Journal of Discrete Mathematics and Its Applications 11 (3) (2026) 199–220

Journal of Discrete Mathematics and Its Applications

Available Online at: http://jdma.sru.ac.ir

Shahid Rajaee Teacher Training University

Review Article

A bibliometric review of the journal of discrete mathematics and its applications (2011–2025)

Sara Gheisari Goudarzi*

Department of Mathematics, Factually of Science, Shahid Rajaee Teacher Training University, Tehran, I. R. Iran

Academic Editor: Razie Alidehi-Ravandi

Abstract. This study evaluates the knowledge structure and thematic development of the *Journal of Discrete Mathematics and Applications* (JDMA) from 2011 to 2025, aiming to clarify the journal's development trajectory and identify strategic opportunities through a bibliometric analysis of 121 documents using R and VOSviewer. The analysis finds that JDMA exhibits a 6.98% annual growth, indicating robust scientific development. Keyword co-occurrence and author network analyses show a concentration on topological indices and molecular graphs. Key authors such as Modjtaba Ghorbani and Gutman play central roles as connectors, advancing the international exchange of scientific ideas. Expanding international collaborations and diversifying research themes, especially in graphs and hypergraphs, are crucial for enhancing JDMA's global standing. Recommendations include supporting established authors in building international networks, organizing joint special issues, and broadening thematic coverage in emerging topics–measures that could strengthen the journal's international scientific impact.

Keywords. Bibliometric analysis; Performance analysis; Co-citation analysis; Keyword co-occurrence; Thematic map.

Mathematics Subject Classification (2020): 01*A*90.

*Corresponding author (Email address: sgheisari@sru.ac.ir)

Received 23 February 2026; Revised 18 March 2026; Accepted 12 June2026

First Publish Date: 01 September 2026

1 Introduction

Discrete mathematics and its applications have become central to scientific disciplines, largely due to the rapid expansion of computer science, networks, and artificial intelligence in recent decades. Nevertheless, systematic evaluation of trends and themes within discrete mathematics remains crucial for informing future research directions. Given the exponential increase in scientific data, bibliometrics has developed as a quantitative, systematic approach to analysing knowledge structures. This methodology reduces personal biases and enhances the transparency of source evaluation. By utilising citation and co-authorship data, bibliometrics offers a replicable, data-driven framework for describing and monitoring scholarly output [1]. These techniques facilitate mapping the social and thematic structure of research domains, thereby revealing emerging trends and identifying research gaps [2,3]. Bibliometric methods are generally categorised into performance analysis and scientific mapping, including citation analysis, co-citation analysis, co-authorship analysis, and keyword co-occurrence analysis [2].

Bibliometric studies of journals reveal their conceptual structure and thematic trends, equipping editorial boards with insights into research trajectories. Bilgili and Sheu [4], for example, used clustering and keyword frequency in a mathematics journal to inform policy and anticipate future directions. Such systematic analyses support innovation and data-driven editorial strategies [2]. This journal was published from 2011 to 2016 under the title *Journal of Mathematical Nanoscience* and, since 2022, has been published under the title *Journal of Discrete Mathematics and Applications* (JDMA) by Shahid Rajaee Teacher Training University. It is considered a specialized reference in discrete mathematics and its applications. Analyzing the journal's scientific development illuminates trends in discrete mathematics research over time. However, no comprehensive bibliometric study has systematically evaluated JDMA's performance or mapped its cognitive structure for the 2011-2025 period. This study aims to clarify the knowledge structure, thematic trends, and research performance of JDMA via bibliometric analysis of published articles. Using R (Bibliometrix) and VOSviewer, the investigation focuses on thematic mapping and co-citation analysis to address the following research questions:

1. What is the growth trend and geographical distribution of JDMA's scholarly output during the 2011–2025 period?
2. Which authors, sources, and themes exert the greatest influence on the journal's knowledge network?
3. Which emerging or declining themes are identified, and what strategies are proposed for the future development of the journal?

2 Methodology

The primary data for the bibliometric analysis were extracted from the journal's website over the 2011-2025 period. Data analysis was conducted in the R programming environment

using the Bibliometrix package. The analysis process followed three main stages, consistent with bibliometric methodological guidelines:

1. Performance Analysis: In the first stage, the quantitative performance of the journal was examined by reviewing basic indicators such as the annual growth rate of publications, the average age of articles, the number of authors per document, and the geographical distribution of authors. This analysis provides a picture of the journal's scale and organizational influence.

2. Intellectual Structure Analysis: In the second stage, the journal's conceptual structure and schools of thought were studied using Co-citation Analysis to identify foundational sources and the most influential theoretical works; scientific mapping techniques visually display such relationships [2].

3. Thematic Analysis: In the third stage, thematic analysis was performed, relying on Keyword Co-occurrence and the development of a thematic strategic map. For this purpose, the VOSviewer software was used to identify thematic clusters, core themes, and emerging themes based on centrality and density indicators [4]. This multi-stage approach provides a framework for the comprehensive evaluation of the journal's performance and intellectual structure.

3 Performance analysis of the journal's activity trend

The descriptive statistical analysis of JDMA during the 2011 to 2025 period, with a total of 121 articles published, indicates a gradual growth trend and a stable structure in scholarly output. Based on the data, the mean annual growth rate of articles is approximately 6.98 percent, which confirms the journal's favorable performance and steady increase in scientific production over the 15-year period. Furthermore, the low average age of articles, which equals 4.26 years, suggests the up-to-date nature of the published content and its rapid impact within the scientific community; this demonstrates that JDMA articles are currently circulating in the citation network and are influential in this academic field. The main information for the analysed dataset is summarized in Figure 1.

3.1 Author Collaboration and Influence Indices

During this period, 178 authors contributed to the production of JDMA articles. However, the collaboration indices indicate the potential for developing authorship networks. Despite the contribution of 31.4 percent (38 articles) by single-authored papers, the average Co-Authors per Document stands at 1.93. Content-wise, the use of 321 author keywords demonstrates the journal's thematic diversity. Furthermore, referencing 2,216 sources confirms the articles' reliance on international scientific literature and the use of multiple sources, which strengthens the journal's scientific credibility and content quality [5]. The average number of citations per document is 4.182. The percentage of international collaboration is 9.1 percent (0.091),

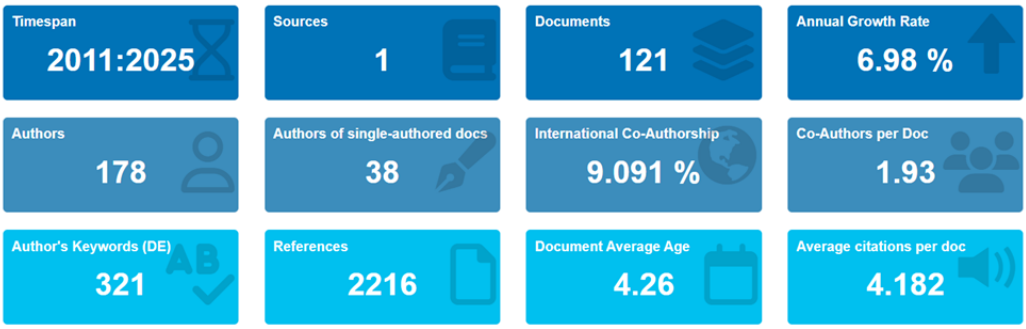

Figure 1. Main information

highlighting an opportunity to incorporate international collaboration development into the journal's future plans and policies, as it is a fundamental factor in increasing citations and developing scientific social capital [6].

