rigopoulos, G., Psarras, J., & Askounis, D. T. (2008a). A decision support system for supervised assignment in banking decisions. *Journal of Applied Sciences, 8*(3), 443–452.

Rigopoulos, G., Psarras, J., & Askounis, D. T. (2008b). Fuzzy assignment procedure based on categories' boundaries. *American Journal of Applied Sciences, 5*(7), 844–851.

Rocha, C., & Dias, L. C. (2008). An algorithm for ordinal sorting based on ELECTRE with categories defined by examples. *Journal of Global Optimization, 42*(2), 255–277.

Rogers, M. G., & Bruen, M. P. (1996). Using electre to rank options within an environmental appraisal: Two case studies. *Civil Engineering Systems, 13*(3), 203–221.

Rogers, M., & Bruen, M. (1998a). Choosing realistic values of indifference, preference and veto thresholds for use with environmental criteria within ELECTRE. *European Journal of Operational Research, 107*(3), 542–551.

Rogers, M., & Bruen, M. (1998b). A new system for weighting environmental criteria for use within ELECTRE III. *European Journal of Operational Research, 107*(3), 552–563.

Rogers, M., & Bruen, M. (2000). Using ELECTRE III to choose route for Dublin port motorway. *Journal of Transportation Engineering, 126*(4), 313–323.

Rotter, P. (2014). Relevance feedback based on n-tuplewise comparison and the ELECTRE methodology and an application in content-based image retrieval. *Multimedia Tools and Applications, 72*(1), 667–685.

Roulet, C. A., Flourentzou, F., Labben, H. H., Santamouris, M., Koronaki, I., Dascalaki, E., et al. (2002). ORME: A multicriteria rating methodology for buildings. *Building and Environment, 37*(6), 579–586.

Roy, B. (1968). Classement et choix en presence de points de vue multiples (La methode ELECTRE). *Revue Francaise D Informatique de Recherche Operationnelle, 2*(8), 57–75.

Roy, B. (1971). Problems and methods with multiple objective functions. *Mathematical Programming, 1*(1), 239–266.

Roy, B. (1977). A conceptual framework for a prescriptive theory of Decision Aid. In M. K. Starr, & M. Zeleny (Eds.), *Multiple criteria decision making* (pp. 179–210). North-Holland Publishing Company.

Roy, B. (1978). ELECTRE III: Un algorithme de classements fondé sur une représentation floue des préférences en présence de critères multiples. *Cahiers du Centre d'Etudes de Recherche Opérationnelle, 20*(1), 3–24.

Roy, B. (1990). Decision-aid and decision-making. *European Journal of Operational Research, 45*(2–3), 324–331.

Roy, B. (1991). The outranking approach and the foundations of electre methods. *Theory and Decision, 31*(1), 49–73.

Roy, B. (1996). *Multicriteria methodology for decision aiding*. Dordrecht: Kluwer Academic Publishers Original version in French: Méthodologie multicritère d'aide à la décision, Paris, Economica, 1985.

Roy, B., & Bertier, P. (1971). La méthode ELECTRE II. Note de travail 142. SEMA-METRA. Metra-International

Roy, B., & Bouyssou, D. (1986). Comparison of two decision-aid models applied to a nuclear power plant siting example. *European Journal of Operational Research, 25*(2), 200–215.

Roy, B., & Bouyssou, D. (1993). *Aide multicritère à la décision: Méthodes et cas*. Paris, France: Economica.

Roy, B., & Hugonnard, J. C. (1982). Ranking of suburban line extension projects on the Paris metro system by a multicriteria method. *Transportation Research Part A: General, 16*(4), 301–312.

Roy, B., & Mousseau, V. (1996). A theoretical framework for analysing the notion of relative importance of criteria. *Journal of Multi-Criteria Decision Analysis, 5*(2), 145–159.

Roy, B., Present, M., & Silhol, D. (1986). A programming method for determining which Paris metro stations should be renovated. *European Journal of Operational Research, 24*(2), 318–334.

Roy, B., & Slowinski, R. (1993). Criterion of distance between technical programming and socio-economic priority. *Revue Française d'Informatique et de Recherche Opérationnelle, 27*(1), 45–60.

Roy, B., & Slowinski, R. (2008). Handling effects of reinforced preference and counter-veto in credibility of outranking. *European Journal of Operational Research, 188*(1), 185–190.

Roy, B., & Słowiński, R. (2013). Questions guiding the choice of a multicriteria decision aiding method. *EURO Journal on Decision Processes, 1*(1–2), 69–97.

