mathematics

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Systematic Review

A Bibliometric Review of the *Mathematics* Journal

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Abstract: In this study, we conduct a bibliometric review of the *Mathematics* journal to map its thematic structure, and to identify major research trends for future research to build on. Our review focuses primarily on the bibliometric clusters derived from an application of a bibliographic coupling algorithm and offers insights into how studies included in the review sample relate to one another to form coherent research streams. We combine this analysis with keyword frequency and topic modeling analyses to reveal the discourse that is taking place in the journal more recently. We believe that a systematic/computer-assisted review of the *Mathematics* journal can open a path for new developments and discoveries in research and help editors assess the performance and historic evolution of the journal and predict future developments. In so doing, the findings should advance our cumulative understanding in those areas consistent with the scope of the *Mathematics* journal, such as applied mathematics, analytics, and computational sciences.

Keywords: bibliographic coupling; bibliometric; network analysis; topic model; mathematics; review

MSC: 01A90

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1. Introduction

Knowledge creation is path dependent. When a scientific field accumulates knowledge over an extended period, it becomes imperative to take stock of that knowledge to provide clear pathways to successive research. In this study, our goal is to provide such clarity to future researchers in applied mathematics by systematically examining the *Mathematics* journal, which self-identifies as "an advanced forum for studies related to mathematical sciences" [1]. Given its broad scope and diverse topical coverage, we focus on examining the thematic structure of the journal using advanced computational techniques, including bibliographic coupling analysis and topic modeling with the Latent Dirichlet Allocation algorithm.

The *Mathematics* journal, originally launched in 2013, was incorporated in the Web of Science database in 2015 [2], thus, our analysis covers publication data in the 2016 and 2022 period, inclusive. We document changes in the community structure of the journal for each year and apply topic modeling and keyword frequency analysis to the latest available data in 2022 to uncover the more recent discourse in the journal in order to provide clear guidance for future research. While our analysis is not meant to be a replacement for a more traditional narrative review, the techniques applied in our study provide new knowledge that would otherwise be difficult to obtain through a more traditional narrative review given the size and scope of the journal. The work presented in this paper builds on prior research in the domain of "science mapping" which aims to "reveal the structure and dynamics of scientific fields" [3] (p. 431) and similar work in other disciplines [4–8]. Bibliometric analysis and visualization techniques are best fitted to deal with substantive data produced within major research domains that are very difficult to process and analyze within the scope of a traditional review. Our sample includes 7667 articles that were published between 2016 and 2022, inclusive. This is a substantive sample of publications that would otherwise be extremely onerous to analyze through a traditional narrative review. Narrative reviews typically focus on a homogenous field of study that is comprised of a limited set of articles or relatively short periods. In contrast, computer-assisted reviews are not bound by these limitations since advanced computational power provides an efficient and more objective means to analyze thousands of publications [3], map out the conceptual and intellectual structure/substructures of a literature [7], and trace the thematic evolution of research. Importantly, bibliometric techniques can be applied to quantify the impact of science contributors/contributions in a particular field of research, providing a means to identify the most influential actors, institutions, and countries, among others [8]. Accordingly, we provide a systematic, transparent, and longitudinal computer-assisted review, the main advantage of which is the ability to analyze a substantive number of publications rigorously and efficiently and to effectively report cumulative findings based on an interpretation of large amounts of quantitative data. Another important benefit of our analysis is that the techniques applied in this study can be replicated and extended by future research.

Overall, we contribute to research in *Mathematics* by (a) uncovering recent trends and themes, such as machine learning, deep learning, and neural networks, and (b) quantifying the extent to which substreams of research that appear in the journal are not only internally coherent, but also externally connected with one another in a way that provides a relatively unified field of knowledge in applied mathematics and computational sciences. Both the presence and absence of relationships (i.e., co-citation/common references) are meaningful data points for future research and provide a foundation to build on. For instance, our bibliographic coupling analysis provides evidence of topical areas that lack substantive relationships among them. Absence of relationships can provide researchers with new opportunities to combine knowledge from multiple fields (e.g., machine learning applications in financial analysis) and deliver innovative solutions to real world problems (e.g., computer-assisted fraud detection).