3.2 Three-Mode Network Analysis of Cited References (CR), Authors (AU), and Keywords (KW)

Figure 2 presents an integrated map of the triple relationship among the key Cited References (CR), influential Authors (AU), and main Keywords (KW) in the JDMA during the 2011–2025 period. Analyzing the intensity (thickness) of the flows present in this network demonstrates the strength of the ties connecting these three modes (references, authors, and central themes) within the studied domain.

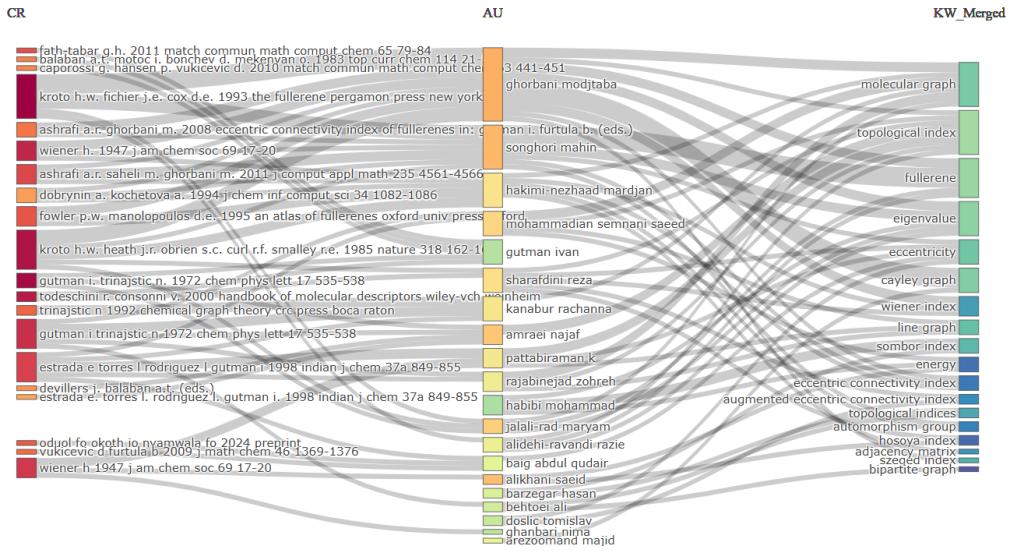

Figure 2. Three-mode network analysis of cited references (CR), authors (AU), and author keywords (KW) in JDMA during the 2011–2025 period.

In this network, the Cited References (CR) and Authors (AU) are displayed in an interconnected manner, illustrating the intellectual connections and collaboration patterns among the

articles and authors. Certain publications, particularly the work of Fath-Tabar [7], have served as key and foundational sources in subsequent research. Furthermore, articles by prominent authors, including Gutman, Modjtaba Ghorbani, and Alireza Ashrafi, are frequently cited. The central keywords observed in this network include ”topological index” and ”molecular graph”.

The thicker flows represent stronger associations among particular cited references, authors, and research themes that play prominent roles in the network. Among the authors, Modjtaba Ghorbani shows substantial connections with keywords such as ”fullerene", ”Cayley graph", ”Wiener index", ”eigenvalue", ”eccentricity connectivity index", and ”topological index". These associations indicate the journal's sustained focus on graph theory, chemical graph theory, Cayley graphs, and topological indices across the 2011–2025 dataset, reflecting its specialization within these research areas.

Until 2016, the use of keywords such as ”molecular graph", ”index", ”topological index", and ”eccentricity” suggests that the journal focused on chemical graphs, topological indices, and fullerenes. However, since 2022, following the journal's name change to *Journal of Discrete Mathematics and Applications*, the keyword ”graph energy” has become more prominent. This signifies a shift in the journal's policy, moving from the domain of chemical indices and their properties toward newer areas of combinatorics, such as graph energy.

3.3 Analysis of Author Performance and Scientific Impact Pattern (2011–2025)

Figures 3 and 4 present the most relevant authors in JDMA during the two publication periods, 2011–2016 and 2022–2025, respectively, based on the number of published documents. These figures demonstrate the distribution of publication output among the most productive authors in each period.

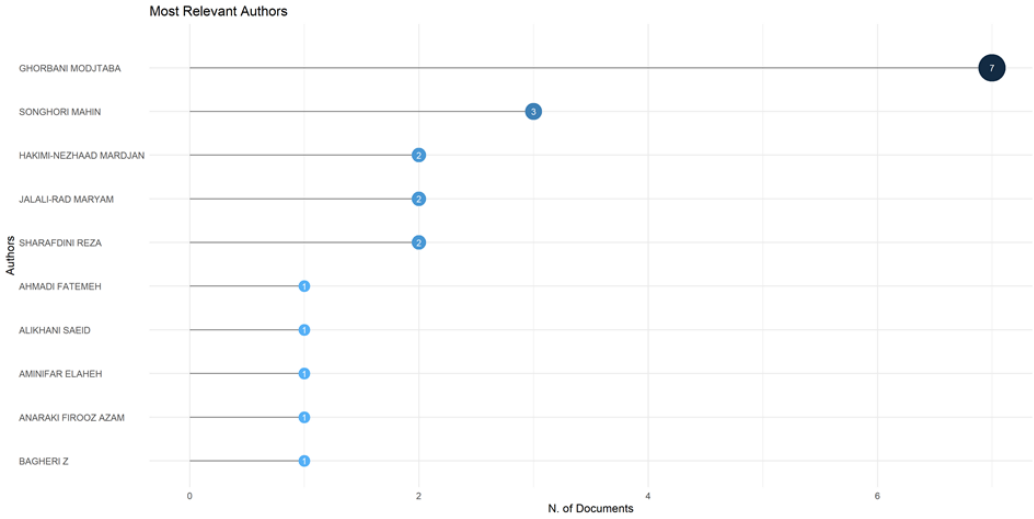

Figure 3. Most relevant authors in JDMA during the 2011–2016 period based on the number of published documents.

During the 2011–2016 period, Modjtaba Ghorbani showed the highest publication output with seven published documents, followed by Mahin Songhori with three documents. Other authors contributed fewer publications, indicating that a limited number of researchers accounted for a substantial share of the journal's scientific output during this period.

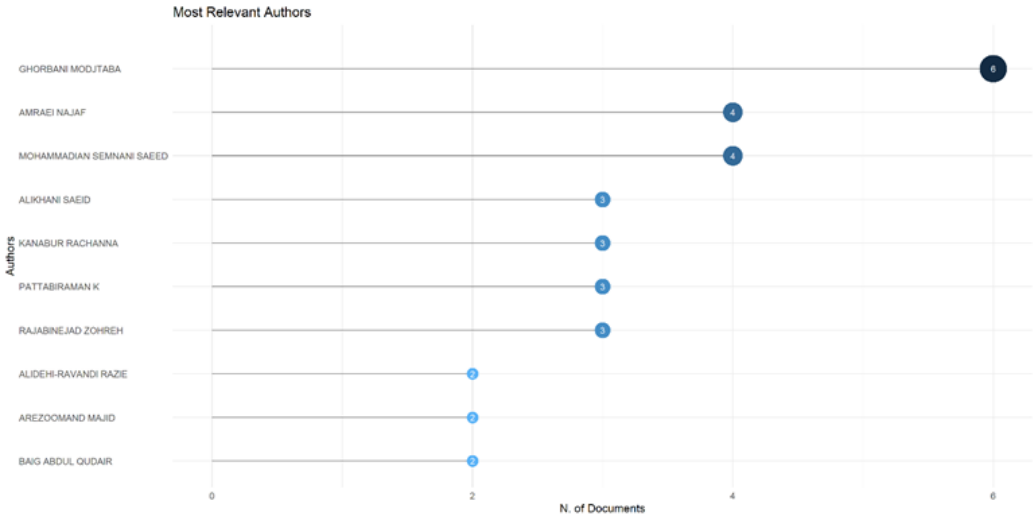

Figure 4. Most relevant authors in JDMA during the 2022–2025 period based on the number of published documents.

