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# Bibliometric Studies on Prospective Scenarios and Multicriteria Decision Aid

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**Abstract** Scenario building and multicriteria methods contribute to strategic planning and support decision-makers. This paper presents the results of a bibliographic research on prospective scenarios and multicriteria decision aid, providing a descriptive overview of scientific production of both themes. It is the initial stage of a doctoral research that aims to propose a methodology for strategy design and decision-making associating prospective scenarios and multicriteria decision aid methods. A bibliometric study was performed on the Scopus library database in February 2020 to identify the distribution of articles by year of publication, journals, keyword clusters, authors and authors' H-index, affiliation, country / territory, fields of knowledge and language. The search found 197 articles on prospective scenarios and 265 articles on multicriteria decision aid. Publications on prospective scenarios began in 1982 and publications on multicriteria decision aid began in 1986. No journal and no author are major references.

**Keywords:** Prospective Scenarios; Multicriteria Methods; Strategic Planning; Decision Making.

## 1 Introdution

Decisions can be made intuitively, impulsively, and automatically, or they can be the result of a process that involves conscious analysis of the situation, different alternatives, and possible consequences (Manrique-Tisnés and Castro-Correa, 2019).

Scenario analysis combines qualitative and quantitative techniques and is a useful tool for decision makers (Gregório and Lapão, 2012). According to (Durance and Godet, 2010), "a scenario is not a future reality but rather a means to represent it with the aim of clarifying present action in light of possible and desirable futures". According to (Schoemaker, 1995), "scenario planning attempts to capture the richness and range of possibilities, stimulating decision makers to consider changes they would otherwise ignore".

The strategies associated to prospective scenarios can anticipate organizational problems while minimizing risks and uncertainties (Barrizonte, Bastida and Alonso, 2015). Such strategies, actions, or

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alternatives should be considered in the complex decision-making process, whose multicriteria methods support decision-makers in choosing, ranking or sorting alternatives, considering value judgments and not only technical issues, and multiple conflicting criteria to evaluate alternatives in order to solve real problems, presenting a highly multidisciplinary (Santos *et al.*, 2015). There are several multicriteria methodologies seek to provide support in the difficult task of making this decision, whose methodologies are being used by purchasing managers of companies, and even by top managers (Silva, Gomes and Costa Junior, 2019).

Since scenario building and multicriteria methods contribute to strategic planning and support decision-makers, these questions arise: How many documents are there in the Scopus database about prospective scenarios and MCDA (Multicriteria Decision Aid)? What is the distribution of articles per year? Which journals have the most articles? What are the keyword clusters? Who are the main authors who published articles? Which institutions have the most published work? Which countries publish the most articles? Which areas have published the most articles?

This paper presents the results of a bibliographic research on prospective scenarios and multicriteria decision aid, providing a descriptive overview of scientific production of both themes. It is part of a doctoral research that aims to propose a methodology for strategy design and decision-making associating prospective scenarios and multicriteria decision aid methods. A bibliometric study was performed on the Scopus library database to answer the research questions.

## 2 Literature Review

### *2.1 Prospective Scenarios*

There are several scenario approaches with different techniques and many applications in different areas of knowledge, as noted in the following examples.

The Scenario Forecasting+Alternative Selection Method (SF+AS) was developed by (Gaspars-Wieloch, 2015), and considers the dominance concept and the level of optimism / pessimism declared by the decision maker. The method ranks scenarios from the sum of dominance cases and assigns a range of values of the coefficient of optimism for each scenario. Thus, the greater the sum of the dominance cases for the scenario, the more optimistic the scenario will be.

The long-term scenarios (2010-2060) was built by (Joshi, Hughes and Sisk, 2015), for the domestic governance of 183 countries, using the 6.68 version of International Futures, an integrated global forecasting system. The analysis considers three dimensions of governance: security, capacity, and inclusion. The results showed that the general trend is for progress, despite the existence of gaps between high-income and low-income countries in 2060. The model proposed by (Maestripieri et al., 2017) aimed to map the trends and possible scenarios related to forest management in southern Chile. The authors constructed two normative and contrasting scenarios. The model combined a Markovian probability maps and a multicriteria evaluation approach.

