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Research Agenda on Multiple-Criteria Decision-Making: New Academic Debates in Business and Management

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Abstract: Systemic disruptions are becoming more continuous, intense, and persistent. Their effects have a severe impact on the economy in volatile, uncertain, complex, and ambiguous (VUCA) environments that are increasingly transversal to productive sectors and activities. Researchers have intensified their academic production of multiple-criteria decision-making (MCDM) in recent years. This article analyzes the research agenda through a systematic review of scientific articles in the Web of Science Core Collection according to the Journal Citation Report (JCR), both in the Social Sciences Citation Index (SSCI) and in the Science Citation Index Expanded (SCIE). According to the selected search criteria, 909 articles on MCDM published between 1979 and 2022 in Web of Science journals in the business and management categories were located. A bibliometric analysis of the main thematic clusters, the international collaboration networks, and the bibliographic coupling of articles was carried out. In addition, the analysis period is divided into two subperiods (1979–2008 and 2009–2022), establishing 2008 as the threshold, the year of the Global Financial Crisis (GFC), to assess the evolution of the research agenda at the beginning of systemic disruptions. The bibliometric analysis allows the identification of the motor, basic, specialized, and emerging themes of each subperiod. The results show the similarities and differences between the academic debate before and after the GFC. The evidence found allows academics to be guided in their high-impact research in business and management using MCDM methodologies to address contemporary challenges. An important contribution of this study is to detect gaps in the literature, highlighting unclosed gaps and emerging trends in the field of study for journal editors.

Keywords: bibliometric analysis; research agenda; multiple-criteria decision-making (MCDM); complexity; VUCA; VOSviewer; SciMAT

MSC: 90B50; 91B06; 60A86; 94D05; 68V30

Citation: Castelló-Sirvent, F.; Meneses-Eraso, C. Research Agenda on Multiple-Criteria Decision-Making: New Academic Debates in Business and Management. *Axioms* **2022**, *11*, 515. https://doi.org/10.3390/axioms11100515

Academic Editors: Amit K. Shukla and Darjan Karabašević

Received: 19 August 2022
Accepted: 24 September 2022
Published: 29 September 2022

1. Introduction

In recent decades, systemic events that have accelerated the speed of economic, social, and political shocks have become widespread and frequent. Increasingly radical and intense disruptions impact society and companies by generating global challenges and affecting the stability of the economic system. Some examples of these shocks in recent years, such as the Global Financial Crisis, (GFC), sustainability challenges of the 2030 Agenda, COVID-19, war in Ukraine, sanctions against Russia, European energy crisis, risks of reversal of globalization, and political and military tensions with China, should be noted. This dynamic economic environment forces companies, governments, and investors to make increasingly agile decisions to try to eliminate bias in decision-making and minimize risks in professional endeavors. Advanced decision-making methods have been gaining popularity among managers and analysts in an increasingly common VUCA environment. The context of implicit uncertainty has changed the analysis paradigm,

affecting management sciences [1–7] and creating a need to articulate efficient mechanisms for decision-making in multiple fields [8–15].

The first radical shock of the contemporary era was the GFC that began after the bankruptcy of Lehman Brothers [16–18], a situation that created a need to develop better and more sophisticated methods for decision-making in such fields as finance, investment, and policymaking, among others. Society was transformed at great speed and academics progressively altered its predominant interests, as the generalization of VUCA environments transformed the archetypes of researchers and their priorities. Some emerging issues in the academic debate after 2008 are specified in the green strategies of the Sustainable Development Goals (SDG) [19–28], evaluation of decision-making systems based on the urgency and effectiveness of the applied models [23,29–37], and the impact disruptions in VUCA environments on global value chains [3,4,19,26,38–42].

The motivation for this research article is a drive to describe the structure of the academic agenda in detail and to identify the opportunities for high-impact publications related to MCDC. This study analyzes the academic discourse on multiple-criteria decision-making (MCDM) within the business and management areas before and after 2008. In addition, the change in the research agenda produced after the intensification of disruptions in VUCA environments is evaluated, and context is offered to understand the driving and emerging issues that articulate the new debate after 2008. The goal of this article is to present an overview and evolution of the research agenda, allowing academics to learn about new emerging trends, gaps not closed in the literature, and high-impact publication opportunities in the MCDM field of research. In addition, the findings of this study should provide a guide and a roadmap for journal editors to the evolution of the research agenda, facilitating the design of editorial lines and the preparation of special issues that may be thematically oriented to a more mainstream scope among scholars. The article is structured as follows. First, the materials and methods section is presented. Next, the results and discussion with a special focus on the opportunities detected for high-impact publications are reported. Finally, the conclusions of the study are formulated.

2. Materials and Methods

The objective of this research article was to develop a comprehensive bibliometric analysis on the methodologies of multiple-criteria decision-making (MCDM). As per Zupic and Čater [43], the study followed this sequence: (1) design of the research; (2) collection of bibliometric data; (3) analysis and reporting of results; and (4) discussion of the findings. The search strategy for the literature review was an analysis of articles published in the Web of Science Core Collection (WoS-CC).

Based on the quality standards established by this study and the purpose of intertemporal comparison between periods, the WoS-CC was chosen, focusing the analysis on journals in the areas of business and management indexed in the Social Sciences Citation Index (SSCI) and the Scientific Citation Index Expanded (SCIE). Journals indexed in the Emerging Sources Citation Index (ESCI) were discarded. The use of Scopus was also ruled out, since the object of analysis began before the creation of Scopus and the inclusion of articles from this database would cause sample biases that would invalidate the analysis and conclusions of this research [44–47]. Thus, the WoS-CC was chosen as a source of robust bibliometric information [48,49], for its coverage [50] and its homogeneous availability throughout the period analyzed. The search discarded chapters, books and proceedings, and focused on articles. Based on the high heterogeneity of terms available to analyze the focus determined by the study, the first step taken was to identify the search terms and operators that would allow the identification of the relevant published studies. The PRISMA statement [51,52], widely used in systematic reviews in business and management research, was used [42,53–57]. In addition, the methodology proposed by Tavares Thomé et al. [58], which suggests that researchers should perform searches both backwards and forwards in order to reinforce the robustness of their studies and through this same practice eliminate the risk of search and/or approach biases, was followed. In this way, the main research

topics published on MCDM or MCDA in business and management journals—according to Web of Science categories—indexed in Journal Citation Reports® (JCR) were identified. Figure 1 shows the selection criteria and the Boolean search string applied to topic (TS), according to the information provided by title (TI), abstract (AB), author keywords (AK) or Keyword Plus® (KP). Figure 2 presents the flow diagram for new systematic reviews and reports the details of the search strategy according to each stage defined by the PRISMA statement [51].

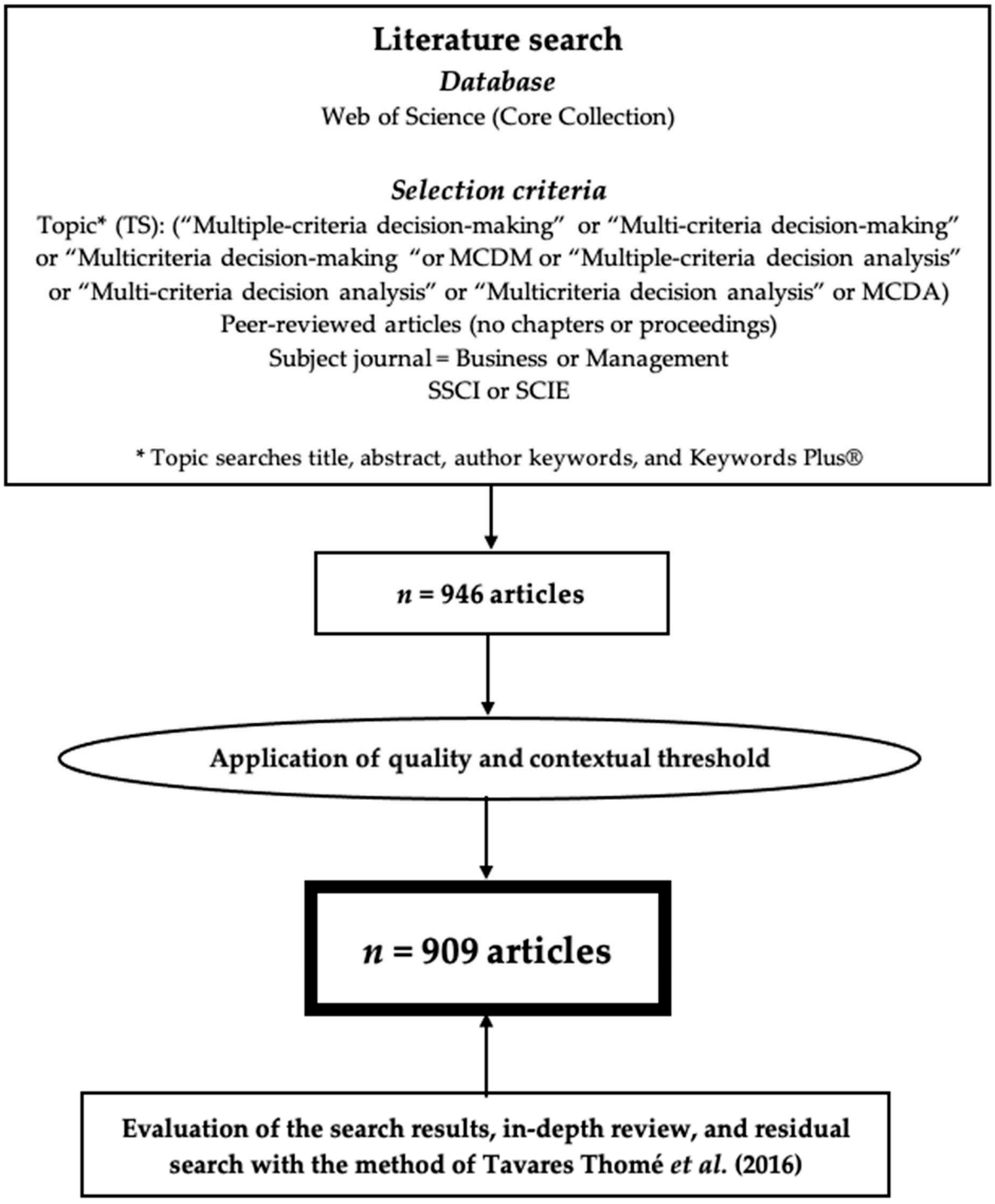

Figure 1. Systematic literature review strategy [58].

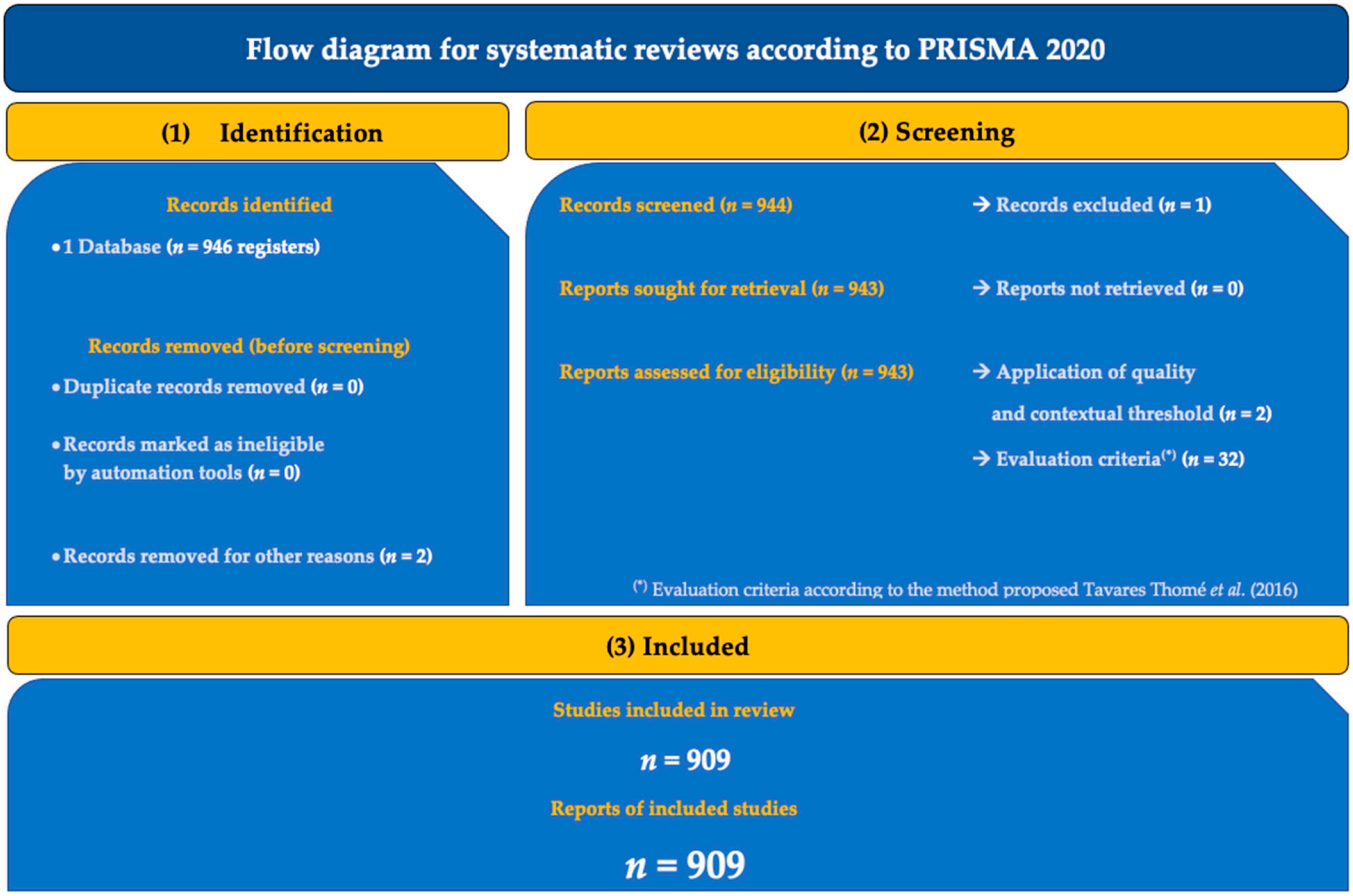

Figure 2. PRISMA 2020 flow diagram. Own elaboration according to Page et al. (2021) [51], Tavares Thomé et al. (2016) [58].