In the 2022–2025 period, Modjtaba Ghorbani remained the most productive author with six published documents, followed by Najaf Amraei and Saeed Mohammadian Semnani, each with four documents. The continued presence of the same leading author across both periods highlights his sustained contribution to the journal's research output.

Table 1. Longitudinal Analysis of Research Productivity and Citation Impact (2011–2025)

Author	Year	Freq	TC	TCpY
Modjtaba Ghorbani	2011	2	337	22.467
Modjtaba Ghorbani	2014	2	12	1
Modjtaba Ghorbani	2013	2	11	0.846
Mahin Songhori	2012	2	10	0.714
Mardjan Hakimi-Nezhaad	2014	1	7	0.583
Maryam Jalali-Rad	2015	1	7	0.636
Modjtaba Ghorbani	2024	2	6	3
Modjtaba Ghorbani	2016	1	5	0.5
Mahin Songhori	2016	1	5	0.5
Saeid Alikhani	2022	1	4	1

Note. TC = total citations; TCpY = total citations per year.

The longitudinal analysis presented in Table 1 further highlights Modjtaba Ghorbani's

sustained research activity and scientific impact within JDMA from 2011 to 2025. His publications span a relatively long period, demonstrating continuous engagement with the journal. In 2011, he published two articles that received a total of 337 citations, corresponding to an average of 22.467 citations per year, indicating the high impact of his early contributions. During the 2013–2016 period, his research activity continued with the publication of five articles, which collectively received 28 citations. He subsequently maintained his contribution to the journal by publishing one article in 2022, two articles in 2023, two articles in 2024, and one article in 2025. Overall, the data indicate that Modjtaba Ghorbani has maintained a consistent presence in JDMA's scientific production over the 2011–2025 period. The TC and TCpY indicators show that his earlier publications achieved the highest citation impact, while his recent contributions, despite having a shorter citation window, represent continued participation in emerging research directions. Therefore, he can be considered one of the central contributors to the journal's scientific output and research network.

3.4 Analysis of Author's Geographical Distribution (2011–2025)

The bibliometric analysis of the geographical distribution of authors in the JDMA journal during the 2011 to 2025 period reveals that Iran constitutes the core and determining nucleus of the journal's authorship network. This national concentration demonstrates the high dynamism of the domestic scientific community and the continuation of local content production, but from an international perspective, it reflects a structural unipolarity that hinders the journal's expansion of global influence. The journal's international collaboration index averages 9.091%. Based on the analyses, JDMA currently exhibits a geographical dependence that may impede the increase in international citations and consequently lead to a decrease in macro-level impact indices.

The geographical distribution of authors contributing to JDMA during the 2011–2025 period indicates that a substantial proportion of the journal's publications originated from Iran. Iran recorded the highest country-level publication frequency, while the international co-authorship rate was 9.1%. This pattern suggests a greater representation of Iranian authors in the journal, while also indicating scope for further development of international research collaboration. Table 2 presents the ten countries with the highest publication frequencies during the study period.

Table 2. Top 10 countries by publication frequency in JDMA (2011–2025).

Country	Frequency
Iran	136
India	18
Pakistan	8
China	7
Turkey	6
Serbia	5
Croatia	4
Kenya	4
Oman	4
Colombia	3

The country-level distribution shows that Iran had the highest publication frequency, with 136 publications, followed by India with 18. Pakistan, China, and Turkey occupied the next positions, while Serbia, Croatia, Kenya, Oman, and Colombia were also among the ten most frequently represented countries. The presence of countries from Asia, Europe, Africa, and Latin America indicates that JDMA has attracted contributions from several geographical regions. However, the difference in publication frequency between Iran and the other countries suggests that the journal's authorship distribution remains largely concentrated in Iran. Overall, the geographical pattern of JDMA authorship reflects a comparatively larger contribution from Iranian authors, alongside a more limited but geographically diverse international presence. Increasing the geographical diversity of authors and encouraging further international research collaboration may help broaden the journal's scientific reach. As Leydesdorff and Wagner (2008) noted, international collaboration can contribute to greater research visibility and the development of scientific networks.

In summary, the analysis of the geographical distribution of JDMA's authors paints a picture of a dynamic local journal with a currently limited global scope. The continuation and enhancement of this journal's international standing require targeted geographical diversification; as Leydesdorff and Wagner [6] emphasized, international collaborations are not only a key factor in increasing visibility and citations but also in the accumulation of scientific social capital and the consolidation of the journal's global position.

3.5 Analysis of Word Occurrence

In the word cloud, "topological index" is the most frequently used keyword in this collection of articles, with 10 occurrences (17% of total instances). This keyword signifies the journal's high research focus on topological graphs, which has been consistently employed by researchers in recent years. "fullerene", with 9 occurrences (15%), and "eigenvalue", with 8 occurrences (13%), rank next, demonstrating a trend of attention to molecular graph structures and the algebraic properties of graphs in research. This pattern suggests researchers' increasing

inclination towards more complex models and the use of specific indices in graph analysis. Keywords such as ”eccentricity” and ”molecular graph” indicate the growth of new research and advancements in fundamental graph concepts. If these trends continue in the coming years, topics such as ”advanced concepts in molecular graphs” and ”advanced structural analyses” will likely become hot areas of research.

The keyword distribution is visualized through the word cloud in Figure 5 and the treemap in Figure 6.

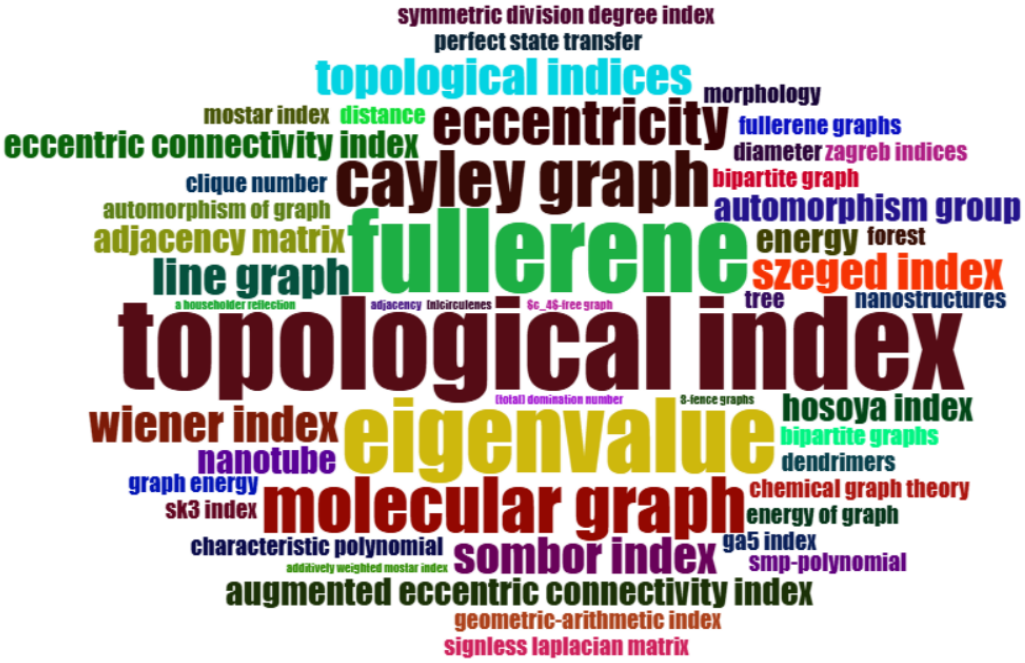

Figure 5. Word cloud of author keywords in JDMA (2011–2025; n = 121). Word size reflects the frequency of keyword occurrences, highlighting the dominance of graph-theoretic themes, particularly topological indices, eigenvalues, molecular graphs, and fullerenes.