In the following sections, we first introduce the key steps of our analytic strategy, then elaborate on our findings of the bibliographic coupling and topic modeling analyses in detail, and finally discuss the implications of our study with concluding remarks. An overview of the major analytic steps that we took in the development of this study and that are in line with best practices discussed elsewhere [9] are presented in Table 1 below. By applying a rigorous and comprehensive computer-assisted analysis to data/metadata on publications that appear in the *Mathematics* journal, we present researchers who are interested in contributing to the field of applied mathematics through the *Mathematics* journal and journal editors with new knowledge on (a) the current state of the historically influential/popular topics that have been emphasized in the *Mathematics* journal (i.e., keyword frequency analysis), (b) how substreams of research relate to one another in systematic ways (i.e., bibliographic coupling), and (c) the scholarly discourse that is taking place in the *Mathematics* journal during the most recent period (i.e., LDA-based topic modeling).

Table 1. Major steps of the bibliometric analysis.

Step 1	**Aim**	The purpose of our study is to conduct a performance analysis and develop a scientific map of research published in the *Mathematics* journal in the period between 2016 and 2022, uncovering the thematic structure of the journal to provide clear guidance to future research.
	Scope	The scope of our review is limited to publications in the *Mathematics* journal. Our sample consists of 7667 articles and article/proceedings papers published in the *Mathematics* journal within the 2016–2022 period.
Step 2	**Methods**	The bibliometric analysis techniques applied in this study are focused on two areas of assessment: (a) performance analysis, (b) science mapping.

	(a) Performance Analysis	For performance analysis, we used data included in the author, affiliation, country, keyword, cited references, and times cited count fields, and relied on count/frequency analysis.
	(b) Science Mapping	For science mapping analysis, we used data included in the author, title, keywords, abstract, and cited references fields, and performed bibliographic coupling and network analyses.
Step 3	**Data**	Data were collected from the Web of Science database for the period between 2016 and 2022. Because the journal was incorporated in the WOS database in 2015, our dataset starts from 2016.
		WOS data were organized as a rectangular dataset where each row is a distinct observation that corresponds to a publication that appeared in the *Mathematics* journal and each column is a variable.
		No specific search terms were used to subset the dataset. Publications were downloaded based on the journal (i.e., *Mathematics*). Data were filtered to remove reviews, corrections, letters, editorial materials, and bibliographical items.
Step 4	**Interpretation**	The findings from our analyses are presented and interpreted in the third section under the "Results" subtitle.

2. Methods

Our analytic strategy encompasses bibliometric analysis techniques, primarily keyword frequency analysis and bibliographic coupling analysis [3,10]. Bibliographic coupling analysis quantifies the number of times two publications have a common reference to a third article. It is assumed that the greater the number of common references among a set of publications, the more likely that those publications are a part of an identifiable research topic/stream [3,10]. Thus, we applied the Louvain clustering algorithm to the network of cited references (i.e., articles are network nodes and shared references between those articles are network edges) in order to identify the subgroups of research in the *Mathematics* journal. As discussed in prior work, the algorithm performs effectively in detecting subcommunities in large networks [3]. We conducted all of our computational analysis using the R programming language and statistical computing software, primarily with functions included in the *tidyverse* [10], *tidygraph* [11], and importantly, *bibliometrix* [12] packages. Other R packages used in our analysis include *ggraph* [13], *textstem* [14], *tidytext* [15], *widyr* [16], and *zoo* [17].