The resulting database was analyzed from a static approach for the total period available according to the criteria reported from the first record located (1Q 1979) and until the last available according to the date of the investigation (2Q 2022). In addition, two subperiods (1979–2008 and 2009–2022) were constructed for the comparative analysis of the academic discourse and the evolution of the scientific debate in the field. The year 2008 was chosen as it established important conjunctural and systemic changes, which were exemplified by the occurrence of the GFC. In addition, since 2008, academic production has increased based on a strong evolution of academic interest, and new fuzzy-related journals have been created [59].

The complexity of the world has been increasing progressively from 2008. In this year, there was an important financial event that began in September 2008 with the bankruptcy of Lehman Brothers [17] and the resulting consequences for the world's main economies (e.g., deep financial crisis in the United States and debt crisis in the Eurozone, quantitative easing of the Federal Reserve and the European Central Bank) [16,18,60–63], a subsequent period of high interdependence of economic agents and global value chains began, the continuing effects of which are further evidence of the fact that the process of generalization of VUCA environments is accelerating [1–3,6,64,65]. Bibliometric studies have analyzed academic discourse in comparative terms for two periods [66]. Based on its relevance, the 2008 cutoff threshold has been used to analyze changes in trends in bibliometric terms [67–69].

According to the specific criteria selected, the applied method reports 909 articles published between Q1 1979 and Q2 2022, corresponding to journals indexed in JCR. Based on the size asymmetry of the two constructed subperiods (30 years vs. 13 years) and the limitations that this asymmetry represents for a measurement of the academic impact of scientific production, the normalized impact per year (NIY) method was used, in accordance

with Castelló-Sirvent [70]. This method calls for the weighing of total academic impact as measured by a count of citations and dividing this number by the number of years elapsed from the publication of an article to the date of completion of this study. Thus, the NIY highlights the most relevant information since it brings to the surface papers that mark an accelerated academic interest of a topic at a certain moment. This facilitates the process of comparing articles published in different subperiods. In this study, the NIY is used for the analysis of articles, and the NIY average for the analysis of the academic production of journals or subperiods.

A citations per document (CpD) ratio was also calculated [70] as an indicator of academic efficiency that divides the total citation count by the number of articles published in a period, or by an author, university, country or journal. In addition, the dynamic comparison of the top 25 articles by total citations and the top 25 articles by NIY for the same subperiod offers information on the articles that quickly become more interesting for researchers, particularly in shorter and more recent subperiods [70]. These types of articles were indicated in this research under the term "strong trend" (ST) and were shown in the results corresponding to the top 25 articles with the greatest impact of citations per year (NIY). This allowed this article to highlight research that did not manage to be placed in the top 25 articles with the greatest impact by total citations. In other words, the articles marked as ST are mainstream articles that arouse growing academic interest based on the trend accelerator that the NIY represents. [71]. The detailed analysis and evaluation of ST articles is likely to serve as an indicator of "hot topics" in the research agenda of a field of study [70,71]. Similarly, this research also applied the ST analysis to the main journals of both subperiods to identify "hot journals" as defined by having the greatest impact in comparative terms. ST analysis is a tool that enables academics to more easily select mainstream topics and journals, so that their research will be oriented to the emerging and most active topics in the area of study. It also helps researchers by offering an in-depth discussion on high-impact publication opportunities. [70,71].

The bibliometric software used was VOSviewer 1.6.17 [72,73] and SciMAT 1.1.04. [74]. VOSviewer enabled the analysis of international collaboration networks in MCDM research and the bibliographic coupling of articles. SciMAT showed the strategic diagrams of the two subperiods analyzed, identifying driving, basic, specialized and emerging themes. According to Cobo et al. [74–77], following Callon's preliminary approaches [78], the bibliometric analysis of topics with SciMAT identifies the thematic clusters in a two-dimensional plane that represents the centrality and density of the academic discourse, in order to know the academic field architecture [77] and visualize and evaluate its space–time path [75]. In this way, it is possible to identify the groups (clusters) of analyzed elements and their links with other related elements [73], according to the relative importance of the elements reviewed with respect to the academic corpus under study [79].

In this way, strategic diagrams built with SciMAT show four quadrants that are configured at the intersection of the X and Y axes, with the topics included in each quadrant being characterized in a specific way. The driving themes show high density and high centrality and, consequently, contribute in a relevant way to research and maintain links with their thematic networks, helping to articulate the research agenda. On the other hand, the emerging themes register low density and low centrality, since they are poorly developed, both in the area and in other areas. In the intermediate positions, the basic topics are shown, characterized by their low density and high centrality, reporting a limited development, although they suppose important contributions in other areas of knowledge. Specialized topics have a high density and low centrality, as they are well developed in the area, but in isolation from other areas.

SciMAT was used to know the typologies of themes for both subperiods and to understand the dynamic evolution of the discourse of academia on MCDM. For the analysis, the equivalence index [78] was used without network reduction, with association strength [80], based on the simple centers algorithm (min. 5; max. 12). In addition, core mapper, inclusion index and Jaccard's index [81] were reported.

3. Results and Discussion

This section is structured as follows. First, an overview of the academic production linked to the study area is reported, both for the total period analyzed and for the two proposed subperiods. Second, the main authors, universities, and international collaboration networks identified are named. Third, the coupling clusters of articles generated in order to understand the construction of the academic debate are shown. Fourth, a general analysis of the dynamic evolution of the research agenda is carried out through the use of overlapping and evolution maps of the transformation process, and then a detailed analysis of this process is presented through strategic diagrams of each subperiod. Fifth, the publication opportunities detected are discussed.

3.1. Academic Production

The results of the longitudinal analysis show an incremental evolution ($R^2 = 0.9293$) of the scientific production on MCDM (Figure 3). As of 2009, an acceleration of the trend, coinciding with the international extension of the GFC is observed. Economic agents, companies and public administrations being forced to make quick and agile decisions in an increasingly interdependent VUCA environment is also evidenced.

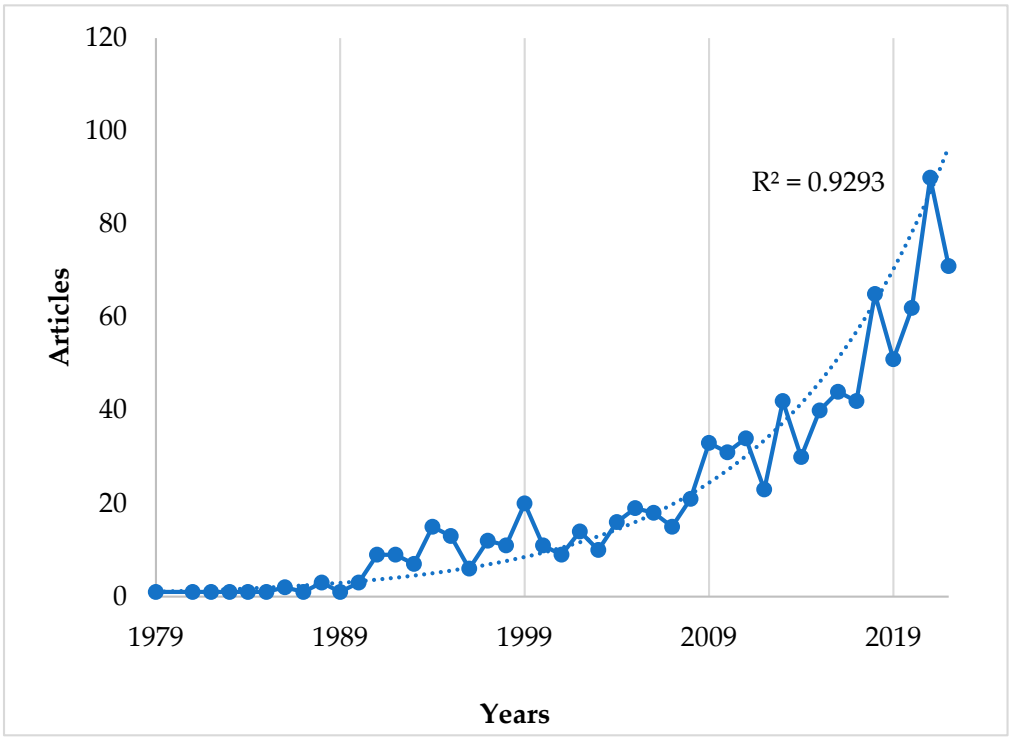

Figure 3. Intertemporal evolution of academic production on MCDM.

In sum, 909 articles published over 43 years (1979–2022) in journals from the business and management areas indexed in JCR were identified and retrieved. The articles generated an impact level of 37,904 citations. The annual averages of the NIY method previously discussed (Figure 4) show that the articles published during the years prior to the GFC (2002 and 2004) achieved greater academic impact per year, and a trend analysis corroborates a change in trend as of 2011. Academic interest in MCDM increased in terms of comparative annual impact.

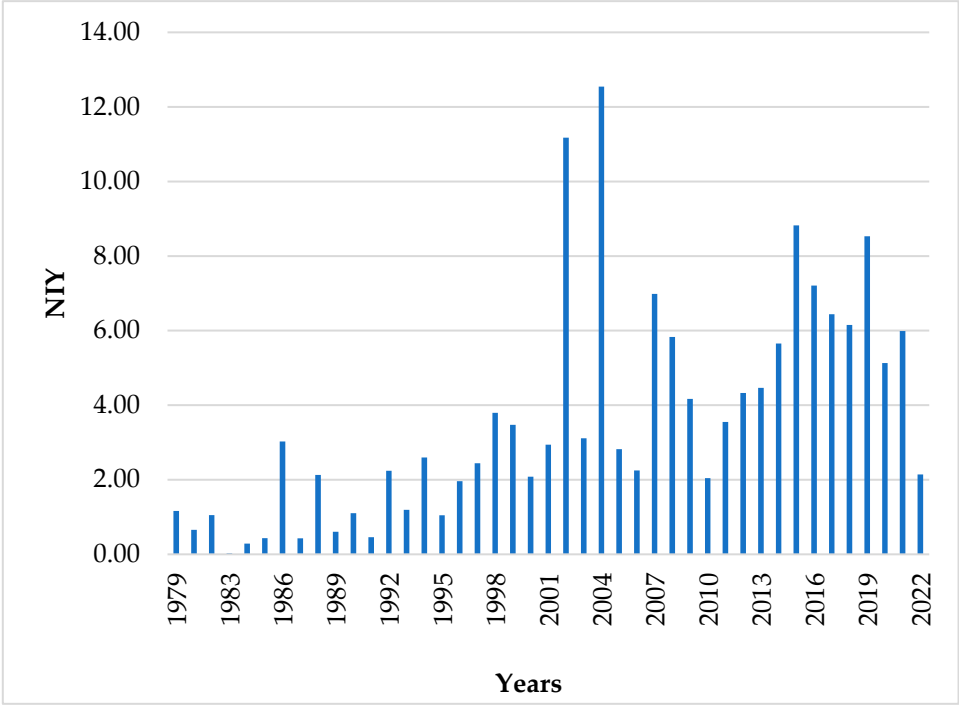

Figure 4. NIY detail analysis. Annual average.