3.6 Analysis of Journal Keywords and Research Trends

Table 3 presents the main keyword trends in JDMA for 2011-2016 and 2022-2025.

These patterns indicate that ”topological index” remains the dominant theme in the 2022–2025 period, while ”Cayley graph", ”eigenvalue", ”Sombor index", and energy-related topics have become more prominent. ”Molecular graph” and ”fullerene” remain part of the journal’s thematic structure, although their relative frequencies are lower than those of the leading recent keywords. To maintain JDMA’s academic standing, researchers should focus on graph and hypergraph theory, enumeration, coding theory, block designs, and partially ordered combinatorics.

Figure 6. Treemap of author keyword frequencies in JDMA (2011–2025).

Table 3. Comparative analysis of high-frequency keywords across two distinct research periods (2011–2016, 2022–2025)

Words (2011–2016)	Occurrences	Words (2022–2025)	Occurrences
Fullerene	5	Topological index	9
Augmented eccentric connectivity index	3	Cayley graph	5
Eccentric connectivity index	3	Eigenvalue	5
Eccentricity	3	Fullerene	4
Eigenvalue	3	Sombor index	4
Molecular graph	3	Topological indices	4
Nanotube	3	Energy	3
Fullerene graphs	2	Line graph	3
Graph energy	2	Molecular graph	3
Hosoya index	2	Wiener index	3

Each row in Figure 7 represents a keyword; the horizontal span indicates its active period in the dataset, and the bubble size reflects its relative frequency, highlighting sustained attention to topological index, eigenvalue, and molecular graph, and the increasing prominence of the Cayley graph in recent years.

3.7 Thematic Map Analysis of Research in the 2011–2016 and 2016–2022 Periods

Thematic maps are crucial tools in bibliometric analyses that utilize two indicators, centrality and density, to visually represent the relationship between research topics and their level of development. The horizontal axis indicates the centrality of the clusters; the more connections a cluster has with other clusters, the higher its centrality and the greater its importance in the research structure. The vertical axis measures the density or internal cohesion of a cluster; high density signifies a high level of topic development and cohesion, while low density indicates topics that still lack sufficient cohesion.

The combination of these two indicators creates four quadrants: Motor Themes, characterized by high centrality and high density; Basic Themes, characterized by high centrality and low density; Niche Themes, characterized by low centrality and high density; and Emerging

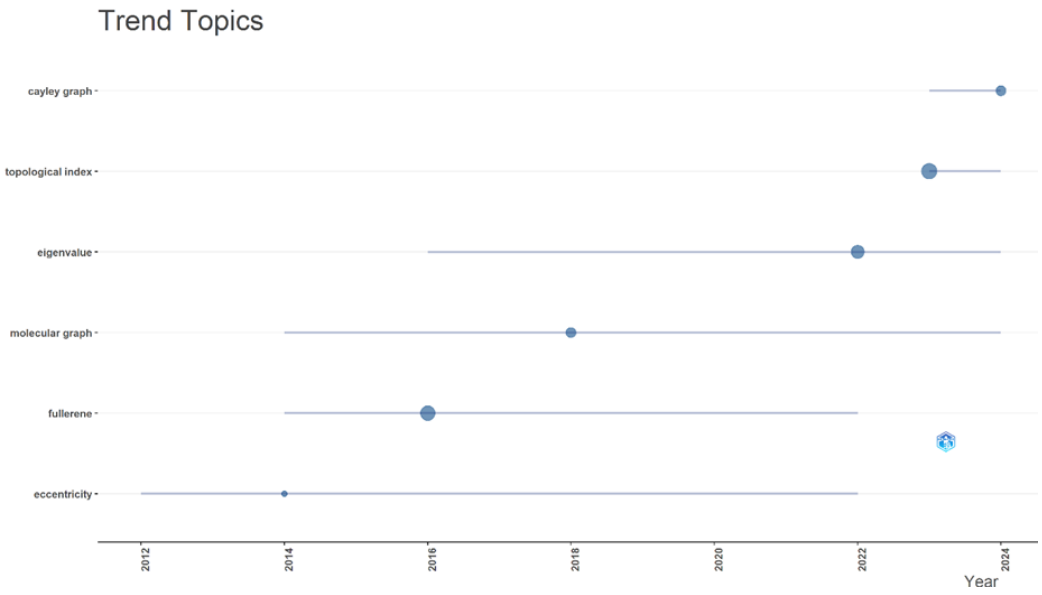

Figure 7. Trend topics in JDMA (2011–2025; n = 121) based on author keywords.

or Declining Themes, characterized by low centrality and low density.

The data were extracted from the collection of articles and analyzed for each time frame using keywords and network indicators, including occurrences, betweenness centrality, closeness centrality, and PageRank centrality. The thematic diagrams generated with Biblioshiny show the position of each cluster within the four quadrants. The results for the 2011–2016 period are examined first, followed by those for the 2016–2022 period and a comparison of the thematic changes between the two periods.

Within the Motor Themes quadrant for the 2011–2016 period, the cluster comprising ”fullerene", ”graph energy", and ”eigenvalue” reflects the importance of research related to graph energy and its connection to chemical structures. Eigenvalues play a critical role in spectral graph theory, and many indices, including graph energy, are defined in terms of them. The presence of ”eigenvalue” alongside ”fullerene” and ”graph energy” in this quadrant indicates that research during this period primarily focused on the spectral analysis of chemical graphs, particularly fullerenes.

Another prominent Motor Themes cluster in the 2011–2016 thematic map comprises the ”augmented eccentric connectivity index", ”eccentric connectivity index” (ECC), and ”eccentricity”. As shown in Figure 8, this red cluster has high centrality and density. Developed primarily by Sharma et al. [8], the ECC represents a pivotal topological descriptor that integrates a vertex’s degree with its eccentricity, a combination that is important for modeling complex biological activities. The position of this cluster indicates its role as a foundational research pillar in chemical graph theory during the 2011–2016 period. This thematic prominence also suggests that JDMA served as an important venue for refining topological indices used in QSAR/QSPR studies, contributing to the journal’s early scientific impact.