A method that combines social, economic and environmental indicators was proposed by (Hély and Antoni, 2019) and used to analyze the sustainability of a territory in France. Based on a participatory approach and GIS modeling, the method was developed in three steps (evaluation, aggregation, and combination) and yielded synthetic indicators.

A prospective scenario method was applied to assess the habitat capacity of an urbanized tropical estuary in relation to ecosystem service provision (Zapata et al., 2018). The authors considered the method developed by the National Center for Strategic Planning of Peru, specially the stages of the prospective analysis phase: analysis and understanding of the research topic; identification and analysis of the trends; selection and diagnosis of the key variables; scenario building.

The life cycle of the water system of an urban area of Paris (France) was evaluated regarding the environmental impacts and provided services (Loubet *et al.*, 2016). The authors developed different urban water system components that could be used to assess scenarios elsewhere in the world.

The biogenic carbon emission and the dynamic and prospective aspects related to the life cycle assessment of constructions were investigated by (Fouquet et al., 2015). The authors carried out a case study from three houses in Chambery (France), which have the same functional unit, but were constructed with different materials and techniques.

A scenario forecasting approach for residential load was developed (Zhang and Zhang, 2019), using historical data and flow-based conditional generative models. The simulation results showed the flow-based approaches provide a wide range of future possibilities with more reliable and more sharp scenarios for residential load.

A hybrid method that combines concepts and techniques for scenario building and MCDA approach was presented by (Gomes, Costa and de Barros, 2017). The method covers the main concepts of the prospective methods and enables to apply different weights for each criterion according to each scenario. It is an evolution of the method proposed by (Gomes and Costa, 2013), called Momentum (Method Unified for Strategic Prospective Planning).

Prospective scenarios for the biodiesel industry in Brazil were built by (de Paula Dias, de Souza Vianna and Felby, 2016). The authors included the sustainable dimensions of (Sachs, 2003) into the scenario method and demonstrated the connection between environmental, territorial and social aspects, as well as the sustainable options for the future, beyond the business as usual scenario.

A scenarios method to explore possible future of the French bovine sector and its impacts on climate change was used by (Mosnier *et al.*, 2017). The simulation was carried out using the Orfee (Optimization of Ruminant Farm for Economic and Environmental assessment) model. The authors built four scenarios based on global scenarios that were defined by experts, French researchers and workers in the beef and dairy sectors. The role of public agencies in the introduction of genetic technologies in health insurance in the Netherlands was explored by (Boon, Aarden and Broerse, 2015). The authors combined a retrospective study to identify the current coverage of these technologies with prospective scenarios for anticipatory governance.

Scenarios to analyze the community pharmacist's future were built by (Gregório and Lapão, 2012), especially their role in the Portugal health system. The authors used the method proposed by (Thore and Lapão, 2002) that grouped the 10 steps of (Schoemaker, 1995) for scenario building into three stages.

## *2.2 Multicriteria Decision Aid (MCDA)*

MCDA methods are used for planning and decision making, replace intuitive choices and make the process traceable and transparent (Lahdelma, Salminen and Hokkanen, 2000). These methods help decision-makers to solve problems characterized by several alternatives that are evaluated using a set of conflicting criteria (El Beggar, 2018). Decisions are submitted to several influences, involve all kinds of decision makers (individuals, companies, governments, etc.), impact people's lives, and often have important consequences for the environment (Brans, 2002).

In the literature, there are many proposals and applications of MCDA methods that combine several techniques and / or tools, as follows. The use of MCDA methods in public environmental planning and decision processes was discussed by (Lahdelma, Salminen and Hokkanen, 2000), defining the following phases: stakeholders; define alternatives and criteria; make measurements; choose the MCDA method; provide preference information; form draft solutions; make final decision.

The relevance of multicriteria decision support systems for the finance area was analyzed by (Zopounidis and Doumpos, 2013). The authors briefly described the main methods of MCDA: Multi-objective optimization (MOO); Multiattribute Utility Theory (MAUT); the outranking methods ELECTRE (*Elimination Et Choix Traduisant la Realité*) and PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations); and Preference Disaggregation Analysis (PDA).