Table 1 shows a comparative analysis for both subperiods. NIY average clearly increases after the GFC. Given the asymmetry of years of the analyzed subperiods, CpD after the GFC is lower than the CpD before the GFC.

Table 1. Published articles, citations and NIY. Detail by subperiods.

Subperiods	Years	Articles	Articles per Year	Total Citations	CpD	NIY Average
Subperiod 1 (1979–2008)	30	251	8.66	20032	80	4.05
Subperiod 2 (2009–2022)	13	658	50.62	17872	27	5.41

Source: Own elaboration.

However, the evidence found corroborates a higher production of articles per year after the GFC, as shown in the bibliometric analysis carried out by Liu [59]. The total number of articles published on MCDM is 2.6 times higher after 2008 and the academic impact of the articles published after 2008 (13 years) is 89% of the academic impact of the articles published before 2008 (30 years).

3.2. Main Authors, Universities and International Collaboration Networks

The main authors with scientific production equal to or greater than 10 articles in MCDM fields are professors Zavdskas, Stewart, Ferreira, Greco, Turskis, Liao, Hashemkhani Zolfani and Ferreira (Table 2). The detailed analysis of academic efficiency reports an excellent performance in the number of citations per document of professors Greco (CpD = 69.2) and Stewart (CpD = 65.82).

On the other hand, Table 3 shows the results of the analysis of universities of those researchers who achieved greater academic efficiency in the publication of MCDM articles from Taiwan (National Chiao Tung University; CpD = 224), Italy (University of Catania; CpD = 76.07) and Portugal (University of Coimbra; CpD = 75.10).

Table 2. Academic production of authors with more than 10 articles.

Rank	Author	Citations	Articles	CpD
1	Zavadskas, Edmundas Kazimieras	1016	26	39.08
2	Stewart, Tj	724	11	65.82
3	Ferreira, Fernando A. F.	717	36	19.92
4	Greco, Salvatore	692	10	69.20
5	Turskis, Zenonas	454	10	45.40
6	Liao, huchang	352	13	27.08
7	Hashemkhani Zolfani, Sarfaraz	321	10	32.10
8	Ferreira, Joao J. M.	311	17	18.29

Source: Own elaboration.

Table 3. Academic production of universities with more than 10 articles.

Rank	Universities	Citations	Articles	CpD
1	Natl. Chiao Tung. Univ.	3808	17	224.00
2	Vilnius Gediminas Tech. Univ.	1413	59	23.95
3	Univ. Catania	1065	14	76.07
4	Univ. Memphis	758	36	21.06
5	Univ. Coimbra	751	10	75.10
6	Kainan Univ.	748	12	62.33
7	Univ. Manchester	672	12	56.00
8	Tech. Univ. Crete	666	18	37.00
9	Univ. Jyvaskyla	625	11	56.82
10	Univ. Inst. Lisbon	588	32	18.38
11	Polish Acad. Sci.	572	12	47.67
12	Poznan Univ. Tech.	541	11	49.18
13	Univ. Portsmouth	474	14	33.86
14	Sichuan Univ.	460	17	27.06
15	Aalto Univ.	421	16	26.31
16	Islamic Azad Univ.	421	25	16.84
17	City Univ. Hong Kong	364	10	36.40
18	Univ. Beira Interior	356	19	18.74
19	Natl. Tech. Univ. Athens	261	10	26.10
20	Univ. Tehran	237	18	13.17

Source: Own elaboration.

Figure 5 reports the connections between countries in international collaboration networks. According to the fractional counting method, the results show five co-authorship clusters between countries for the MCDM area. Cluster 1 (green) includes European countries (Portugal, France, Belgium and Greece) and the American continent (USA, Canada and Brazil). Cluster 2 (blue) includes England and European countries (Italy, Poland, Denmark, Germany). Cluster 3 (pink) links the academic production of countries such as Iran, Lithuania or Malaysia. Cluster 4 (red) shows the way in which European countries (Spain and Netherlands) and the Pacific area (India, Taiwan and Australia) connect their academic production through co-authorships. Cluster 5 (yellow) reports the connection of publication co-authors in MCDM from Finland, Switzerland, Scotland and South Korea.

The evaluation of academic production reports 27 countries with at least 10 articles for the period analyzed (Table 4). The detailed analysis of academic efficiency places Serbia, Netherlands and Denmark above 100 citations per article.

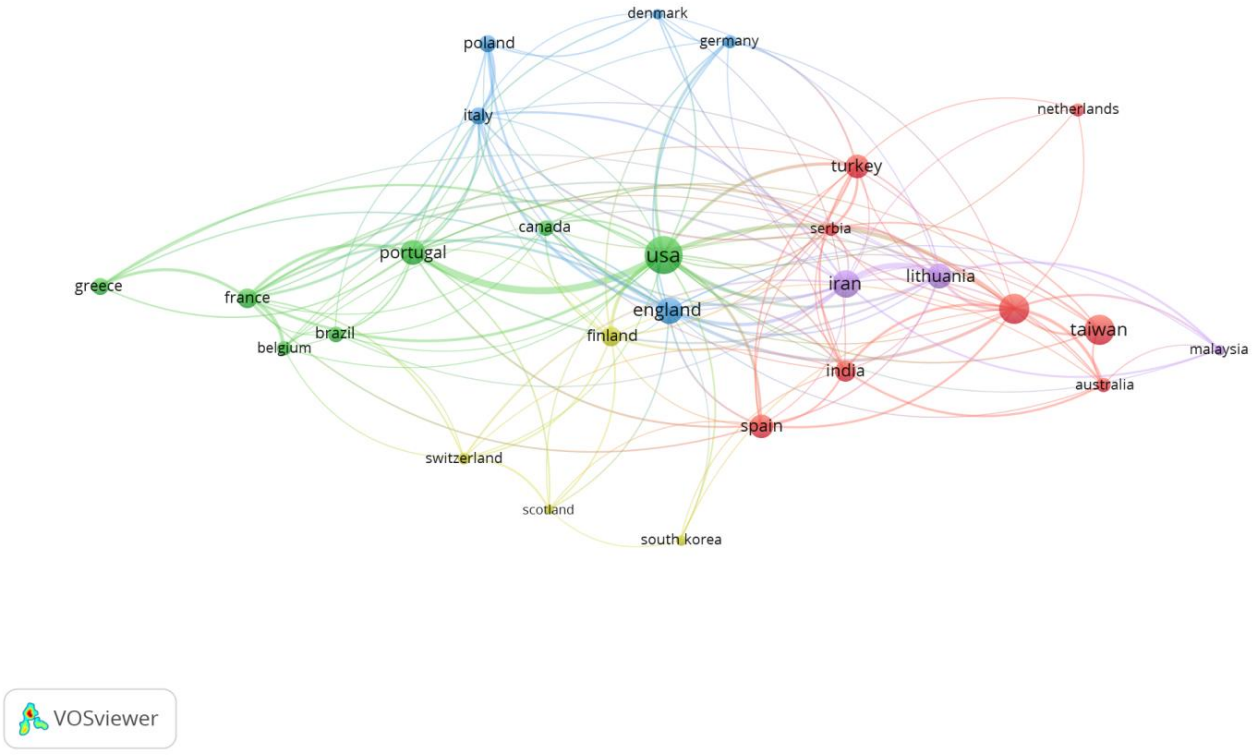

Figure 5. International collaboration networks.

Table 4. Collaboration networks in co-authorship. Countries with more than 10 articles.

Rank	Countries	Citations	Articles	CpD
1	Taiwan	6684	91	73.45
2	USA	5183	151	34.32
3	Serbia	3289	18	182.72
4	China	3184	90	35.38
5	Spain	2426	57	42.56
6	Portugal	2312	66	35.03
7	Netherlands	2163	18	120.17
8	England	2122	68	31.21
9	Finland	1812	43	42.14
10	Iran	1611	81	19.89
11	Poland	1587	30	52.90
12	France	1582	43	36.79
13	Lithuania	1472	64	23.00
14	Germany	1470	20	73.50
15	Italy	1329	32	41.53
16	Denmark	1279	12	106.58
17	Belgium	1211	23	52.65
18	Greece	1055	32	32.97
19	Turkey	1042	59	17.66
20	Canada	1032	27	38.22
21	India	796	48	16.58
22	Brazil	512	27	18.96
23	South Korea	368	13	28.31
24	Australia	308	22	14.00
25	Switzerland	287	15	19.13
26	Malaysia	263	12	21.92
27	Scotland	157	10	15.70

Source: Own elaboration.

Among the countries with the greatest impact, located in positions 1 to 13 in the ranking, the USA, China, Spain, Portugal, England, Finland, France and Lithuania stand out for their low academic efficiency (CpD below average). These are countries that, in order to achieve academic impact, must increase their production of articles, but the average impact per article is low in comparative terms. In contrast, Australia, Scotland, India, Turkey, Brazil, Iran or Switzerland recorded little impact in comparative terms, given their high level of production, with CpD levels of fewer than 20 citations per article.

3.3. Bibliographic Coupling per Documents

The analysis of bibliographic coupling per documents (Figure 6) set a minimum cutoff threshold of 150 citations of a document, establishing four clusters that include 36 central articles.

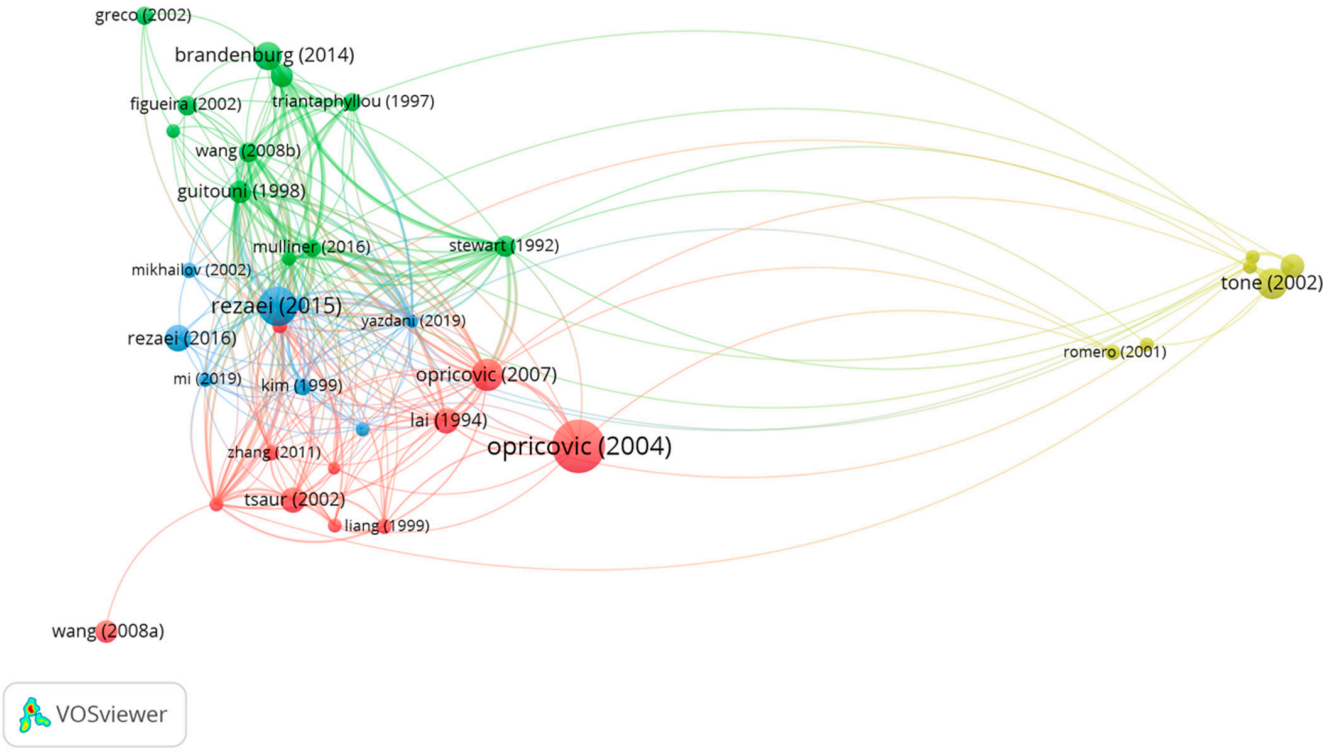

Figure 6. Coupling of articles with at least 150 citations.