The network indicators for the 2011–2016 period further show that ”fullerene", with five occurrences, has the highest closeness value of 0.011 and PageRank value of 0.041, confirming

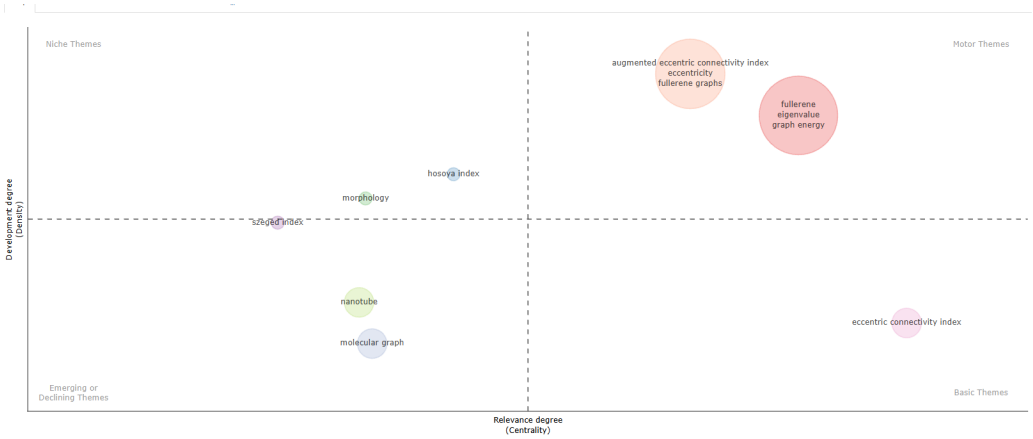

Figure 8. Thematic map of JDMA author keywords for the 2011–2016 period.

its central role during this period. The ”augmented eccentric connectivity index” and ”eccentric connectivity index", with betweenness values of 202 and 285, respectively, acted as important bridges between different topics. In contrast, ”graph energy", despite its thematic importance, had a betweenness score of zero, suggesting that it was largely confined to the fullerene cluster and had fewer connections with other sub-disciplines. The ”Szeged index", with a closeness value of 0.2, is positioned in the upper-left quadrant, indicating that although this index was relatively specialized, it possessed high internal cohesion.

Within the Motor Themes quadrant for the 2016–2022 period, the largest red cluster comprises ”Sombor index", ”topological indices", and ”bipartite graph". As illustrated in Figure 9, the position of this cluster in the upper-right quadrant indicates that it was both well developed and strongly connected to the broader thematic structure. The Sombor index, introduced by Gutman [9] in 2021, emerged as a prominent topic during this period. The presence of bipartite graphs within the same cluster suggests a thematic connection between degree-based topological indices and the structural analysis of bipartite graphs. Having recently entered the graph theory literature, the Sombor index rapidly attracted researchers' attention, leading to studies of its mathematical properties and chemical applications. Its position in the Motor Themes quadrant indicates that the Sombor index and related topological indices became major research topics during this period, while their association with bipartite graphs reflects their connection to two-directional structures and network studies.

Within the Basic Themes quadrant for the 2016–2022 period, the orange cluster comprises ”Cayley graph", ”eigenvalue", and ”fullerene". The position of these terms in the lower-right quadrant indicates that although they remained important, their internal cohesion developed less strongly than in the previous period, or they were transitioning into more generalized theoretical foundations. Cayley graphs represent groups as graphs and constitute fundamental tools in group theory and algebraic geometry, with applications in biomechanics, processor networks, coding, cryptography, and quantum computing. Their presence in this cluster suggests that the connection among group theory, topological indices, and chemical graphs continued at a foundational level.

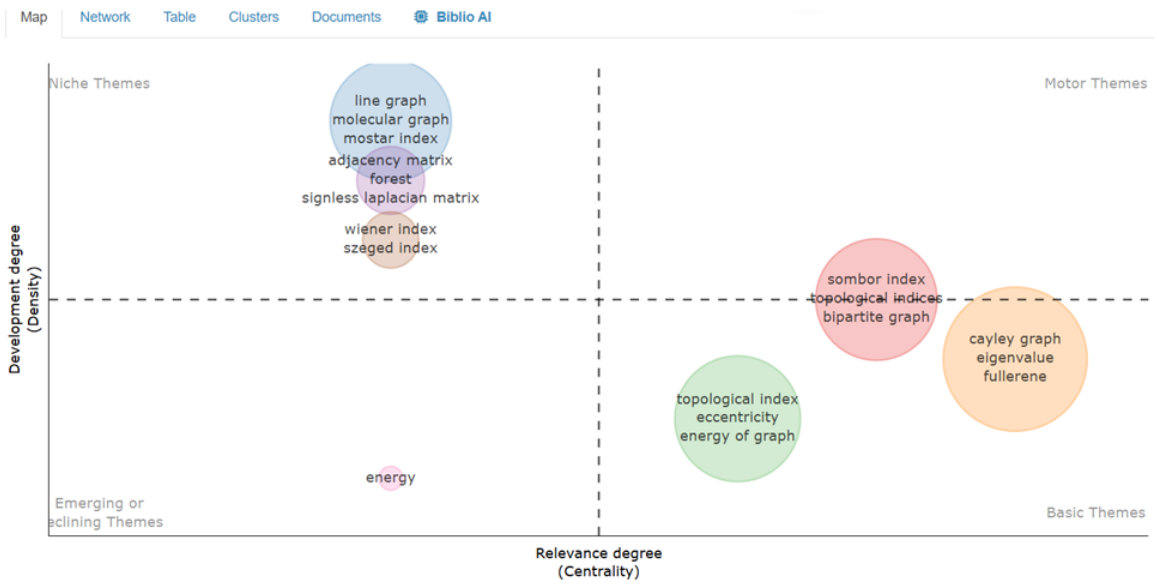

Figure 9. Thematic map of JDMA author keywords for the 2016–2022 period.

The presence of ”fullerene” within the same Basic Themes cluster indicates that this topic remained important, although its movement from the Motor Themes quadrant to the Basic Themes quadrant suggests that it had matured and was no longer the primary driver of research. Nevertheless, fullerene graphs remained important models for studying carbon structures and spectral properties. Eigenvalues were also present in this cluster, indicating that spectral graph analysis continued to serve as one of the principal tools for understanding graph structures and graph energy.

A second cluster within the Basic Themes quadrant comprises ”topological index", ”eccentricity", and ”energy of graph". Represented by the light green bubble in the lower-right quadrant, this cluster indicates that general indices, including degree-based, distance-based, and energy indices, continued to function as theoretical foundations for modeling molecular structures. Graph energy also remained an important concept and continued to be defined as the sum of the absolute values of the eigenvalues of the adjacency matrix. However, the relatively low density of this cluster suggests that a broader variety of research was being conducted around this concept.

Within the Niche Themes quadrant for the 2016–2022 period, the blue cluster comprises ”line graph", ”molecular graph", ”Mostar index", ”adjacency matrix", ”forest", and ”signless Laplacian matrix". Its position in the upper-left quadrant, characterized by high density but low centrality, indicates that these topics were conceptually well developed but had fewer connections to the main research stream. The adjacency matrix and signless Laplacian matrix are spectral tools for analyzing graph structures, although their applications were often concentrated within specific sub-domains. Similarly, the Mostar index and the analysis of line graphs, whose vertices correspond to the edges of the original graph, were applied in specialized studies, explaining their location in the Niche Themes quadrant.

Another specialized cluster near the center of the thematic map comprises the ”Wiener

index" and "Szeged index". The small purple bubble representing this cluster indicates moderate internal cohesion and centrality. The Wiener index is one of the oldest and most widely used distance-based indices in chemical graph theory; it was introduced by Harold Wiener in 1947 and is used to analyze the internal properties of molecules. The Szeged index is a modified form of the Wiener index defined in terms of edge partitioning. The position of this cluster indicates that these indices continued to be used as important but relatively specialized analytical tools.

Within the Emerging or Declining Themes quadrant, the small pink cluster represents the term "energy". Its location in the lower-left quadrant indicates low centrality and low density and appears to reflect research on graph energy. Given the long history of this concept, its position may indicate a focus on modified forms of energy, including Laplacian energy and signless Laplacian graph energy. These specialized research directions had not yet developed extensive connections with the other thematic areas.