The ELETRE TRI method was applied to evaluate the competencies of the professionals of a call center company in Pernambuco (Brazil) (de Moura and Sobral, 2016). The authors applied a questionnaire to identify the respondents' profile and to map the competence axes (skills, knowledge, and attitude).

The financial performance of European banks that have participated in the tests applied by the European Banking Authority after the global credit crisis in 2007-2008 was evaluated by (Doumpos, Zopounidis and Fragiadakis, 2016). The Fuzzy PROMETHEE method (F-PROMETHEE) – an extension of the PROMETHEE method – was proposed by (El Beggar, 2018) to evaluate agile methods used in IT (Information Technology) projects.

The results obtained with the THOR ($S_1$, $S_2$ and $S_3$), ELECTRE (I and II) and PROMETHEE II methods were compared by (Gomes and Costa, 2015) in order to support the decision-maker in choosing the electronic payment model by credit card. The THOR 2 method was applied in military problems by Tenorio *et al*. (2020), selecting a ship for purchase, and by Costa *et al*. (2020), choosing a hospital assistance ship to fight the Covid-19 pandemic in Brazil.

A new function, the "Negotiation function", and a new variable, the "Negotiator's weight", were proposed by (Gomes, 2006) in the framework of negotiation and group decision. The author applied the THOR method in two case studies and compared results with ELECTRE-GD, PROMETHEE II, ELECTRE III and Ternary AHP.

The decision-making process must consider three poles of influence: the rational, the subjective and the ethical (Brans, 2002). The author described the evolution of Operational Research from the pure rationality in the optimization problems to the subjectivity in the MCDA approaches, and defended the inclusion of ethics in the methodologies, due to the need to respect the social and natural environment.

## 3 Methods

This study considered the Webibliomining model proposed by (Costa, 2010) and (da Silva, Costa and de Barros, 2015). Initially, the following strategy was tested in the Scopus database to find the documents on prospective scenarios and MCDA, linking both research themes; however, with no result: ((TITLE-ABS-KEY (“prospective scenarios” OR “scenario forecasting”) AND TITLE-ABS-KEY (“multicriteria decision aid”). Therefore, we decided to search for the terms separately, using the following strategies:

- (TITLE-ABS-KEY ("prospective scenarios") OR TITLE-ABS-KEY ("scenario forecasting")).
- TITLE-ABS-KEY (“multicriteria decision aid”).

The research was carried out in the Scopus database in February 2020 and found 302 documents on prospective scenarios (197 articles) and 380 documents on MCDA (265 articles). A bibliometric study was developed to identify the year of publication, journals, keyword clusters, authors (including authors’ H-index and author network), affiliation, country / territory, fields of knowledge and language. Increasing rates of publications and fragmented research streams make the use of bibliometrics essential for science mapping (Aria and Cuccurullo, 2017).

## 4 Results and Analysis

The search on “prospective scenarios” OR “scenario forecasting” found 197 articles published in journals. Fig. 1 shows the distribution of articles by year of publication. Distribution started in 1982 with two articles. From 1983 to 1993, there are only two articles, one published in 1985 and the other in 1989. From 1994 to 2006, the publications range from one to three articles. As of 2007, there was a growth with fluctuations and a decrease in 2011. In 2018, there is the highest total of publications (26 articles).

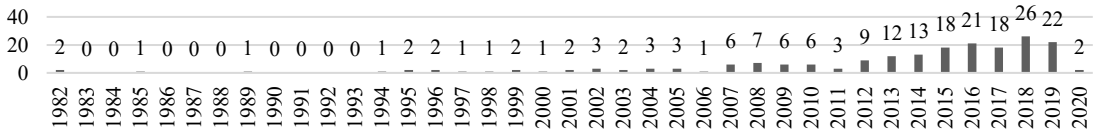


**Fig. 1** Distribution of articles by year.

The distribution of articles by journal shows that *Espacios* ranks first with eight articles, followed by Energy Policy and Science of the Total Environment with six articles each. Futures published five articles. Agricultural Systems, Energy, Journal of Cleaner Production and Land Use Policy published three articles each. There are also 11 journals with two articles each and 137 with only one article each, totaling 156. Therefore, the articles are distributed through several journals.