Cluster 1 (red) includes articles on the comparison of methods (e.g., VIKOR and TOPSIS) [82,83], Qualiflex [84], Electre I [85], TOPSIS [86], fuzzy AHP [87], fuzzy MCDM [8,88–90], and practical applications based on firm technological innovation capabilities under uncertainty [91] or tourism destination competitiveness [92]. Cluster 2 (green) focuses on supply chain management [19], portfolio optimization [93], social multicriteria evaluations [94] and methodological advances [10–12,20,95–97]. Cluster 3 (blue) focuses on advanced methodological aspects such as geometrical representations [98], combined compromise solutions [99], procedure under incomplete information [100], linear models [29] and worst methods in decision-making [101]. This cluster also includes seminal articles on practical applications of the MCDM methodology to virtual enterprises [102], robust portfolios [103] or port performance [104]. Cluster 4 (yellow) is located at a great distance from the three previous clusters and is made up of Romero's articles on goal programming [105,106], and peripheral articles on ranking methods [9], superefficiency [107], value efficiency [13] and data envelopment analysis [15].

3.4. Dynamic Evolution of the Research Agenda

The analysis of the overlapping map (Figure 7) reports the comparison of the dominant academic production between subperiods. A total of 87 seminal articles articulated the debate before the GFC and 158 after the GFC. After 2008, the new research agenda incorporated 75 new articles that became central to shaping the scientific debate. In fact, in the VUCA era, the 83 articles from the previous period accounted for 51% of the 158 core articles that researchers used to build their references and advance science in fields such as MCDM.

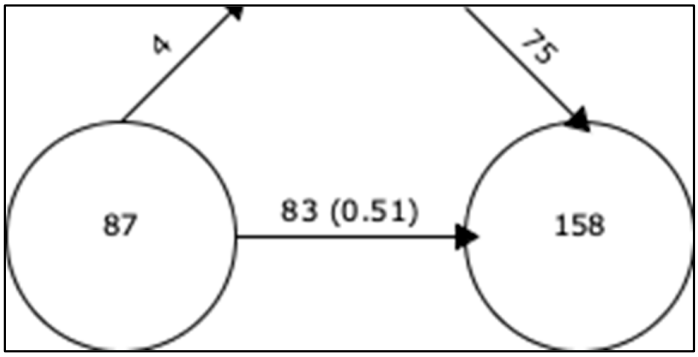

Figure 7. Overlapping map.

Important research that dominated the debate addressed the study of strategic performance [37], sustainable housing affordability [20], tourism policy implementation [108] or urban sewage sludge and transitions for eco-cities [22]. In this sense, the VUCA environments promoted research on blockchain [53,109], green supply chain management [42], new business models based in sharing economy [110], development of smart cities [111–114], mobility systems [115,116], fuzzy and MCDM methodologies to prioritize the best alternatives [90,117,118], wastewater treatment [119] and solution of challenges of water management of developing countries [120,121].

Figures 8 and 9 and Tables 5 and 6 report the results of the analysis carried out with SciMAT for both subperiods. The detailed evaluation based on the compared thematic clusters offers relevant information to guide future research according to the evolution of the research agenda.

Table 5. Cluster information. Subperiod 1 (1979–2008).

Cluster Name	CDC *	CDHI	DAC	CDSC	Centrality	CR	Density	DR
Ranking	17	13	64.18	1091	42.68	1	16.27	0.5
Decision	5	5	59.8	299	26.81	0.67	29.84	0.67
Multiple-criteria-decision-making	39	23	41.67	1625	30.1	0.83	9.18	0.17
Decision-support-systems	8	7	153.5	1228	21.55	0.5	9.19	0.33
Multi-criteria-decision-making	4	4	44.5	178	11.27	0.33	33.77	1
Preference-modelling	2	2	112	224	3.41	0.17	32.5	0.83

* See Acronyms for details of acronyms. Source: Own elaboration.

Emerging themes before 2008, year in which one of the biggest global economic crises broke out (GFC) as seen in Figure 8 and Table 5 were tangentially related to decision support systems [14], and after 2008, Figure 9 and Table 6 new academic debates arise about multi-objective optimization [30,93] and additive value functions [32]. Basic themes also evolved between both subperiods. Before 2008 (Figure 8; Table 5), multiple-criteria decision-making [82,88,89] was the most important basic theme, while after 2008 (Figure 9; Table 6) the theory of the firm [122,123] and the analysis of decision weights [97,124,125] became basic themes. Specialized topics were also transformed after 2008. Before 2008 (Figure 8; Table 5) the preference modeling theme stood out [103] and after 2008 (Figure 9; Table 6) the

niche themes that were identified where the preferences [126], distance measures [37,104] and impacts [36,124] themes.

Figure 8. Strategic diagram of subperiod 1 (1979–2008).

Before 2008 (Figure 8; Table 5) were the multiple-criteria decision-making [82,88,89], while after 2008 (Figure 9; Table 6) the theory of the firm [122,123] and the analysis of decision weights [97,124,125] became basic themes (Figure 8; Table 5), the motor themes were decisions and rankings, while the motor themes after 2008 (Figure 9; Table 6) were multicriteria [22,29,34,38,94,99,119,124,125,127,128], environment [41,120,124,129,130] and models [5,19,38,107,108,116]. The strong irruption of the 2030 Agenda in the academic debate is verified. The influence of the SDGs was articulated in a transversal way around the main research topics of the subperiod analyzed after 2008. The understanding of the models and methodologies for multicriteria decision-making in contexts of environmental and social sustainability helped to improve adherence and the impact of their application to reality. Emerging themes before 2008 (Figure 8; Table 5) were tangentially related to decision support systems [14], and after 2008 (Figure 9; Table 6) new academic debates arise about multiobjective optimization [30,93] and additive value functions [32]. The basic themes also evolved between both subperiods. Before 2008 (Figure 8; Table 5) were the multiple-criteria decision-making [82,88,89], while after the GFC (Figure 9; Table 6) the theory of the firm [122,123] and the analysis of weights in decision analysis [97,124,125] became basic topics. Specialized topics were transformed after 2008. Before 2008 (Figure 8; Table 5), preference modeling stood out [103], and after 2008 (Figure 9; Table 6), niche themes were preferences [126], distance measures [37,104], and impacts [36,124].

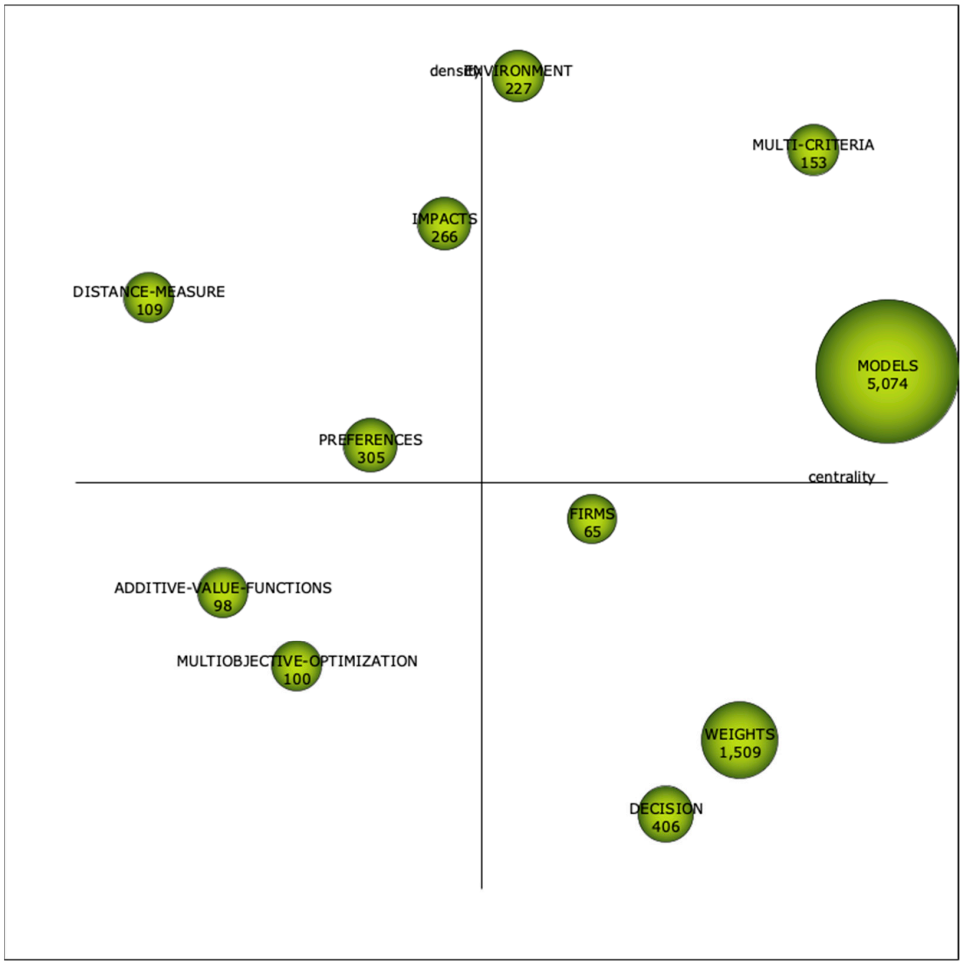

Figure 9. Strategic diagram of subperiod 2 (2009–2022).

Table 6. Clusters information. Subperiod 2 (2009–2022).

Cluster Name	CDC *	CDHI	DAC	CDSC	Centrality	CR	Density	DR
Environment	9	7	25.22	227	20.92	0.6	11.93	1
Models	141	34	35.99	5074	33.08	1	5.98	0.6
Preferences	14	9	21.79	305	19.04	0.4	5.39	0.6
Impacts	11	9	24.18	266	20.79	0.5	8.74	0.8
Multi-criteria	9	6	17	153	29.32	0.9	10.24	0.9
Weights	9	8	167.7	1509	28.11	0.8	3.06	0.2
Decision	12	8	33.83	406	23.58	0.7	1.77	0.1
Firms	7	4	9.29	65	20.95	0.6	4.56	0.5
Multiobjective-optimization	6	5	16.67	100	15.26	0.3	3.79	0.3
Distance-measure	4	3	27.25	109	10.53	0.1	6.67	0.7
Additive-value-functions	5	5	19.6	98	12.26	0.2	3.97	0.4

* See Acronyms for details of acronyms. Source: Own elaboration.

Figure 10 reports the details of the transformation of the academic debate on MCDM after 2008. The evolution map for both subperiods shows the connection of preceding and subsequent themes. Among others, four major conversion nuclei of the academic debate stand out: (a) rankings [9,11] towards models [5,19,38,108,116]; (b) MCDM [8,82,88,89,93] towards models, preferences, weights, decision, firms and distance measure [5,85,104,124–126,131]; (c) decision support systems [14] towards weights analysis [124,125]; (d) preference modeling [13,103] towards multiple criteria [38,95,124–128,132] and additive value functions [32].

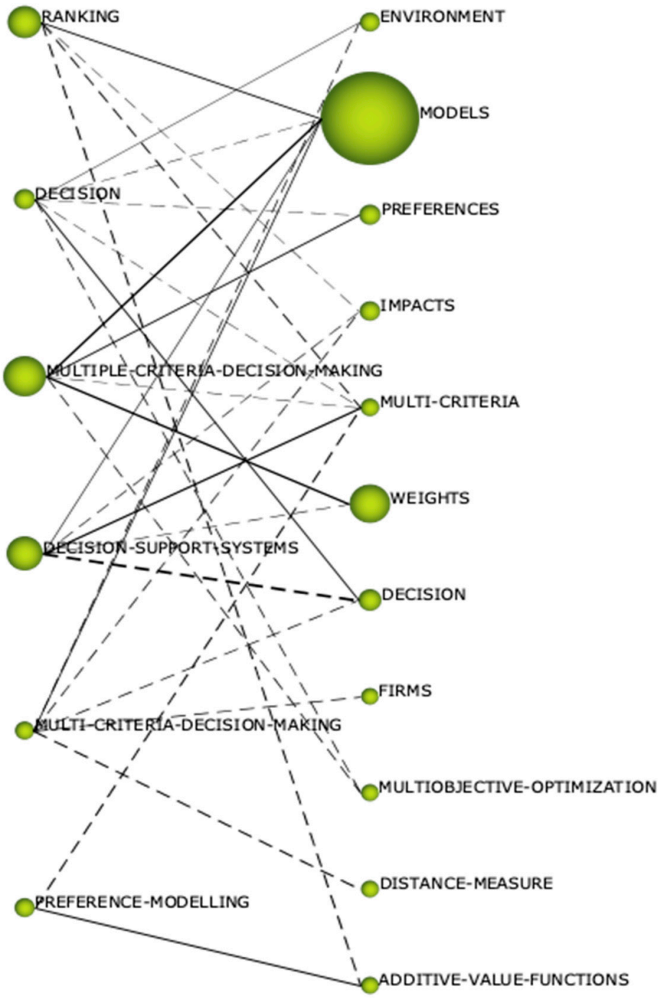

Figure 10. Evolution map. Subperiod 1 (1979–2008) vs. subperiod 2 (2009–2022).