Roy, B., Slowinski, R., & Treichel, W. (1992). Multicriteria programming of water supply systems for rural areas. *Water Resources Bulletin, 28*(1), 13–31.

Roy, B., & Vanderpooten, D. (1996a). Response to F. A. Lootsma's comments on our paper 'The European School of MCDA: Emergence, Basic Features and Current Works'. *Journal of Multi-Criteria Decision Analysis, 5*(2), 165–166.

Roy, B., & Vanderpooten, D. (2007b). The European school of MCDA: Emergence, basic features and current works. *Journal of Multi-Criteria Decision Analysis, 5*(1), 22–38.

Roy, B., & Vincke, P. (1981). Multicriteria analysis: Survey and new directions. *European Journal of Operational Research, 8*(3), 207–218.

Roy, B., & Vincke, P. (1984). Relational systems of preference with one or more pseudo-criteria: Some new concepts and results. *Management Science, 30*(11), 1323–1335.

Rutman, E., Inard, C., Bailly, A., & Allard, F. (2005). A global approach of indoor environment in an air-conditioned office room. *Building and Environment, 40*(1), 29–37.

Sadok, W., Angevin, F., Bergez, J.-E., Bockstaller, C., Colomb, B., Guichard, L., et al. (2008). Ex ante assessment of the sustainability of alternative cropping systems: Implications for using multi-criteria decision-aid methods. A review. *Agronomy for Sustainable Development, 28*(1), 163–174.

Salminen, P., Hokkanen, J., & Lahdelma, R. (1998). Comparing multicriteria methods in the context of environmental problems. *European Journal of Operational Research, 104*(3), 485–496.

Sawicka, H., Weglinski, S., & Witort, P. (2010). Application of multiple criteria decision aid methods in logistic systems. *LogForum, 6*(3, Article 10), 99–110.

Scarelli, A., & Narula, S. C. (2002). A multicriteria assignment problem. *Journal of Multi-Criteria Decision Analysis, 11*(2), 65–74.

Scott, J. A., Ho, W., & Dey, P. K. (2012). A review of multi-criteria decision-making methods for bioenergy systems. *Energy, 42*(1), 146–156.

Shanian, A., & Savadogo, O. (2006a). A non-compensatory compromised solution for material selection of bipolar plates for polymer electrolyte membrane fuel cell (PEMFC) using ELECTRE IV. *Electrochimica Acta, 51*(25), 5307–5315.

Shanian, A., & Savadogo, O. (2006b). ELECTRE I decision support model for material selection of bipolar plates for Polymer Electrolyte Fuel Cells applications. *Journal of New Materials for Electrochemical Systems, 9*(3), 191–199.

Shanian, A., & Savadogo, O. (2006). Using multi-pseudocriteria and fuzzy outranking relation analysis for material selection of bipolar plates for PEFCs. *Journal of the Electrochemical Society, 153*(5), A887–A896.

Silva, V. B. S., Morais, D. C., & de Almeida, A. T. (2010). Prioritizing complex issues of hydrographic basin committees by group decision approach. *Brazilian Journal of Operations & Production Management, 7*(1), 123–139.

Simpson, L. (1996). Do decision makers know what they prefer?: MAVT and ELECTRE II. *Journal of the Operational Research Society, 47*(7), 919–929.

Siskos, J., Lombard, J., & Oudiz, A. (1986). The use of multicriteria outranking methods in the comparison of control options against a chemical pollutant. *Journal of the Operational Research Society, 37*(4), 357–371.

Siskos, J., Wäscher, G., & Winkels, H. M. (1984). Outranking approaches versus MAUT in MCDM. *European Journal of Operational Research, 16*(2), 270–271.

Siskos, Y., Grigoroudis, E., Krassadaki, E., & Matsatsinis, N. (2007). A multicriteria accreditation system for information technology skills and qualifications. *European Journal of Operational Research, 182*(2), 867–885.

Slowinski, R. (1989). Interactive multiobjective optimization based on outranking and ordinal regression. *Foundations of Control Engineering, 14*(3), 127–134.

Sobral, M. F. F., & Costa, A. P. C. S. (2012). Negotiation model for group decision with ELECTRE TRI—The ELECTRE TRI-NG. *Journal of Decision Systems, 21*(2), 121–136.

Stamelos, I., Vlahavas, I., Refanidis, I., & Tsoukiás, A. (2000). Knowledge based evaluation of software systems: A case study. *Information and Software Technology, 42*(5), 333–345.