We developed our sample by downloading publication data from the Web of Science Core Collection database. This database provides data on manuscripts published in the *Mathematics* journal, including article titles, authors, abstracts, publication years, author-entered keywords, and cited references, among others. Our initial sample included 7831 articles published in the *Mathematics* journal. We subset this sample into those classified as articles and article/proceedings paper, excluding reviews, corrections, letters, editorial materials, and bibliographical items. This resulted in a sample of 7667 articles during the period between 2016 and 2022, inclusive. Figure 1 shows a breakdown of the number of publications per year in our sample. While there are relatively fewer publications in years 2016 and 2017, the period between 2018–2021 witnessed staggering growth in the total number of publications. The yearly growth rate in total publications was 24% in 2017, 293% in 2018, 275% in 2019, 81% in 2020, and 46% in 2021. Although there is a noticeable slowdown in percentage growth in total publications, this is somewhat expected considering that there were 3229 total publications in 2021, which indicates an average monthly rate of 269 publications. At the time this dataset was collected, there were 536 publications that marked the first quarter of 2022.

Our sample statistics indicate that the journal accepts papers from authors affiliated with a diverse set of countries, including China (1843), Spain (947), Korea (471), Russia (439), USA (308), Italy (284), Romania (275), Saudi Arabia (228), Mexico (199), and Egypt (144) among the top 10 affiliations. Our analysis indicates that the number of authors appearing in the journal to date is 15,332, which suggests a ratio of approximately 2 authors per publication.

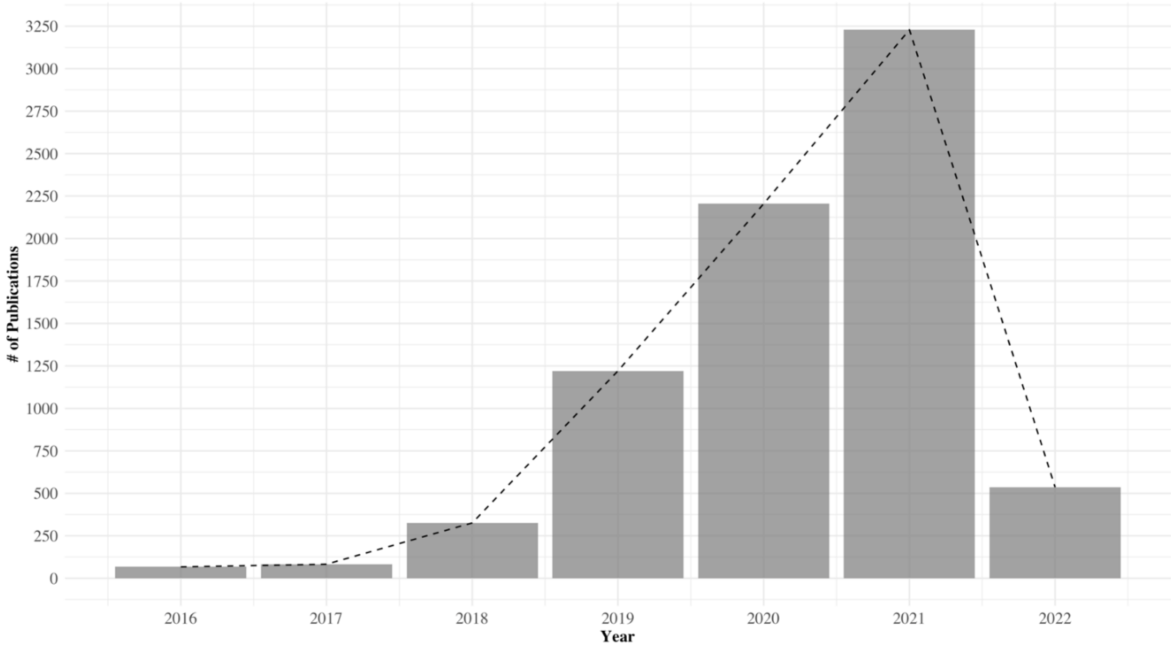


Figure 1. Journal publication trends based on number of publications by year. The sample data were collected in the first quarter of 2022.

Table 2 provides frequency statistics to assess author productivity in the *Mathematics* journal. The columns are sorted by frequency from highest to lowest number first and by author name in alphabetical order next. The second and third columns provide author rankings in productivity based on a simple count measure that quantifies the number of times the corresponding author appeared in a published article in the *Mathematics* journal, while the fourth and fifth columns show similar productivity rankings based on fractionalized frequency scores.