3.5. High-Impact Publishing Opportunities

Proper understanding of the evolving research agenda offers important opportunities for high-impact publishing. There are multiple gaps not yet closed by the literature and in recent years issues have emerged that are of growing interest to scholars. Appendix A reports the top 25 articles and journals. From the perspective of the total impact expressed as the total count of citations for the subperiod prior to 2008 (Appendix A; Table A1), seminal articles on MCDM are located in the index with the highest impact [8–15,82,83,86–89,91,93,94,96–98,100,102,106,107,133], and those that stand out for their high performance expressed in academic efficiency through the normalized impact per year (NIY) method the seminal works of Opriocovic and Tzeng [82] on comparative analysis of VIKOR and TOPSIS (NIY = 132,11) and extended VIKOR method in comparison with outranking methods (NIY = 60,27), and Tone [107] on measure of superefficiency (NIY = 46,50). The academic performance of these three articles is markedly superior to the rest of the research indexed in the top 25 articles by citations.

Based on the asymmetry of years included in both subperiods, the NIY analysis for the top 25 articles by citations (Appendix A; Table A2) [19–23,29–37,84,85,92,95,99,101,108,134–137] offers relevant information on "hot topics" for scholars. This evaluation of WHAT research is likely to have a greater impact in the contemporary academic context. Thus, WHAT is determined from the NIY analysis, in order to identify mainstream themes for each of the two subperiods. In particular, the evaluation of the articles included in the top 25 per NIY that were not included in the top 25 articles by citations (Appendix A; Tables A3 and A4; second column: strong trend (ST), shows that before 2008, four very important articles

published in the years immediately prior to the 2008 stood out for NIY). These articles addressed topics of academic interest such as robust portfolio modeling [103,138], goal programming models [105] and multiobjective optimization [139]. The articles that are part of the top 25 per NIY after 2008 and that did not achieve enough total impact to be included in the top 25 per citations are articles with high academic efficiency, since they generate many citations in the trade-off per year since posting. Thus, given that subperiod 2 includes only 13 years, a detailed analysis of the "hot topics" allows us to identify mainstream topics in recent years. Given the high level of impact achieved by these articles in just a few years, issues such as linguistic analysis for smart health care emerge [140] and MCDM under uncertainty [141], decision-makers' psychological preferences [142], cognitive mapping [113,143–145], stochastic MCDM [146], big data analytics capabilities and firm performance [147], open innovation in SMEs [145], smart cities [113] and sustainable supplier selection for megaprojects [25,130,148].

The evidence found suggests that the reported topics are presented in the first line of advancement of scientific knowledge. These themes and their semantic connecting detail represent important high-impact publishing opportunities. In this sense, Appendix B (Figures A1–A11) offers detailed information on how to connect the topics based on the clusters of greatest interest in academia, so the "how" shows the connection between the subtopics through the cluster's networks of subperiod 2. These are thematic nuclei required with interest by the journals, and that make up the academic vanguard. Researchers can identify the way in which contemporary discourse is articulated and build their research on the environment (Figure A1), models (Figure A2), preferences (Figure A3), impacts (Figure A4), multiple criteria (Figure A5), weights (Figure A6), decisions (Figure A7), firms (Figure A8), multiobjective optimization (Figure A9), distance measures (Figure A10) and additive value functions (Figure A11).

On the other hand, after analyzing what to research and how to connect the topics to achieve maximum impact, it is necessary to look at where it is most effective to publish high-impact research. Analogously to the previous analysis, evidence is presented for both subperiods. Table A5 (Appendix B) shows the main journals of subperiod 1, ordered by total citations. Before 2008, the 10 journals with the greatest impact on MCDM were the *European Journal of Operational Research*, *Omega—International Journal of Management Science*, *Journal of the Operational Research Society*, *Decision Sciences*, *Tourism Management*, *Management Science*, *Technovation*, *IEEE Transactions on Engineering Management*, *Systems Research and Behavioral Science*, and *Group Decision and Negotiation*. The ComD evaluation offers indicators of high academic efficiency for three journals that manage to register at least 100 citations per article: *Tourism Management* (CpD = 544), *Systems Research and Behavioral Science* (CpD = 146), and the *European Journal of Operational Research* (CpD = 103.78).

Table A6 (Appendix A) shows the 25 journals with the greatest academic impact in the second subperiod analyzed, offering a useful guide to determine where to publish research on MCDM. According to the second column of Table A6, according to the strong trend (ST) indication, several journals are evidenced, characterized by their emerging impact within the field in comparative intertemporal terms. After 2008, 16 journals appear in the ranking that were not included in the same top 25 ranking of the previous subperiod. The finding of these journals is a very useful recommendation for scholars on where to direct their research on MCDM within the area of business and management once the systemic change in the research agenda after the 2008 took place. The strong trend (ST) evidence found shows 16 "hot journals" in the field: *Journal of Business Economics and Management*, *Technological Forecasting and Social Change*, *International Journal of Strategic Property Management*, *International Transactions in Operational Research*, *Journal of Enterprise Information Management*, *Transformations in Business and Economics*, *Journal of Business Research*, *Total Quality Management and Business Excellence*, *Socio-Economic Planning Sciences*, *International Journal Of Logistics Management*, *E a M: Ekonomie a Management*, *Business Strategy and the Environment*, *Engineering Construction and Architectural Management*, *Journal of Purchasing and Supply Management*, *and Tourism Management Perspectives*.

The results of this article should give researchers a better understanding of the structure of research done on MCDM and MCDA. Among the new contributions to the literature that this article represents is the evaluation of new motor topics though the SciMAT software, which permits the visualization of the most current mainstream thematic nuclei of the academic discourse on MCDM and MCDA.

Although the research was not designed or conducted as a meta-analysis, it can be deemed valuable due to the clarity of the information provided. As such, the findings of this study are relevant to the academic community and advance the scientific debate on MCDM. When information is focalized, it constitutes a resource that makes academic interaction more accessible for researchers, allowing for scholarly discussions based on decision-making traditions.

4. Conclusions

The recent succession of economic, social, health, and war crises has generalized the irruption of a continuum of VUCA environments (volatile, uncertain, complex, and ambiguous) that have become global and hegemonic. The existing interdependence among the different systems has a substantial effect on companies, entrepreneurs, and investors, as well as governments and civil society, and forces accurate and rapid decisions to be made. On the other hand, shocks are becoming more frequent, deep, and persistent. In the contemporary era, the first recent systemic crisis that caused major economic and social disruption in most developed countries was the GFC. Since 2008, all kinds of disruptive events have taken place that force managers and governors to make quick and concrete decisions. Following 2008, academic interest in multiple-criteria decision-making (MCDM) or multiple-criteria decision-analysis (MCDA) has clearly increased. Articles published on these topics in scientific journals in the business and management area in recent years have achieved a much higher normalized impact per year (NIY). In addition to the increase in interest from academia, there has been an important paradigm shift causing the transformation of the research agenda. International collaboration networks have intensified, and Taiwan, USA, Serbia, China, and Spain are leaders in total citations. However, academic efficiency measured as citations per document (CpD) is very strong in Serbia, Netherlands, and Denmark and very weak in Australia, Scotland, India, Turkey, Brazil, Iran, and Switzerland. The theme construction of the scientific vanguard and bibliographic coupling per article analysis show four large clusters that contribute to a better understanding of the structure of the academic debate on MCDM.

The dynamic evolution of the research agenda shows a profound transformation of the driving, basic, and emerging issues, offering important recommendations on the construction of the academic debate. The evolution of specialized topics advises scholars on major emerging trends that allow them to increase the impact of their future research. From the perspective of the practical application of the methodologies analyzed, a finding of this study guides future academic production around "hot topics", such as mobility, management of scarce resources, such as water or energy, electrification, and electric vehicles, and new models of business based on blockchain or the sharing economy. In addition, from a particular approach, the evidence found suggests that future research on portfolio modeling, multiobjective optimization, or goal-programming models were emerging topics before 2008, but high-impact publication opportunities are focused on the study of the construction of cognitive maps and a better understanding of the psychological preferences of decision-makers, as well as the application of MCDM methodologies to specific problems, such as smart cities, green supply chain alternatives, open innovation in SMEs, and the impact of big data capabilities on firm performance.

The axes of systematic review and analysis carried out by this research offer new vectors to be explored and developed by scholars. In addition, researchers and journal editors can find in this article a roadmap to be used in the planning, design, and publishing of research in the field. Further value can be found in the identification of "hot topics" and changing trends defined on the basis of the methodologies used. The main contribution of

this study is to offer a panoramic view of the field of research published in business and management areas on MCDM, and to help academics in understanding how the research agenda has been transformed. In addition, the identification of the change vectors of the internal structure of the area guides and advises researchers in their future academic production, informing about gaps not closed by the scientific literature. This research provides journal editors with specific guidance on new emerging topics and the forefront of the scientific debate on MCDM, as well as the uses and applications with the greatest academic impact.

A limitation of this study is in the bibliographic methodology used. Future research should complement the scientometric knowledge generated by this research with a qualitative approach that is provided by researchers who are building the cutting edge of science on MCDM. In addition, this research could include a classification of the MCDM methodology that identifies its evolution and its fields of application. Among others, future lines of research should hybridize bibliographic methodologies with others of a qualitative type, such as design and system thinking or focus group, to improve the understanding of the underlying motivations of the researchers, as well as sources of funding, that explain the transformation of the research agenda. Other research should delve into the detailed analysis of specific methodologies used for decision-making, such as fuzzy analytic hierarchy process (F-AHP) or fuzzy-set qualitative comparative analysis (fsQCA), extending the analysis to the construction and selection of sociotechnical transitions designed to achieve the SDGs.

Author Contributions: Conceptualization, F.C.-S.; methodology, F.C.-S.; software, F.C.-S.; validation, F.C.-S. and C.M.-E.; formal analysis, F.C.-S.; investigation, F.C.-S.; resources, F.C.-S.; data curation, F.C.-S.; writing—original draft preparation, F.C.-S.; writing—review and editing, F.C.-S. and C.M.-E.; visualization, F.C.-S. and C.M.-E.; supervision, F.C.-S.; project administration, F.C.-S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Data sharing not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Acronyms

AB	abstract
AHP	analytical hierarchy process
AK	author keywords
CDAC	core documents average citations
CDC	core documents count
CDHI	core documents h-index
CR	centrality range
CDSC	core document sum citations
DpY	documents per year
DR	density range
fsQCA	fuzzy-set qualitative comparative analysis
JCR	Journal Citation Reports®
KP	Keyword Plus®
MCDM	multiple-criteria decision-making or multicriteria decision-making
MCDA	multiple-criteria decision analysis or multicriteria decision analysis
NIY	normalized impact per year
SSCI	Social Sciences Citation Index
SCIE	Science Citation Index Expanded
ST	strong trend
TI	title
TS	topic
WoS-CC	Web of Science Core Collection

Appendix A. Top 25 Articles and Journals

Table A1. Top 25 articles by citations. Subperiod 1 (1979–2008).