Stewart, T. J. (1992). A critical survey on the status of multiple criteria decision making theory and practice. *Omega, 20*(5–6), 569–586.

Stewart, T. J., & Losa, F. B. (2003). Towards reconciling outranking and value measurement practice. *European Journal of Operational Research, 145*(3), 645–659.

Swenson, P. A., & McCahon, C. S. (1991). A MADM justification of a budget reduction decision. *Omega, 19*(6), 539–548.

Tavares, L. V. (2012). An acyclic outranking model to support group decision making within organizations. *Omega, 40*(6), 782–790.

Tecle, A. (1992). Selecting a multicriterion decision making technique for watershed resources management. *Water Resources Bulletin, 28*(1), 129–140.

Tecle, A., Fogel, M., & Duckstein, L. (1988a). Multicriterion selection of wastewater management alternatives. *Journal of Water Resources Planning and Management, 114*(4), 383–398.

Tecle, A., Fogel, M. M., & Duckstein, L. (1988b). Multicriterion analysis of forest watershed management alternatives. *Water Resources Bulletin, 24*(6), 1169–1178.

Teghem, J., Delhaye, C., & Kunsch, P. L. (1989). An interactive decision support system (IDSS) for multicriteria decision aid. *Mathematical and Computer Modelling, 12*(10–11), 1311–1320.

Tervonen, T., & Figueira, J. R. (2008). A survey on stochastic multicriteria acceptability analysis methods. *Journal of Multi-Criteria Decision Analysis, 15*(1–2), 1–14.

Tervonen, T., Figueira, J. R., Lahdelma, R., Almeida-Dias, J., & Salminen, P. (2009a). A stochastic method for robustness analysis in sorting problems. *European Journal of Operational Research, 192*(1), 236–242.

Tervonen, T., Linkov, I., Figueira, J. R., Steevens, J., Chappell, M., & Merad, M. (2009b). Risk-based classification system of nanomaterials. *Journal of Nanoparticle Research, 11*(4), 757–766.

Thibault, J., Lanouette, R., Fonteix, C., & Kiss, L. N. (2002). Multicriteria optimization of a high-yield pulping process. *Canadian Journal of Chemical Engineering, 80*(5), 897–902.

Thiel, T. (2000). Application of multicriteria decision-aid methodology in building production engineering. *Statyba, 6*(6), 420–430.

Thiel, T. (2008). Determination of the relative importance of criteria when the number of people judging is a small sample. *Technological and Economic Development of Economy, 14*(4), 566–577.

Tlili, Y., & Nafi, A. (2012). A practical decision scheme for the prioritization of water pipe replacement. *Water Science and Technology: Water Supply, 12*(6), 895–917.

Triantaphyllou, E. (2000). *Multi-criteria decision making methods: A comparative study*. Dordrecht: Springer Science+Business Media.

Trojan, F., & Morais, D. C. (2012a). Prioritising alternatives for maintenance of water distribution networks: A group decision approach. *Water SA, 38*(4), 555–564.

Tsamboulas, D., Yiotis, G., & Panou, K. (1999). Use of multicriteria methods for assessment of transport projects. *Journal of Transportation Engineering, 125*(5), 407–414.

Ulubeyli, S., & Kazaz, A. (2009). A multiple criteria decision making approach to the selection of concrete pumps. *Journal of Civil Engineering and Management, 15*(4), 369–376.