Table 1 shows the distribution of articles by author, in descending order according to H-Index, considering three or more published articles. The H-index is "defined as the number of articles with citation number higher or equal to h, as a useful index to characterize the scientific output of a researcher" (Hirsch, 2005, p. 1). There are two authors with four articles each: Billen, G. with h = 63 and Garnier, J. with h = 52. Six authors published three articles each; but have different H-indexes. In addition, there are 26 authors with two articles each and 125 with only one article each, totaling 159 authors. Therefore, there is no predominance of authors.

**Table 1.** Distribution of articles by author

| Authors | Articles | H-Index |
|---|---|---|
| Billen, G. | 4 | 63 |
| Garnier, J. | 4 | 52 |
| Ruelland, D. | 3 | 18 |
| Cappello, A. | 3 | 16 |
| Bilotta, G. | 3 | 14 |
| Hérault, A. | 3 | 15 |
| Ksenofontov, M.Y. | 3 | 4 |
| Kolpakov, A. Y. | 3 | 3 |

The distribution of articles by affiliation shows that the *Centre National de la Recherche Scientifique* ranks first with 13 articles, followed by three institutions that published five articles each (*INRA Institut National de La Recherché Agronomique*; Russian Academy of Sciences; Stavropol State Agrarian University). In addition, there are three institutions that published four articles each; 13 institutions with three articles each; 40 institutions with two articles each; and 99 institutions with only one article each, totaling 159. The findings by (Oliveira et al., 2018) also pointed out that the *Centre National de la Recherché Scientifique* is the institution that most published documents on prospective scenarios.

Analyzing the articles by country, the search found 39 countries. France ranks first with 46 articles, followed by Brazil with 23 articles. Europe is represented by 20 countries with 160 published articles (63% of the total). The American continent, with 10 countries, has 62 articles (24% of the total). Asia, with six countries, has 18 articles (7% of the total). Oceania, through Australia, has five articles (2% of the total). Africa is represented by two countries (Egypt and Tunisia) with two articles (1% of the total).

Analyzing the distribution of articles by field of knowledge, Environmental Science (21%) and Social Sciences (14%) stand out compared to other areas. 64 articles on prospective scenarios were analyzed by (Araújo and Casimiro, 2020) and classified in eight areas: Administration; Agriculture and Climate; Fuel; Education; Energy; Engineering, Architecture and Geography; Health; and Technology.

The search on "multicriteria decision aid" found 265 articles published in journals. Fig. 2 shows the distribution of articles by year of publication. Distribution started in 1986 with five articles. It ranged over time and, in 2013, distribution reached 31 articles. There were two-time gaps, one in 1987 and another in 1996.

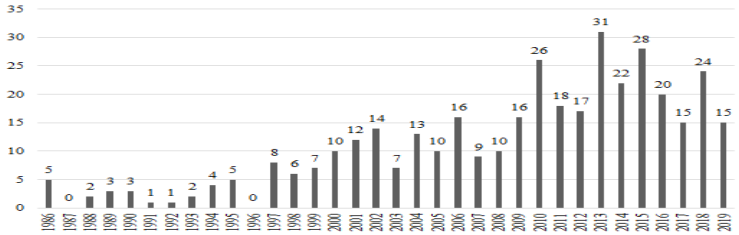


**Fig. 2.** Distribution of articles by year.

The distribution of articles by journal shows that the European Journal of Operational Research stands out with 37 articles, followed by Production with seven articles and *Pesquisa Operacional* with six articles. Additionally, three journals published five articles each; four journals published four articles each; nine journals published three articles each, 19 journals published two articles each and 119 journals have only one article each, totaling 157.

Table 2 presents the distribution of articles by author, in descending order according to H-Index, considering four or more published articles. Zopounidis, C. and Doumpos, M. are the authors with the highest H-index and with more articles, followed by De Almeida, A. T. with h = 25, but with only four articles. In addition, there are 17 authors with three articles each, 47 authors with two articles each and 79 authors with one article each, totaling 161 authors.