Table 2. Author productivity rankings by publication count and fractionalized frequency.

Rank	Author	Frequency	Author	Fractionalized Frequency
1	De La Sen, M	39	Wu, Hc	15.53
2	Kumam, P	37	De La Sen, M	13.52
3	Baleanu, D	36	Argyros, Ik	11.23
4	Argyros, Ik	33	Trojovsky, P	11.00
5	Karapinar, E	30	Treanta, S	10.23
6	Aydi, H	27	Han, Se	10.17
7	Liu, Jb	27	Karapinar, E	10.03
8	Srivastava, Hm	27	Baleanu, D	9.05
9	Sarkar, B	26	Kumam, P	8.99
10	Bazighifan, O	25	O'regan, D	8.78
11	Nisar, Ks	24	Sarkar, B	8.53
12	Ntouyas, Sk	24	Bazighifan, O	8.13
13	Beh,l R	22	Kim, Yh	7.25
14	Pop, I	22	Ludkowski, Sv	7.00
15	O'regan, D	21	Tarasov, Ve	7.00

Table 3 provides a list of top cited articles in the *Mathematics* journal as of the first quarter of 2022. We developed this table based on the total cited count statistic of the Web of Science database. Notably, Garrappa's [18] comprehensive work on fractional-order problems is the most cited article in the *Mathematics* journal followed by the work of Kamran and colleagues on extended b-metric space [19] and Kumar and colleagues' work on solving fractional differential equations drawing on Bernstein wavelets [20].

Table 3. Most cited papers in the *Mathematics* journal based on the WOS times cited count.

Year	Author	Article Title	Times Cited
2018	Garrappa R	Numerical Solution of Fractional Differential Equations: A Survey and A Software Tutorial	136
2017	Kamran T; Samreen M; Ain Qul	A Generalization Of B-Metric Space and Some Fixed Point Theorems	109
2020	Kumar S; Ahmadian A; Kumar R; Kumar D; Singh J; Baleanu D; Salimi M	An Efficient Numerical Method for Fractional Sir Epidemic Model of Infectious Disease by Using Bernstein Wavelets	107
2019	Baleanu D; Fernandez A	On Fractional Operators and Their Classifica-tions	80
2019	Wang Ph; Xue F; Li Hj; Cui Zh; Xie Lp; Chen Jj	A Multi-Objective Dv-Hop Localization Algo-rithm Based on Nsga-Ii in Internet of Things	74
2019	Wang P; Wang J; Wei Gw; Wei C	Similarity Measures Of Q-Rung Orthopair Fuzzy Sets Based on Cosine Function and Their Applications	74
2018	Mlaiki N; Aydi H; Souayah N; Abdeljawad T	Controlled Metric Type Spaces and The Re-lated Contraction Principle	73
2019	Wang Yc; Wang Ph;Zhang Jj; Cui Zh; Cai Xj; Zhang Ws; Chen Jj	A Novel Bat Algorithm with Multiple Strate-gies Coupling for Numerical Optimization	72
2018	Karapinar E; Agarwal R; Aydi H	Interpolative Reich-Rus-Ciric Type Contrac-tions on Partial Metric Spaces	71
2020	Baleanu D; Fernandez A; Akgul A	On A Fractional Operator Combining Propor-tional and Classical Differintegrals	69
2020	Pinter G; Felde I; Mosavi A; Ghamisi P; Gloaguen R	COVID-19 Pandemic Prediction for Hungary; A Hybrid Machine Learning Approach	68
2019	Rajchakit G; Pratap A; Raja R; Cao Jd; Alzabut J; Huang Cx	Hybrid Control Scheme for Projective Lag Synchronization of Riemann-Liouville Sense Fractional Order Memristive Bam Neuralnet-works With Mixed Delays	68
2019	Alqahtani B; Aydi H; Karapinar E; Rakocevic V	A Solution for Volterra Fractional Integral Equations by Hybrid Contractions	67
2019	Yao Yh; Postolache M; Yao Jc	An Iterative Algorithm for Solving General-ized Variational Inequalities and Fixed Points Problems	67
2018	Abdeljawad T; Mlaiki N; Aydi H; Souayah N	Double Controlled Metric Type Spaces and Some Fixed Point Results	66