Rank	Tittle	Authors	Journal	Year	Cites	NIY
1	Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS [83]	Opricovic, S; Tzeng, GH	European journal of operational research	2004	2378	132.11
2	A slacks-based measure of super-efficiency in data envelopment analysis [107]	Tone, K	European journal of operational research	2002	930	46.50
3	Extended VIKOR method in comparison with outranking methods [83]	Opricovic, S; Tzeng, GH	European journal of operational research	2007	904	60.27
4	Topsis for MODM [86]	Lai, YJ; Liu, TY; Hwang, CL	European journal of operational research	1994	565	20.18
5	The evaluation of airline service quality by fuzzy MCDM [8]	Tsaur, SH; Chang, TY; Yen, CH	Tourism management	2002	544	27.20
6	Review of ranking methods in the data envelopment analysis context [9]	Adler, N; Friedman, L; Sinuany-Stern, Z	European journal of operational research	2002	532	26.60
7	On the extent analysis method for fuzzy AHP and its applications [87]	Wang, YM; Luo, Y; Hua, Z	European journal of operational research	2008	465	33.21
8	Social multi-criteria evaluation: Methodological foundations and operational consequences [94]	Munda, G	European journal of operational research	2004	458	25.44
9	Tentative guidelines to help choosing an appropriate MCDA method [10]	Guitouni, A; Martel, JM	European journal of operational research	1998	446	18.58
10	A critical survey on the status of multiple criteria decision-making theory and practice [96]	Stewart, TJ	Omega-international journal of management science	1992	387	12.90
11	Rough sets methodology for sorting problems in presence of multiple attributes and criteria [133]	Greco, S; Matarazzo, B; Slowinski, R	European journal of operational research	2002	348	17.40
12	Determining the weights of criteria in the ELECTRE type methods with a revised Simos' procedure [97]	Figueira, J; Roy, B	European journal of operational research	2002	337	16.85
13	Ranking irregularities when evaluating alternatives by using some ELECTRE methods [11]	Wang, XT; Triantaphyllou, E	Omega-international journal of Management science	2008	327	23.36
14	A sensitivity analysis approach for some deterministic multi-criteria decision-making methods [12]	Triantaphyllou, E; Sanchez, A	Decision sciences	1997	305	12.20

Table A1. *Cont.*

Rank	Tittle	Authors	Journal	Year	Cites	NIY
15	Interactive group decision making procedure under incomplete information [100]	Kim, SH; Ahn, BS	European journal of operational research	1999	290	12.61
16	Fuzzy MCDM based on ideal and anti-ideal concepts [88]	Liang, GS	European journal of operational research	1999	231	10.04
17	Fuzzy analytical approach to partnership selection in formation of virtual enterprises [102]	Mikhailov, L	Omega-international journal of Management science	2002	216	10.80
18	Extended lexicographic goal programming: a unifying approach [106]	Romero, C	Omega-international journal of Management science	2001	196	9.33
19	Evaluating firm technological innovation capability under uncertainty [91]	Wang, CH; Lu, IY; Chen, CB	Technovation	2008	178	12.71
20	A value efficiency approach to incorporating preference information in data envelopment analysis [13]	Halme, M; Joro, T; Korhonen, P; Salo, S; Wallenius, J	Management science	1999	176	7.65
21	An MCDM approach to portfolio optimization [93]	Ehrgott, M; Klamroth, K; Schwehm, C	European journal of operational research	2004	172	9.56
22	Decision Support Systems in action: Integrated application in a multicriteria decision aid process [14]	Bana E Costa, CA; Ensslin, L; Correa, EC; Vansnick, JC	European journal of operational research	1999	169	7.35
23	Evaluating sustainable fishing development strategies using fuzzy MCDM approach [89]	Chiou, HK; Tzeng, GH; Cheng, DC	Omega-international journal of management science	2005	168	9.88
24	Geometrical representations for MCDA [98]	Mareschal, B; Brans, JP	European journal of operational research	1988	164	4.82
25	Relationships between data envelopment analysis and multicriteria decision analysis [15]	Stewart, TJ	Journal of the operational research society	1996	162	6.23

Source: Own elaboration.

Table A2. Top 25 articles by citations. Subperiod 2 (2009–2022).

Rank	Tittle	Authors	Journal	Year	Cites	NIY
1	Best-worst multi-criteria decision-making method [134]	Rezaei, J	Omega-international journal of management science	2015	1263	180.43
2	Quantitative models for sustainable supply chain management: Developments and directions [19]	Brandenburg, M; Govindan, K; Sarkis, J; Seuring, S	European journal of operational research	2014	666	83.25
3	Best-worst multi-criteria decision-making method: Some properties and a linear model [29]	Rezaei, J	Omega-international journal of management science	2016	576	96.00
4	Comparative analysis of MCDM methods for the assessment of sustainable housing affordability [20]	Mulliner, E; Malys, N; Maliene, V	Omega-international journal of management science	2016	225	37.50
5	An extension of the Electre I method for group decision-making under a fuzzy environment [85]	Hatami-Marbini, A; Tavana, M	Omega-international journal of management science	2011	210	19.09
6	The evaluation of tourism destination competitiveness by TOPSIS & information entropy—A case in the Yangtze River Delta of China [92]	Zhang, H; Gu, CL; Gu, LW; Zhang, Y	Tourism management	2011	207	18.82
7	g-dominance: Reference point based dominance for multiobjective metaheuristics [30]	Molina, J; Santana, LV; Hernandez-Diaz, AG; Coello, CAC; Caballero, R	European journal of operational research	2009	179	13.77
8	Generalised framework for multi-criteria method selection [95]	Watrobski, J; Jankowski, J; Ziemba, P; Karczmarczyk, A; Ziolo, M	Omega-international journal of management science	2019	177	59.00
9	The state-of-the-art survey on integrations and applications of the best worst method in decision making: Why, what, what for and what's next? [101]	Mi, XM; Tang, M; Liao, HC; Shen, WJ; Lev, B	Omega-international journal of management science	2019	167	55.67
10	The extended QUALIFLEX method for multiple criteria decision analysis based on interval type-2 fuzzy sets and applications to medical decision making [84]	Chen, TY; Chang, CH; Lu, JFR	European journal of operational research	2013	160	17.78
11	A combined compromise solution (CoCoSo) method for multi-criteria decision-making problems [99]	Yazdani, M; Zarate, P; Zavadskas, EK; Turskis, Z	Management decision	2019	150	50.00
12	Strategic performance measurement in a healthcare organisation: A multiple criteria approach based on balanced scorecard [37]	Grigoroudis, E; Orfanoudaki, E; Zopounidis, C	Omega-international journal of management science	2012	150	15.00
13	FAMCDM: A fusion approach of MCDM methods to rank multiclass classification algorithms [31]	Peng, Y; Kou, G; Wang, GX; Shi, Y	Omega-international journal of management science	2011	150	13.64

Table A2. *Cont.*

Rank	Tittle	Authors	Journal	Year	Cites	NIY
14	An assessment of sustainable housing affordability using a multiple criteria decision making method [21]	Mulliner, E; Smallbone, K; Maliene, V	Omega-international journal of management science	2013	147	16.33
15	Improving tourism policy implementation—The use of hybrid MCDM models [108]	Liu, CH; Tzeng, GH; Lee, MH	Tourism management	2012	136	13.60
16	An extended TODIM approach with intuitionistic linguistic numbers [135]	Yu, SM; Wang, J; Wang, JQ	International transactions in operational research	2018	135	33.75
17	Building a set of additive value functions representing a reference preorder and intensities of preference: GRIP method [32]	Figueira, JR; Greco, S; Slowinski, R	European journal of operational research	2009	133	10.23
18	Urban sewage sludge, sustainability, and transition for Eco-City: Multi-criteria sustainability assessment of technologies based on best-worst method [22]	Ren, JZ; Liang, HW; Chan, FTS	Technological forecasting and social change	2017	128	25.60
19	Using fuzzy multiple criteria decision making approach to enhance risk assessment for metropolitan construction projects [33]	Kuo, YC; Lu, ST	International journal of project management	2013	123	13.67
20	Hesitant fuzzy Bonferroni means for multi-criteria decision making [34]	Zhu, B; Xu, ZS	Journal of the operational research society	2013	123	13.67
21	Non-additive robust ordinal regression: A multiple criteria decision model based on the Choquet integral [35]	Angilella, S; Greco, S; Matarazzo, B	European journal of operational research	2010	123	10.25
22	An intelligent-agent-based fuzzy group decision making model for financial multicriteria decision support: The case of credit scoring [136]	Yu, L; Wang, SY; Lai, KK	European journal of operational research	2009	120	9.23
23	Application of a novel PROMETHEE-based method for construction of a group compromise ranking to prioritization of green suppliers in food supply chain [23]	Govindan, K; Kadzinski, M; Sivakumar, R	Omega-international journal of management science	2017	116	23.20
24	A modified TOPSIS with a different ranking index [137]	Kuo, T	European journal of operational research	2017	116	23.20
25	The sustainability balanced scorecard as a framework for selecting socially responsible investment: an effective MCDM model [36]	Tsai, WH; Chou, WC; Hsu, W	Journal of the operational research society	2009	114	8.77

Source: Own elaboration.

Table A3. Top 25 articles by NIY. Subperiod 1 (1979–2008).

Rank	ST	Title	Authors	Journal	Year	Cites	NIY
1		Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS [82]	Opricovic, S; Tzeng, GH	European journal of operational research	2004	2378	132.11
2		Extended VIKOR method in comparison with outranking methods [83]	Opricovic, S; Tzeng, GH	European journal of operational research	2007	904	60.27
3		A slacks-based measure of super-efficiency in data envelopment analysis [107]	Tone, K	European journal of operational research	2002	930	46.50
4		On the extent analysis method for fuzzy AHP and its applications [87]	Wang, YM; Luo, Y; Hua, Z	European journal of operational research	2008	465	33.21
5		The evaluation of airline service quality by fuzzy MCDM [8]	Tsaur, SH; Chang, TY; Yen, CH	Tourism management	2002	544	27.20
6		Review of ranking methods in the data envelopment analysis context [9]	Adler, N; Friedman, L; Sinuany-Stern, Z	European journal of operational research	2002	532	26.60
7		Social multi-criteria evaluation: Methodological foundations and operational consequences [94]	Munda, G	European journal of operational research	2004	458	25.44
8		Ranking irregularities when evaluating alternatives by using some ELECTRE methods [11]	Wang, XT; Triantaphyllou, E	Omega-international journal of Management science	2008	327	23.36
9		TOPSIS FOR MODM [86]	Lai, YJ; Liu, TY; Hwang, CL	European journal of operational research	1994	565	20.18
10		Tentative guidelines to help choosing an appropriate MCDA method [10]	Guitouni, A; Martel, JM	European journal of operational research	1998	446	18.58
11		Rough sets methodology for sorting problems in presence of multiple attributes and criteria [133]	Greco, S; Matarazzo, B; Slowinski, R	European journal of operational research	2002	348	17.40
12		Determining the weights of criteria in the ELECTRE type methods with a revised Simos' procedure [97]	Figueira, J; Roy, B	European journal of operational research	2002	337	16.85
13		A critical survey on the status of multiple criteria decision-making theory and practice [96]	Stewart, TJ	Omega-international journal of Management science	1992	387	12.90
14		Evaluating firm technological innovation capability under uncertainty [91]	Wang, CH; Lu, IY; Chen, CB	Technovation	2008	178	12.71

Table A3. *Cont.*

Rank	ST	Title	Authors	Journal	Year	Cites	NIY
15		Interactive group decision making procedure under incomplete information [100]	Kim, SH; Ahn, BS	European journal of operational research	1999	290	12.61
16		A sensitivity analysis approach for some deterministic multi-criteria decision-making methods [12]	Triantaphyllou, E; Sanchez, A	Decision sciences	1997	305	12.20
17		Fuzzy analytical approach to partnership selection in formation of virtual enterprises [102]	Mikhailov, L	Omega-international journal of management science	2002	216	10.80
18	✓	Preference programming for robust portfolio modeling and project selection [18]	Liesio, J; Mild, P; Salo, A	European journal of operational research	2007	159	10.60
19	✓	Robust portfolio modeling with incomplete cost information and project interdependencies [138]	Liesio, J; Mild, P; Salo, A	European journal of operational research	2008	145	10.36
20		Fuzzy MCDM based on ideal and anti-ideal concepts [88]	Liang, GS	European journal of operational research	1999	231	10.04
21		Evaluating sustainable fishing development strategies using fuzzy MCDM approach [89]	Chiou, HK; Tzeng, GH; Cheng, DC	Omega-international journal of management science	2005	168	9.88
22		An MCDM approach to portfolio optimization [93]	Ehrgott, M; Klamroth, K; Schwehm, C	European journal of operational research	2004	172	9.56
23		Extended lexicographic goal programming: a unifying approach [106]	Romero, C	Omega-international journal of Management science	2001	196	9.33
24	✓	A general structure of achievement function for a goal programming model [105]	Romero, C	European journal of operational research	2004	160	8.89
25	✓	Synchronous approach in interactive multiobjective optimization [139]	Miettinen, K; Makela, MM	European journal of operational research	2006	130	8.13

Source: Own elaboration.

Table A4. Top 25 articles by NIY. Subperiod 1 (2009–2022).