**Table 2.** Distribution of articles by author

| Author | Article | H-index |
|---|---|---|
| Zopounidis, C. | 33 | 40 |
| Doumpos, M. | 28 | 34 |
| De Almeida, A.T. | 4 | 25 |
| Dias, L.C. | 4 | 24 |
| Pasiouras, F. | 9 | 21 |
| Mareschal, B. | 8 | 19 |
| Vincke, P. | 4 | 19 |
| Ensslin, L. | 14 | 16 |
| Brans, J.P. | 8 | 16 |

**Table 2.** Distribution of articles by author (continued)

| Author | Article | H-index |
|---|---|---|
| Chabchoub, H. | 4 | 16 |
| Ensslin, S.R. | 10 | 15 |
| Waaub, J. P. | 4 | 14 |
| Gaganis, C. | 7 | 13 |
| De Smet, Y. | 8 | 12 |
| Nemery, P. | 5 | 12 |
| Costa, H.G. | 5 | 10 |
| Dutra, A. | 4 | 6 |
| Boujelben, M.A. | 4 | 4 |

The distribution of articles by affiliation shows that Technical University of Crete ranks first with 40 articles, followed by *Université Libre de Bruxelles* with 28 articles, *Universidade Federal de Santa Catarina* with 17 articles and *Universidade Federal Fluminense* with 13 articles. Furthermore, there are two institutions with eight articles each; four institutions with six articles each; five institutions with five articles each, 10 institutions with four articles each, 16 institutions with three articles each, 34 institutions with two articles and 84 institutions with only one article, totaling 160.

Universities stand out in the publication of articles, as well as the study by (de Carvalho Pereira, Costa and Pereira, 2017). However, the authors found a misalignment between articles indexed in the ISI Web of Science database and patent filings indexed in the Derwent Innovation Index database. The results showed that 58.9% of the total patents were filed by companies against 3.3% filed by universities and 0.5% filed by university-company interaction.

Analyzing the distribution of articles by field of knowledge, Computer Science (20%), Decision Sciences (20%), Mathematics (14%) and Business, Management and Accounting (12%) stand out.

## 5 Conclusions

The bibliometric study provided a descriptive overview of scientific production on prospective scenarios and MCDA. The research in the Scopus database showed that no results were found when the strategies

linked the two themes. Therefore, the terms were searched separately. The search found 197 articles on prospective scenarios and 265 articles on MCDA.

There are several scenario approaches and many applications in different areas. Research on prospective scenarios is distributed. No journal and no author are major references, but France stand out with 46 articles. The distribution by field of knowledge showed that the articles are spread over several areas; however, Environmental Sciences concentrates 21% of articles and Social Sciences has 14. The predominance of France is particularly related to the French term la prospective, which was the focus of this research and its limitation. For future research, terms such as “scenario techniques”, “scenario planning”, “foresight future scenarios” can be searched in different library databases.

Research on MCDA has some highlights. European Journal of Operational Research stands out with 37 articles, while other journals have less than seven articles. The authors Zopounidis and Doumpos published 33 articles (h = 40) and 28 (h = 34), respectively. Among the institutions with more than 10 articles, one is Greek (Technical University of Crete with 40 articles), one is Belgian (*Université Libre de Bruxelles* with 28 articles) and two are Brazilian (Universidade Federal de Santa Catarina with 17 articles and Universidade Federal Fluminense with 13). Computer Science (20%), Decision Sciences (20%), Mathematics (14%) and Business, Management and Accounting (12%) published more than half of the articles on MCDA.

The literature review, although not exhaustive, showed several methods and approaches, their concepts, paradigms, and applications in different areas of the private and public sectors. Among the articles in the literature review, only five combine scenario planning with MCDA methods. The AHP method for the weighting factor was used by (Maestripieri et al., 2017); The Momentum method for scenario building with MCDA approach was proposed by (Gomes, Costa and de Barros, 2017); The Scenario Forecasting+Alternative Selection Method (SF+AS) was developed by (Gaspars-Wieloch, 2015); A method to evaluate the sustainability of a territory, including multicriteria analysis, was proposed by (Hély and Antoni, 2019). This may indicate a gap in the literature and the need for further studies.

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