Vahdani, B., Mousavi, S. M., Moghaddam, R. T., & Hashemi, H. (2013). A new design of the elimination and choice translating reality method for multi-criteria group decision-making in an intuitionistic fuzzy environment. *Applied Mathematical Modelling, 37*(4), 1781–1799.
Vaidya, O. S., & Kumar, S. (2006). Analytic hierarchy process: An overview of applications. *European Journal of Operational Research, 169*(1), 1–29.
van Delft, A., & Nijkamp, P. (1976). A multi-objective decision model for regional development, environmental quality control and industrial land use. *Papers of the Regional Science Association, 36*(1), 35–57.
Vandervoort, A., Thibault, J., & Gupta, Y. P. (2011). Multi-objective optimization of an ethylene oxide reactor. *International Journal of Chemical Reactor Engineering, 9*(1).
Van Huylenbroeck, G. (1995). The conflict analysis method: Bridging the gap between ELECTRE, PROMETHEE and ORESTE. *European Journal of Operational Research, 82*(3), 490–502.
Van Huylenbroeck, G., & Tagarino, D. D. (1998). Analysing crop choice of Philippine vegetable farmers with multicriteria analysis. *Journal of Multi-Criteria Decision Analysis, 7*(3), 160–168.
Vetschera, R. (1986). Sensitivity analysis for the ELECTRE multicriteria method. *Zeitschrift Für Operations Research, 30*(4), B99–B117.
Vetschera, R. (1988). An interactive outranking system for multiattribute decision making. *Computers & Operations Research, 15*(4), 311–322.
Vincke, P. (1986). Analysis of multicriteria decision aid in Europe. *European Journal of Operational Research, 25*(2), 160–168.
Vincke, P. (1992). Exploitation of a crisp relation in a ranking problem. *Theory and Decision, 32*(3), 221–240.
Vlahavas, I., Stamelos, I., Refanidis, I., & Tsoukias, A. (1999). ESSE: An expert system for software evaluation. *Knowledge-Based Systems, 12*(4), 183–197.
Wachowicz, T. (2010). Decision support in software supported negotiations. *Journal of Business Economics and Management, 11*(4), 576–597.
Wallenius, J., Dyer, J. S., Fishburn, P. C., Steuer, R. E., Zionts, S., & Deb, K. (2008). Multiple criteria decision making, multiattribute utility theory: Recent accomplishments and what lies ahead. *Management Science, 54*(7), 1336–1349.
Wang, J. J., Jing, Y. Y., Zhang, C. F., & Zhao, J. H. (2009). Review on multi-criteria decision analysis aid in sustainable energy decision-making. *Renewable and Sustainable Energy Reviews, 13*(9), 2263–2278.
Wang, X., & Triantaphyllou, E. (2008). Ranking irregularities when evaluating alternatives by using some ELECTRE methods. *Omega, 36*(1), 45–63.
Wäscher, G., & Müller, H. (1986). Developing a computer program for cutting problems in a steel rolling mill. *Systems Analysis Modelling Simulation, 3*(4), 321–330.
Wu, M. C., & Chen, T. Y. (2011). The ELECTRE multicriteria analysis approach based on Atanassov's intuitionistic fuzzy sets. *Expert Systems with Applications, 38*(10), 12318–12327.
Xidonas, P., Askounis, D., & Psarras, J. (2009). Common stock portfolio selection: A multiple criteria decision making methodology and an application to the Athens Stock Exchange. *Operational Research—An International Journal, 9*(1), 55–79.
Xidonas, P., & Psarras, J. (2009). Equity portfolio management within the MCDM frame: A literature review. *International Journal of Banking, Accounting and Finance, 1*(3), 285–309.
Xu, B., & Ouenniche, J. (2012). Performance evaluation of competing forecasting models: A multidimensional framework based on MCDA. *Expert Systems with Applications, 39*(9), 8312–8324.
Yu, W. (1992). ELECTRE TRI: Aspects méthodologiques et manuel d'utilisation. Document du LAMSADE 74, Université-Paris-Dauphine.
Zandi, F., Tavana, M., & Martin, D. (2011). A fuzzy group Electre method for electronic supply chain management framework selection. *International Journal of Logistics Research and Applications, 14*(1), 35–60.
Zavadskas, E. K., & Turskis, Z. (2011). Multiple criteria decision making (MCDM) methods in economics: An overview. *Technological and Economic Development of Economy, 17*(2), 397–427.
Zavadskas, E. K., Ustinovichius, L., & Stasiulionis, A. (2004). Multicriteria valuation of commercial construction projects for investment purposes. *Journal of Civil Engineering and Management, 10*(2), 151–166.
Zhou, P., Ang, B. W., & Poh, K. L. (2006). Decision analysis in energy and environmental modeling: An update. *Energy, 31*(14), 2604–2622.
Zielina, E. R. (2010). Methods for selecting the best partner construction enterprise in terms of partnering relations. *Journal of Civil Engineering and Management, 16*(4), 510–520.
Zopounidis, C. (1999). Multicriteria decision aid in financial management. *European Journal of Operational Research, 119*(2), 404–415.
Zopounidis, C., & Doumpos, M. (2002a). Multi-criteria decision aid in financial decision making: Methodologies and literature review. *Journal of Multi-Criteria Decision Analysis, 11*(4–5), 167–186.
Zopounidis, C., & Doumpos, M. (2002b). Multicriteria classification and sorting methods: A literature review. *European Journal of Operational Research, 138*(2), 229–246.