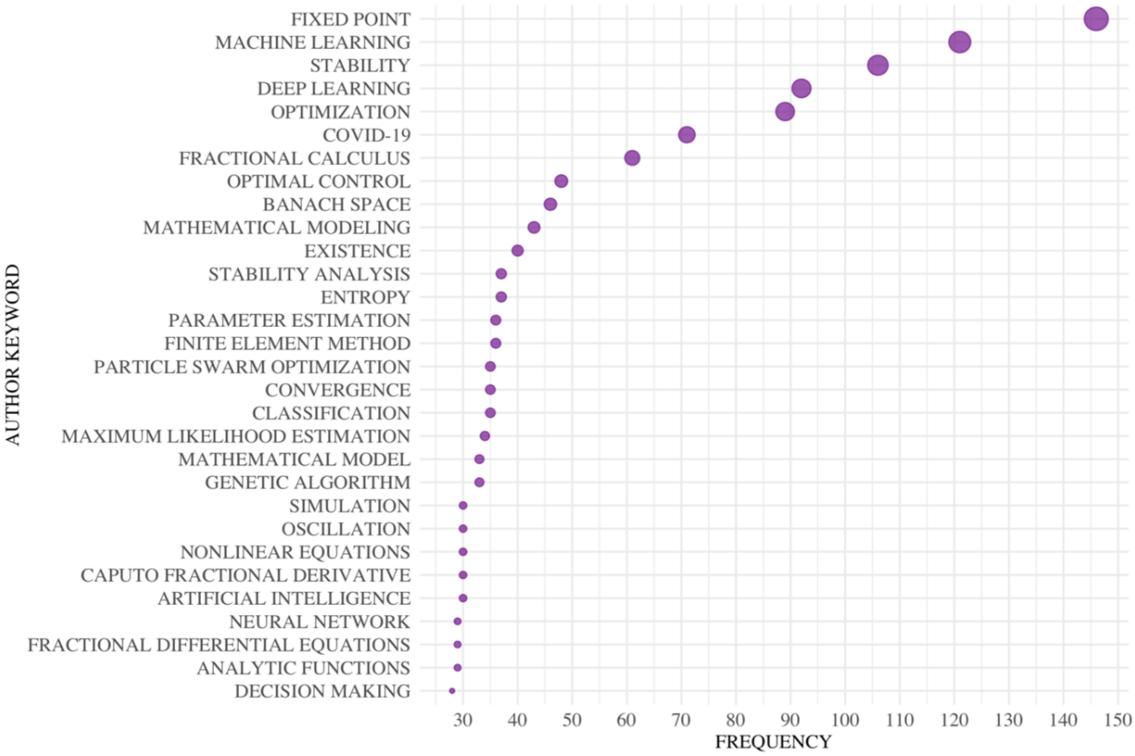
In the sections that follow, we conduct additional bibliometric analyses to uncover the major themes in the *Mathematics* journal and identify substreams of research by conducting network analysis and applying community-finding algorithms to relational data.