Rank	ST	Title	Authors	Journal	Year	Cites	NIY
1		Best-worst multi-criteria decision-making method [134]	Rezaei, J	Omega-international journal of management science	2015	1263	180.43
2		Best-worst multi-criteria decision-making method: Some properties and a linear model [29]	Rezaei, J	Omega-international journal of management science	2016	576	96.00
3		Quantitative models for sustainable supply chain management: Developments and directions [19]	Brandenburg, M; Govindan, K; Sarkis, J; Seuring, S	European journal of operational research	2014	666	83.25
4		Generalised framework for multi-criteria method selection [95]	Watrobski, J; Jankowski, J; Ziemba, P; Karczmarczyk, A; Ziolo, M	Omega-international journal of management science	2019	177	59.00
5		The state-of-the-art survey on integrations and applications of the best worst method in decision making: Why, what, what for and what's next? [101]	Mi, XM; Tang, M; Liao, HC; Shen, WJ; Lev, B	Omega-international journal of management science	2019	167	55.67
6		A combined compromise solution (CoCoSo) method for multi-criteria decision-making problems [99]	Yazdani, M; Zarate, P; Zavadskas, EK; Turskis, Z	Management decision	2019	150	50.00
7	✓	Probabilistic double hierarchy linguistic term set and its use in designing an improved VIKOR method: The application in smart healthcare [140]	Gou, XJ; Xu, ZS; Liao, HC; Herrera, F	Journal of the operational research society	2021	41	41.00
8	✓	Generalised probabilistic linguistic evidential reasoning approach for multi-criteria decision-making under uncertainty [141]	Fang, R; Liao, HC; Yang, JB; Xu, DL	Journal of the operational research society	2021	39	39.00
9		Comparative analysis of MCDM methods for the assessment of sustainable housing affordability [20]	Mulliner, E; Malys, N; Maliene, V	Omega-international journal of management science	2016	225	37.50
10		An extended TODIM approach with intuitionistic linguistic numbers [135]	Yu, SM; Wang, J; Wang, JQ	International transactions in operational research	2018	135	33.75
11	✓	Stochastic multicriteria decision-making approach based on SMAA-ELECTRE with extended gray numbers [146]	Zhou, H; Wang, JQ; Zhang, HY	International transactions in operational research	2019	84	28.00
12	✓	Big data analytics capabilities and firm performance: An integrated MCDM approach [147]	Yasmin, M; Tatoglu, E; Kilic, HS; Zaim, S; Delen, D	Journal of business research	2020	56	28.00
13	✓	SMART-C: Developing a Smart City Assessment System Using Cognitive Mapping and the Choquet Integral [113]	Castanho, MS; Ferreira, FAF; Carayannis, EG; Ferreira, JJM	IEEE transactions on engineering management	2021	27	27.00

Table A4. *Cont.*

Rank	ST	Title	Authors	Journal	Year	Cites	NIY
14	✓	Sustainable Supplier Selection in Megaprojects: Grey Ordinal Priority Approach [130]	Mahmoudi, A; Deng, XP; Javed, SA; Zhang, N	Business strategy and the environment	2021	26	26.00
15		Urban sewage sludge, sustainability, and transition for Eco-City: Multi-criteria sustainability assessment of technologies based on best-worst method [22]	Ren, JZ; Liang, HW; Chan, FTS	Technological forecasting and social change	2017	128	25.60
16	✓	Measuring SMEs Propensity for Open Innovation Using Cognitive Mapping and MCDA [145]	Silva, ARD; Ferreira, FAF; Carayannis, EG; Ferreira, JJM	IEEE transactions on engineering management	2021	25	25.00
17	✓	An integrated method for cognitive complex multiple experts multiple criteria decision making based on ELECTRE III with weighted Borda rule [143]	Liao, HC; Wu, XL; Mi, XM; Herrera, F	Omega-international journal of management science	2020	49	24.50
18		Application of a novel PROMETHEE-based method for construction of a group compromise ranking to prioritization of green suppliers in food supply chain [23]	Govindan, K; Kadzinski, M; Sivakumar, R	Omega-international journal of management science	2017	116	23.20
19		A modified TOPSIS with a different ranking index [137]	Kuo, T	European journal of operational research	2017	116	23.20
20	✓	Probabilistic linguistic multi-criteria decision-making based on evidential reasoning and combined ranking methods considering decision-makers' psychological preferences [142]	Tian, ZP; Nie, RX; Wang, JQ	Journal of the operational research society	2020	44	22.00
21	✓	Selection of a sustainable third-party reverse logistics provider based on the robustness analysis of an outranking graph kernel conducted with ELECTRE I and SMAA [25]	Govindan, K; Kadzinski, M; Ehling, R; Miebs, G	Omega-international journal of management science	2019	62	20.67
22		An extension of the Electre I method for group decision-making under a fuzzy environment [85]	Hatami-Marbini, A; Tavana, M	Omega-international journal of management science	2011	210	19.09
23		The evaluation of tourism destination competitiveness by TOPSIS & information entropy—A case in the Yangtze River Delta of China [92]	Zhang, H; Gu, CL; Gu, LW; Zhang, Y	Tourism management	2011	207	18.82
24	✓	Sustainable Supplier Selection and Order Allocation Under Risk and Inflation Condition [149]	Almasi, M; Khoshfetrat, S; Galankashi, MR	IEEE transactions on engineering management	2021	18	18.00
25		The extended QUALIFLEX method for multiple criteria decision analysis based on interval type-2 fuzzy sets and applications to medical decision making [84]	Chen, TY; Chang, CH; Lu, JFR	European journal of operational research	2013	160	17.78

Source: Own elaboration.

Table A5. Top journals in period 1 (1979–2008) for citations.

Rank	Journal	Citations	Articles	CpD
1	European journal of operational research	14,218	137	103.78
2	Omega-international journal of management science	1829	20	91.45
3	Journal of the operational research society	1136	33	34.42
4	Decision sciences	603	10	60.30
5	Tourism management	544	1	544.00
6	Management science	489	10	48.90
7	Technovation	286	5	57.20
8	IEEE transactions on engineering management	215	6	35.83
9	Systems research and behavioral science	146	1	146.00
10	Group decision and negotiation	144	7	20.57
11	Information systems research	107	3	35.67
12	Information & management	100	3	33.33
13	Interfaces	73	3	24.33
14	Journal of productivity analysis	45	1	45.00
15	Journal of engineering and technology management	25	1	25.00
16	Electronic commerce research and applications	18	1	18.00
17	Operations research	15	1	15.00
18	Canadian journal of administrative sciences-revue canadienne des sciences de l'administration	12	2	6.00
19	Long range planning	9	1	9.00
20	International journal of technology management	7	1	7.00
21	Quality progress	6	1	6.00
22	Management decision	3	1	3.00
23	Journal of management information systems	1	1	1.00
24	Zbornik radova ekonomskog fakulteta u rijeci-proceedings of rijeka faculty of economics	1	1	1.00

Source: Own elaboration.

Table A6. Top 25 journals in period 2 (2009–2022) for citations.

Rank	ST	Journal	Cites	Articles	CpD
1		Omega-international journal of management science	4069	44	92.48
2		European journal of operational research	4015	88	45.63
3		Journal of the operational research society	1297	52	24.94
4	✓	Journal of business economics and management	816	33	24.73
5		Tourism management	782	10	78.20
6	✓	Technological forecasting and social change	748	31	24.13
7		Management decision	637	31	20.55
8	✓	International journal of strategic property management	596	25	23.84
9	✓	International transactions in operational research	489	26	18.81
10		Group decision and negotiation	481	23	20.91
11	✓	Journal of enterprise information management	367	22	16.68
12		IEEE transactions on engineering management	292	37	7.89
13		International journal of project management	287	4	71.75
14	✓	Transformations in business & economics	230	18	12.78
15	✓	Journal of business research	204	9	22.67
16	✓	Total quality management & business excellence	203	4	50.75
17	✓	Socio-economic planning sciences	201	21	9.57
18	✓	International journal of logistics management	154	9	17.11
19	✓	E & M ekonomie a management	138	9	15.33
20	✓	Business strategy and the environment	134	4	33.50
21	✓	Engineering construction and architectural management	111	11	10.09
22	✓	Journal of purchasing and supply management	105	2	52.50
23	✓	Tourism management perspectives	81	3	27.00
24		Operations research	76	2	38.00
25		Electronic commerce research and applications	75	4	18.75

Source: Own elaboration.

Appendix B. Cluster Network for Subperiod 2 (2009–2022)

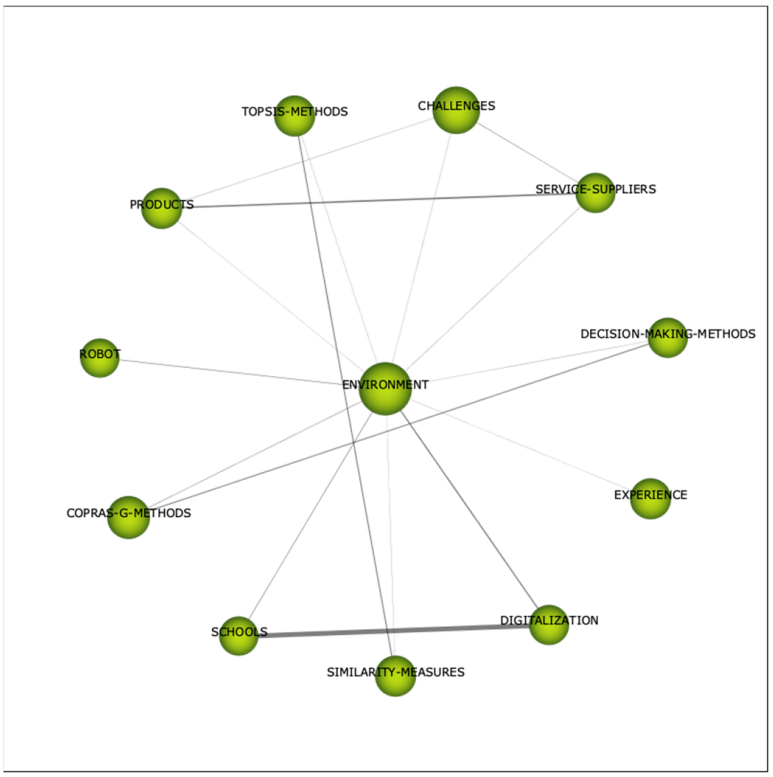

Figure A1. Environment cluster network.

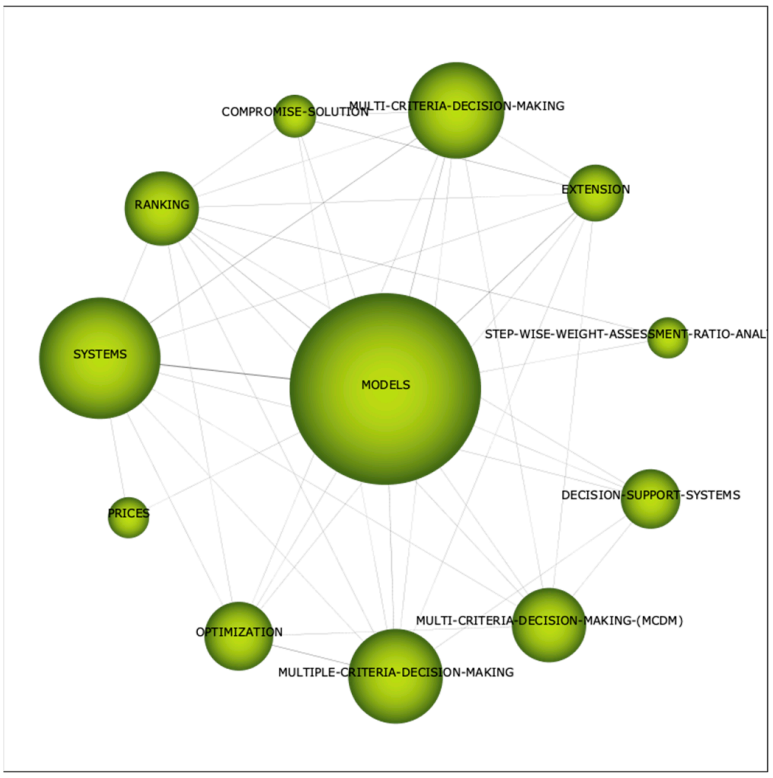

Figure A2. Model cluster network.

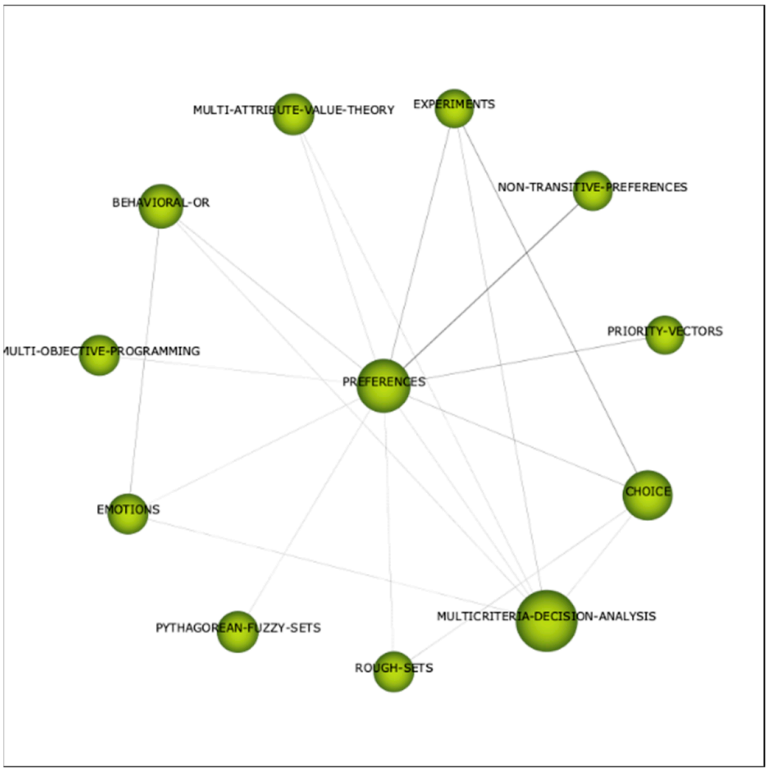

Figure A3. Preference cluster network.