The network indicators for the 2016–2022 period show that "topological index", with nine occurrences and a betweenness score of 2,163.017, held the largest share and played the most significant mediating role among the topics. "Eigenvalue", with a betweenness score of 1,825.383 and a PageRank value of 0.012, and "Sombor index", with a betweenness score of 1,599.483, were also influential components of the thematic network. At the same time, the "Wiener index" had the highest closeness value among the reported terms, with a score of 0.11, indicating strong connectivity in studies related to this index.

A comparison of the two periods reveals notable changes in research related to graph energy and topological indices. One of the most visible changes concerns the role of fullerene and graph energy. During 2011–2016, the combination of "fullerene", "graph energy", and "eigenvalue" formed a Motor Themes cluster; however, during 2016–2022, this cluster moved to the Basic Themes quadrant. This movement suggests that research on fullerenes and graph energy had matured and was no longer the principal driver of research, although these concepts retained their importance as theoretical foundations.

Another important change was the emergence of the Sombor index. Introduced in 2021, the Sombor index rapidly became one of the Motor Themes during the 2016–2022 period, indicating a growing interest in novel graph indices. Research examining the relationship between the Sombor index and classical indices, including the Zagreb and Wiener indices, or investigating its application in molecular property modeling, may therefore represent an attractive and influential research direction.

The integration of eccentricity-based indices also changed between the two periods. During 2011–2016, the eccentric connectivity index and its augmented version appeared among the Motor Themes. During the second period, however, these indices were either absent from the thematic map or integrated into other clusters. This pattern may suggest that ECC-related research had reached a level of saturation or was being replaced by newer indices such as the Sombor index. Comparative investigation of these indices may consequently provide another potential research direction.

The growth of niche topics is reflected in the high-density cluster comprising "line graph",

"molecular graph", "Mostar index", and "signless Laplacian matrix" during the second period. These specialized areas had achieved considerable internal cohesion but remained only weakly connected to the mainstream research themes. Interdisciplinary studies linking these areas to the central themes could therefore contribute to the further development of the journal's research network.

The changing position of "nanotube" also reflects either a decline or a transformation in thematic emphasis. During 2011–2016, "nanotube" was positioned in the Emerging Themes quadrant, whereas it was absent from the second-period map. This absence may indicate that the topic was not represented in the reviewed literature during the second period or that it had become sufficiently specialized to be integrated into other clusters. Given the importance of carbon nanotubes in modern technologies, medicine, and drug delivery, interdisciplinary research in this area remains advisable.

A potential future direction involves greater attention to novel indices. Given the rapid growth of the Sombor index, examining its relationships with classical indices and investigating its applications in modeling physical and chemical properties may provide suitable subjects for future articles.

Another possible direction involves strengthening the connection between niche and core research areas. The niche cluster containing the adjacency matrix, signless Laplacian matrix, and Mostar index indicates that these topics are conceptually strong but remain less connected to the mainstream. Combining these tools with chemical graph analysis or graph-energy studies may strengthen their connection to the central thematic structure.

Revisiting classical indices may also create new research opportunities. Although the Wiener and Szeged indices are well established, developments in data mining and machine learning may produce new applications for these indices. The development of weighted or modified versions could also provide additional avenues for investigation.

Advanced spectral studies represent another potential direction because graph energy and eigenvalues continued to play important roles across both periods. The application of recently developed spectral techniques, including Laplacian energy and signless Laplacian graph energy, may open new possibilities for analyzing complex graph structures.

Overall, the thematic maps for the 2011–2016 and 2016–2022 periods demonstrate that research on graph energy and topological indices underwent substantial changes. During the first period, fullerenes, graph energy, and eccentric connectivity indices formed the main research axes. During the second period, the Sombor index and other novel indices became more prominent, while fullerenes and graph energy shifted toward more foundational positions. These changes reflect the dynamism and continued development of chemical graph theory.

3.8 Analysis of the Keyword Co-occurrence Network

The analysis of the author's keyword co-occurrence network in JDMA focuses on understanding the structural roles of core scientific concepts and how knowledge is transferred within the journal. Concepts such as Eigenvalue, which has high Betweenness Centrality (4)

and PageRank (0.165), act as central themes and key bridge-builders in graph research. These indices highlight Eigenvalue's significant influence in connecting intellectual groups and transferring ideas. In contrast, applied concepts like Fullerene (PageRank = 0.118) and Cayley Graph (Betweenness = 3) have lower Betweenness Centrality than Eigenvalue, but they play strong roles in molecular-chemical research, as well as algebraic-graphical and algorithmic modeling. These concepts also maintain important connections with other key terms, and these relationships are visualized in Figure 10.

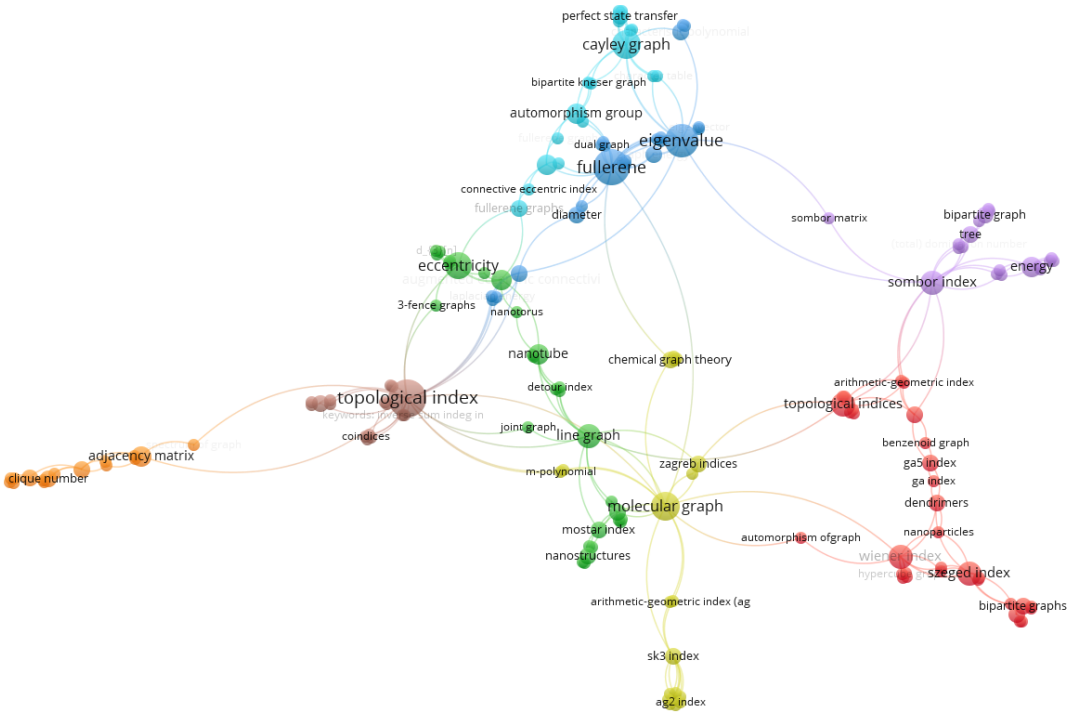

Figure 10. Author-keyword co-occurrence network in JDMA during the 2011–2025 period.

As visualized in Figure 10, the network also includes more specialized indices, such as the Szeged Index and Wiener Index, which have a narrower influence and primarily support specific topological analyses. To drive progress in graph research and molecular modeling, the journal should prioritize research on Molecular Graphs and Fullerene, while also monitoring emerging concepts such as Eccentricity and the Augmented Eccentric Connectivity Index. Finally, strengthening collaboration with authors who have high Betweenness Centrality will support knowledge flow and expand research within the network by focusing on both core concepts and collaborative links. The occurrence frequencies and centrality measures of the most frequent author keywords are summarized in Table 4.