3. Results

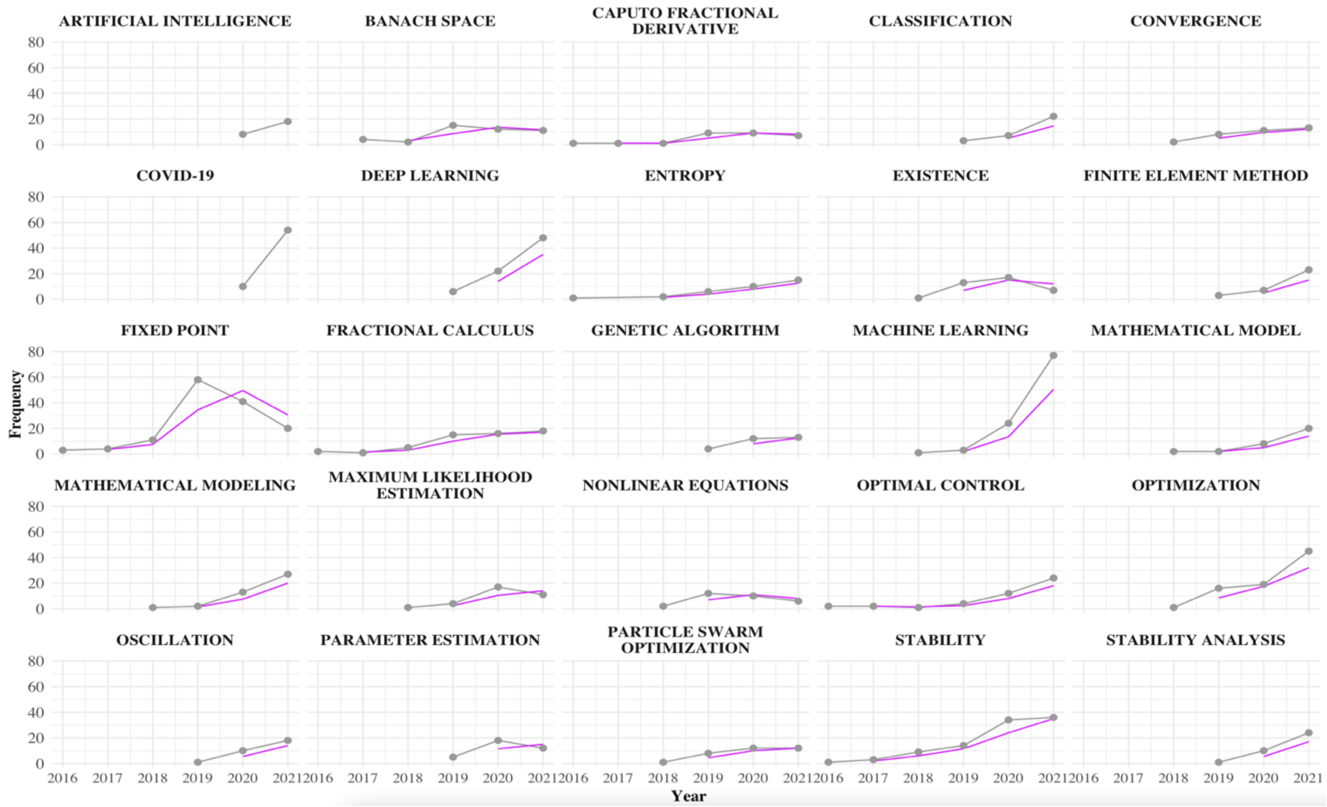
3.1. Keyword Frequency Analysis

We first conducted a keyword analysis to understand the topical emphasis in the *Mathematics* journal. For this analysis, we used author-entered keywords as we had only three articles with missing data in the author-entered keywords field, giving us enough data points for a robust analysis. Among the most frequently author-entered keywords are: "Fixed Point" (146), "Machine Learning" (121), "Stability" (106), "Deep Learning" (92), "Optimization" (89), "COVID–19" (71), "Fractional Calculus" (61), "Optimal Control" (48), "Banach Space" (46), and "Mathematical Modeling" (43). Figure 2a provides a complete list of the top keywords that have been specified by authors of manuscripts published in the *Mathematics* journal.