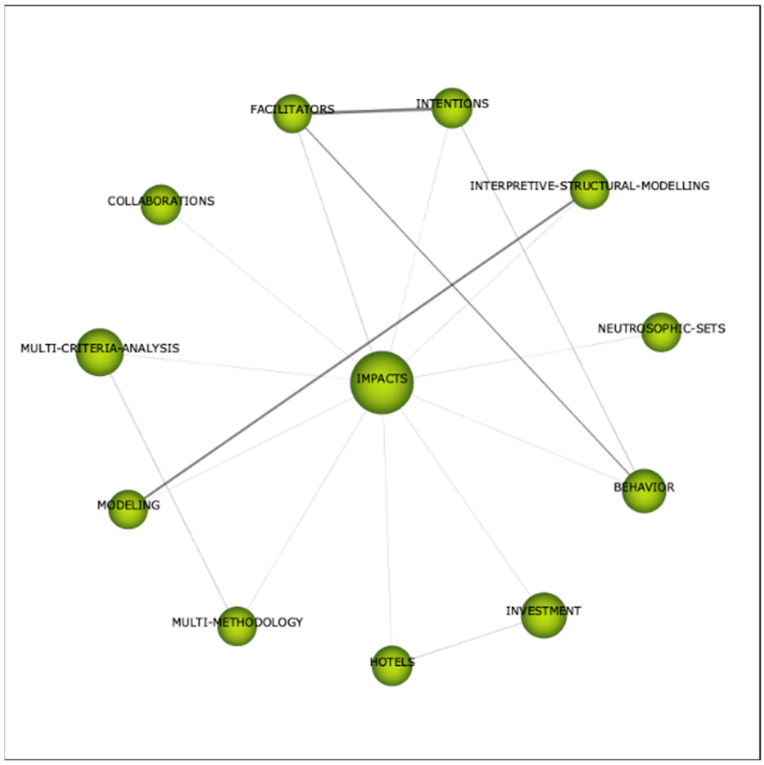

Figure A4. Impact cluster network.

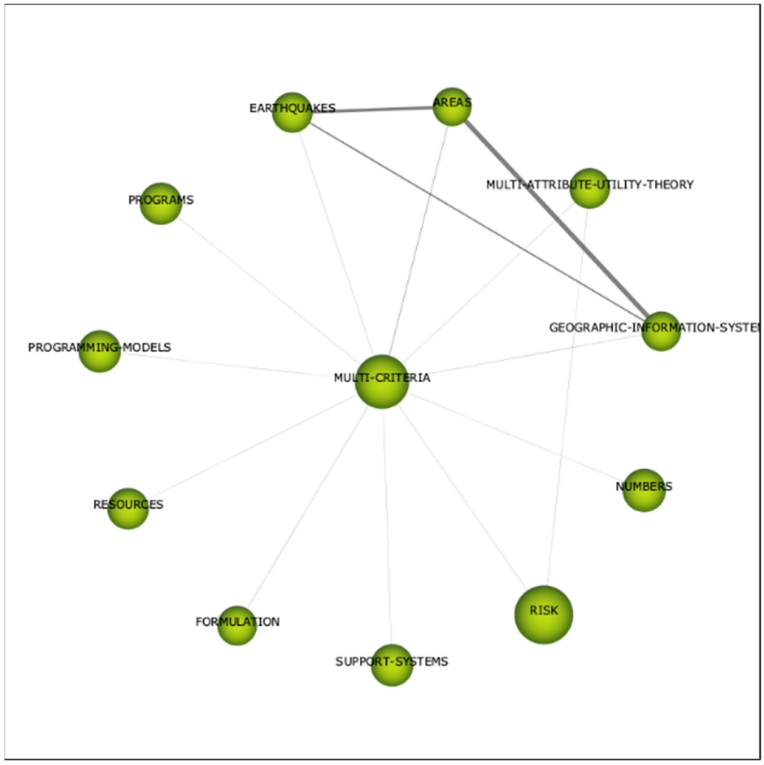

Figure A5. Multi-criteria cluster network.

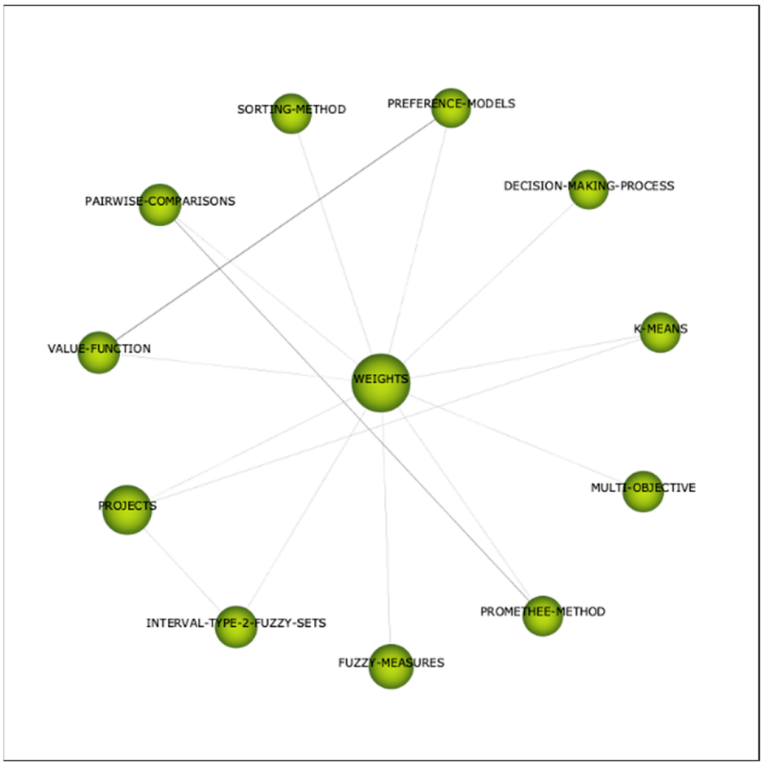

Figure A6. Weight cluster network.

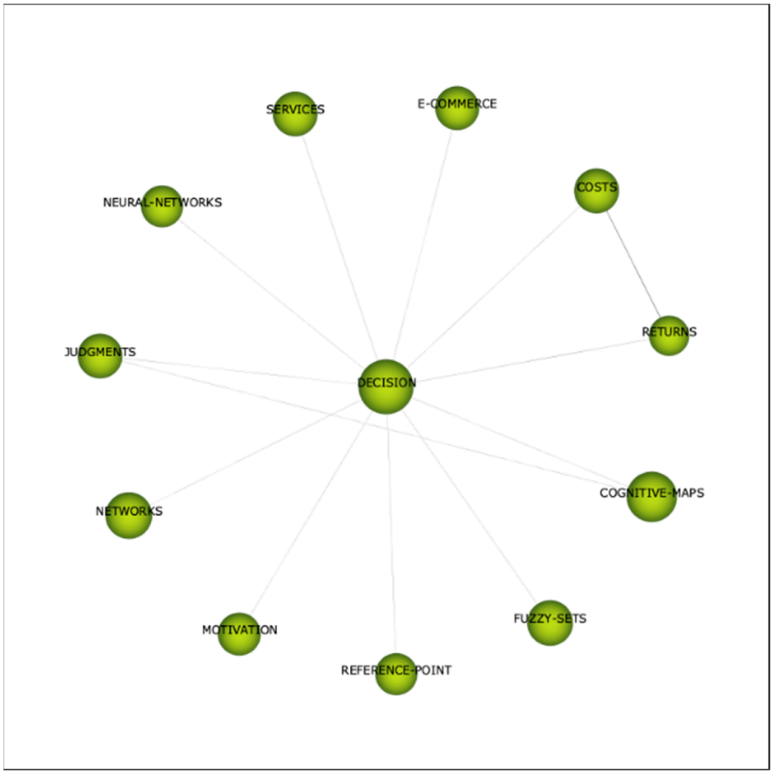

Figure A7. Decision cluster network.

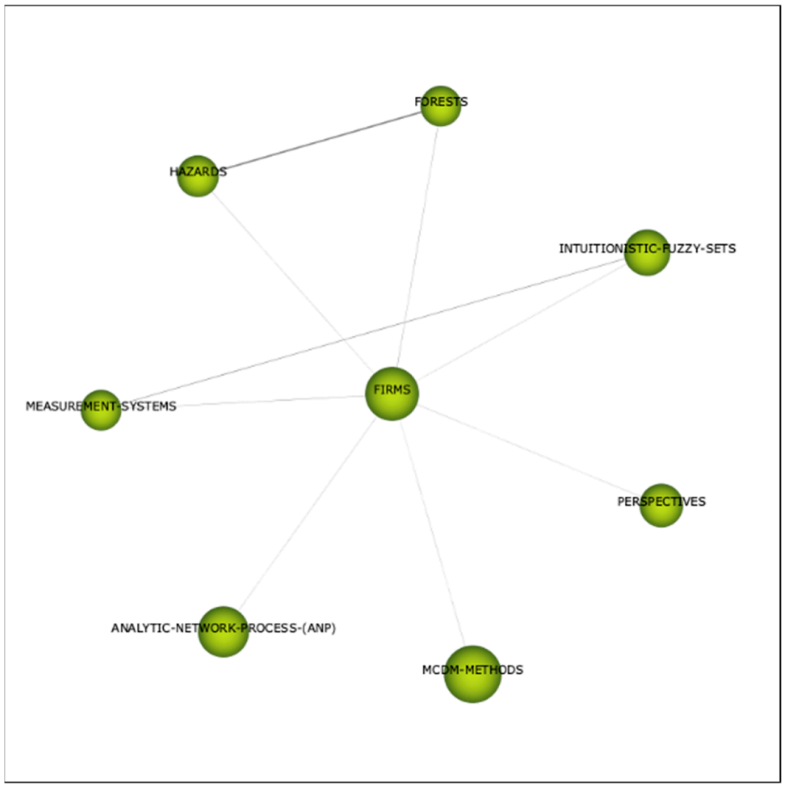

Figure A8. Firm cluster network.

Figure A9. Multiobjective-optimization cluster network.

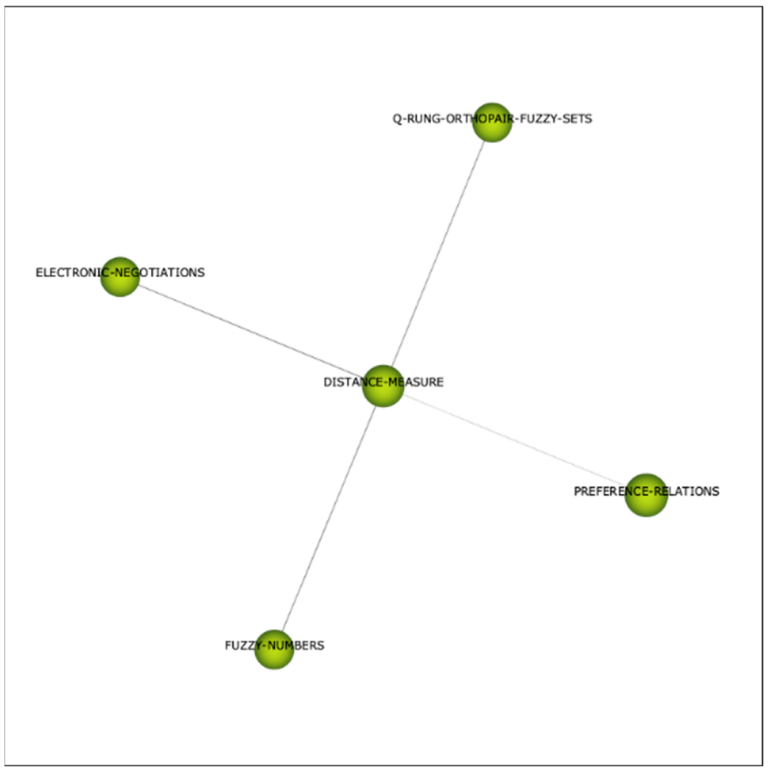

Figure A10. Distance-measure cluster network.

Figure A11. Additive-value-function cluster network.

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