Table 4. Keyword occurrences for the most frequent author keywords in JDMA (2011–2025)

Words	Occurrences	Betweenness Centrality	Closeness Centrality	PageRank Centrality
Topological index	9	2,163.017	0.004	0.021
Cayley graph	5	670.192	0.003	0.011
Eigenvalue	5	1,825.383	0.004	0.012
Sombor index	4	1,599.483	0.003	0.01
Fullerene	4	443.975	0.003	0.01
Line graph	3	1,310.208	0.003	0.006
Molecular graph	3	1,125.292	0.003	0.008
Wiener index	3	17	0.111	0.008
Energy	3	466	0.003	0.008

3.9 Co-citation Network Analysis

The Authors' Co-citation Network of JDMA reflects the journal's intellectual focus on graph theory and its applications. Each node in the network represents an author, with its size reflecting how often the author is cited within the journal. Co-citation links show strong relationships between authors whose works are frequently referenced together. Centrality indices identify different types of influential authors: those with high Betweenness Centrality act as bridges connecting intellectual clusters and fostering the transfer of ideas, while those with high PageRank gain scientific authority through quality citations. This network reveals the main schools of thought and the key channels of influence in discrete mathematics by highlighting influential and bridge-building authors. The use of PageRank, Betweenness, and Closeness indices helps pinpoint which authors drive knowledge transfer and shape the network's credibility, providing clear guidance for future research directions; the corresponding centrality metrics for the leading authors in the JDMA author co-citation network are reported in Table 5.

Table 5. Co-citation Network Analysis

Node	Cluster	Betweenness	Closeness	PageRank
Gutman	1	439.806	0.011	0.064
Ghorbani	2	91.979	0.009	0.063
Ashrafi	2	20.879	0.009	0.053
Kroto	2	0.266	0.008	0.04
Doslic	2	8.388	0.009	0.037
Das K.C.	1	12.987	0.009	0.037
Diudea	3	63.69	0.01	0.035
Drinajstic	3	25.266	0.01	0.033
Harary	2	162.453	0.01	0.032
Fowler	2	0.038	0.008	0.032

3.10 Analysis of the Co-citation Network and Core Authors

A co-citation network forms when articles are cited together by subsequent works. Analyzing this network reveals the structural role of core authors and the conceptual links among key research groups. In this study, three main clusters emerge, each with distinct characteristics: the red cluster, which functions as a structural influence hub; the blue cluster, centered on Ashrafi and Ghorbani; and the green cluster, which focuses on spectral and structural properties, as visualized in Figure 11.

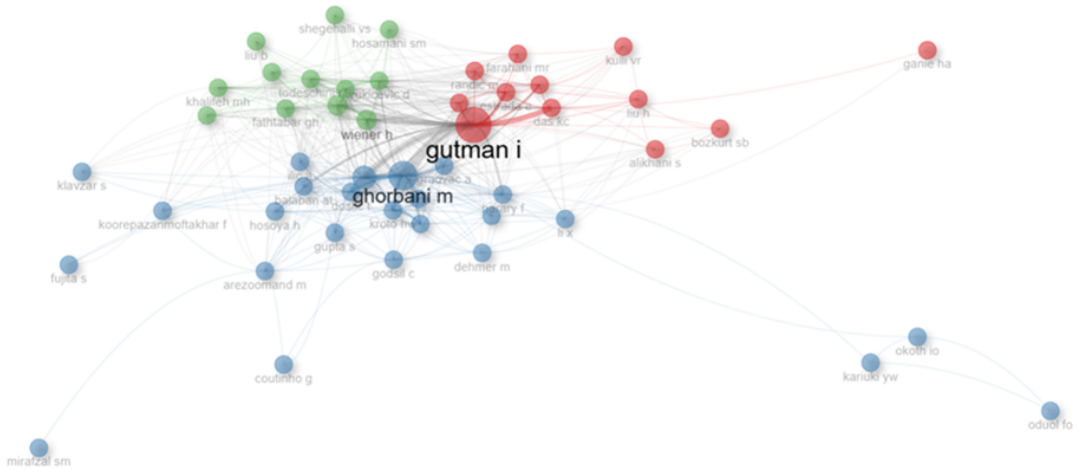

Figure 11. Author co-citation map for JDMA (2011–2025). Nodes represent cited authors (larger nodes indicate higher co-citation frequency), and links represent co-citation relationships (stronger links indicate more frequent joint citation). Colors denote co-citation clusters, illustrating the journal's main intellectual groupings and the prominent positions of key cited authors (e.g., Gutman and Ghorbani) within the cited knowledge base.

The red cluster is centered on Gutman, who serves a critical role in disseminating ideas and mediating between different conceptual clusters, as demonstrated by the highest Betweenness Centrality (BC = 439.806) and PageRank (PR = 0.064) values. His elevated Betweenness Centrality indicates that his works serve as vital intermediary channels for information flow within the network and actively guide scholarly communication. While authors such as Das K.C. and Estrada E. are also prominent in this cluster, their capacity to bridge disciplines is less substantial than Gutman's.

The blue cluster, centered on Ashrafi and Ghorbani, includes domestic authors who occupy important structural positions within the co-citation network. Ashrafi and Ghorbani possess Betweenness Centrality values of 20.879 and 91.979, respectively, and are acknowledged in this cluster as regional hubs with international impact. Owing to their extensive scholarly networks and distinguished research profiles, these authors are instrumental in advancing domestic research and integrating new investigations with established knowledge. In this cluster, references with significant PageRank, including Wiener H. and Kroto H.W., though exhibiting

lower Betweenness Centrality, are recognized as influential sources and substantially impact the disciplines of chemistry and molecular graph theory. This cluster is notably effective in fostering interdisciplinary connections and linking theoretical research to novel indices such as the Eccentric Connectivity Index.

The green cluster focuses on spectral and structural properties and includes authors whose works address structural characteristics and the development of spectral indices. This cluster, encompassing authors such as Wiener, focuses on structural properties and the formulation of new indices, such as spectral indices. Due to its high internal connectivity, this thematic area has strongly influenced the advancement of research on complex graphs and molecular simulations and continues to expand.

4 Discussion

This study examined the knowledge structure and thematic development of the *Journal of Discrete Mathematics and Applications* (JDMA) using bibliometric data from 121 articles published between 2011 and 2025. Data analyses were performed in R, and scientific maps were generated with VOSviewer to examine the journal's functional structure and thought patterns over this period.

The results of the bibliometric analysis indicate that the JDMA journal has undergone a structural evolution process through a systematic pattern during the period under review. The upward trend in growth and the relatively low average document age (4.26 years) indicate the journal's content dynamism and its special focus on emerging areas of graph and hypergraph theory. A comparative analysis of the journal's publication periods—from the first period under the title *Journal of Mathematical Nanoscience* to the current period under the title JDMA—explains the metamorphosis in keywords and subject clusters. These changes reflect a revision in the journal's scope and scientific identity, as evidenced by the co-occurrence analysis of published words and texts.

The analysis of the authorship structure in the JDMA journal reveals a pattern consistent with the characteristics of research in mathematics. According to the extracted data, 178 authors have contributed to this journal's scientific production. Of the articles analysed, 31.4% (n = 38) are single-authored, with the remaining publications co-authored. The mean authorship size is 1.93 authors per paper, indicating a predominantly small-team collaboration structure.

In terms of content and citation indicators, 321 unique keywords were used by the authors, and a total of 2216 sources were cited; this volume of lexical diversity and breadth of sources provides the necessary foundation for thematic mapping and analysis of intellectual impacts. Also, the international collaboration index for this journal is 9.1% (0.091), which serves as a statistical baseline for assessing the extent of the journal's cross-border exchange of ideas and interactions within scientific networks.

Analysis of the geographical distribution of authors shows that Iran is in first place, followed by India, Pakistan, China, and Turkey; thereafter, countries such as Serbia, Croatia, Kenya,

Oman, Colombia, Poland, Japan, and Germany have also contributed to this journal. This diversity of countries provides a suitable capacity to shape international cooperation and develop future partnerships, and, along with the international cooperation index, it can serve as a basis for targeted policies to strengthen scientific communication and expand the scope of research interactions.

At the level of knowledge structure, the results of the author co-citation network and the citation-author-keyword (CR-AU-KW) tridimensional mapping together show that JDMA has formed a coherent "cognitive core" around graph theory and its applications. In the co-citation network, Gutman has a prominent role, with the highest Betweenness Centrality and PageRank among the presented nodes, and Ghorbani and Ashrafi are also influential nodes. At the same time, in the 3-dimensional mapping, the focus of the flows around the keywords "topological index" and "molecular graph" is also aligned with the prominence of key authors and basic citations, indicating that the journal's citation path is organized around these conceptual axes. The connecting position of these authors in citation and conceptual networks can, from a functional perspective, facilitate the circulation of ideas and strengthen international scientific exchange.

Keyword analysis and thematic maps also provide a detailed picture of the main axes and trends of development. In the frequency analysis of words, "topological index" is the most frequent concept in the entire collection (10 occurrences; 17%), followed by "fullerene" (9; 15%), a combination that is consistent with the research tradition in chemical graph theory. A comparison of the two time periods of the most frequent keywords shows that in 2011–2016, in addition to fullerene (5), eccentricity-based indices such as the augmented eccentric connectivity index (3) and the molecular graph (3) were prominent. In the more recent period (2022–2025), the main axis with the topological index (9) remains prominent, along with the emergence of concepts such as the Cayley graph (5) and the eigenvalue (5), and the introduction/enhancement of the Sombor index (4). These changes are also consistent with the results of the thematic maps; in the period 2016–2022, the Sombor index–topological indices–bipartite graph cluster appears among the motor themes, while concepts such as Cayley graph, fullerene, and topological index–eccentricity–graph energy remain as basic and fundamental themes.

In the period 2016–2022, the topological index has a high mediating role in the concept network, and the Sombor index also appears as one of the important connecting components. In the keyword co-occurrence network, eigenvalues also play a significant role in connecting conceptual clusters, indicating that spectral language remains one of the key pathways for connecting conceptual clusters in JDMA articles. In the first period (2011–2016), according to the index table, concepts such as eccentric connectivity index and connectivity index have acted as conceptual bridges between subtopics, and fullerene has been in the spotlight in terms of PageRank and closeness; therefore, both the continuity of the specialized identity and traceable changes in the thematic paths of the journal have occurred over time.

5 Conclusion

This bibliometric study analysed 121 articles published in the *Journal of Discrete Mathematics and Its Applications* between 2011 and 2025 to evaluate the journal's performance, intellectual structure, and thematic evolution. The findings indicate a positive publication growth trend and a relatively recent literature base. The prevalence of single-authored and small-team papers, together with an international collaboration rate of 9.1%, shows that the development of broader collaborative networks remains an important opportunity for the journal.

The journal's intellectual structure is centred on graph theory and its applications, particularly topological indices, molecular graphs, fullerenes, eigenvalues, and graph energy. The author co-citation and three-mode network analyses identify Gutman, Ghorbani, and Ashrafi as influential connecting authors. The thematic maps reveal continuity in these established research areas alongside the emergence of the Sombor index and more diverse graph structures.

Based on this evidence, the developmental trajectory of JDMA can be interpreted as continuation of the specialized identity and purposeful expansion of the scope". Continuity in that the journal's conceptual scope around topological indices, molecular graphs, fullerenes, eigenvalues, and graph energy has remained stable; and expansion in that the prominence of indices such as the Sombor index and their connection to more diverse graph structures, such as the Cayley graph, has the potential to enhance the scope of applications of discrete mathematics within the journal. In this context, expanding international collaborations and purposefully diversifying topics, particularly in the areas of graphs and hypergraphs, could provide practical avenues for strengthening JDMA's global standing, especially if this expansion is achieved through mechanisms such as joint special issues, international guest editors, and multi-institutional review/topical articles. Also, since the thematic maps show that some specialized clusters (such as line graphs, adjacency matrix, and signless Laplacian matrix) have high internal coherence, designing axes that link these clusters to highly connected central themes (such as topological indices and spectral components) can help both generate frontier articles and contribute to the overall coherence of the thematic portfolio. In this regard, the development of complementary topics compatible with the title Discrete Mathematics and Applications—including graphs and hypergraphs, as well as coding theory—can open new horizons for its body.

Acknowledgement

We would like to sincerely thank the esteemed referees for their comments, which improved the quality of the article.

Funding

This research received no external funding.

Data Availability Statement

Data is contained within the article.

Conflicts of Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

[1] G. Abramo, C. A. D'Angelo, How do you define and measure research productivity?, Scientometrics 101(2) (2014) 1129–1144. https://doi.org/10.1007/s11192-014-1269-8
[2] W. M. Lim, S. Kumar, N. Donthu, How to combine and clean bibliometric data and use bibliometric tools synergistically: Guidelines using metaverse research, Journal of Business Research 182 (2024) Article 114760. https://doi.org/10.1016/j.jbusres.2024.114760
[3] J. Mingers, L. Leydesdorff, A review of theory and practice in scientometrics, European Journal of Operational Research 246(1) (2015) 1–19. https://doi.org/10.1016/j.ejor.2015.04.002
[4] H. Bilgili, C. Sheu, A bibliometric review of the Mathematics journal, Mathematics 10(15) (2022) Article 2701. https://doi.org/10.3390/math10152701
[5] I, Zupic, T. Čater, Bibliometric methods in management and organization, Organizational Research Methods 18(3) (2015) 429–472. https://doi.org/10.1177/1094428114562629
[6] L. Leydesdorff, C. S. Wagner, International collaboration in science and the formation of a core group. Journal of Informetrics 2(4) (2008) 317–325. https://doi.org/10.1016/j.joi.2008.07.003
[7] G. H. Fath-Tabar, Old and new Zagreb indices of graphs. MATCH Communications in Mathematical and in Computer Chemistry 65 (2011) 79–84. https://match.pmf.kg.ac.rs/ electronic_versions/ Match65/n1/ match65n1_79-84.pdf
[8] V. Sharma, R. Goswami, A. K. Madan, Eccentric connectivity index: A novel highly discriminating topological descriptor for structure–property and structure–activity studies, Journal of Chemical Information and Computer Sciences 37(2) (1997) 273–282. https://doi.org/10.1021/ci960049h
[9] I. Gutman, Geometric approach to degree-based topological indices: Sombor indices. MATCH Communications in Mathematical and in Computer Chemistry 86 (2021) 11–16. https://match.pmf.kg.ac.rs/electronic_versions/Match97/n1/match97n1_135-164.pdf

Citation: S. Gheisari Goudarzi, A bibliometric review of the journal of discrete mathematics and its applications (2011–2025), J. Disc. Math. Appl. 11(3) (2026) 199–220.
https://doi.org/10.22061/jdma.2026.12996.1190