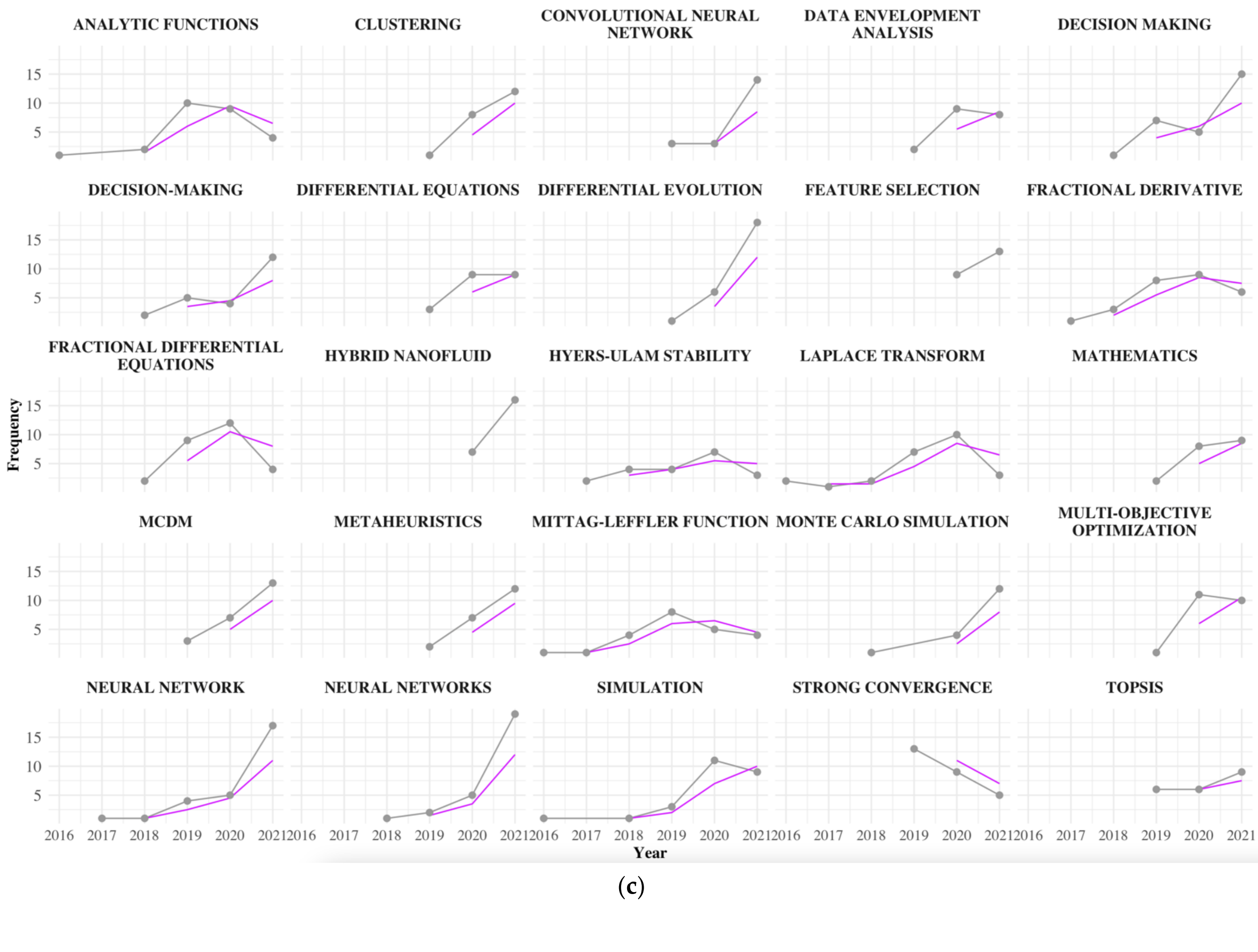
Figure 2b,c show year-over-year breakdown of the usage of the most frequently occurring keywords. The results show several emerging and declining themes during the period between 2016 and 2021 based on their popularity or lack thereof. (Because we collected journal metadata in the first quarter of 2022, we excluded the year 2022 from our keyword trend analysis.) Our analysis shows that "Artificial Intelligence", "Classification", "Clustering", "Deep Learning", "Finite Element Method", "MCDM", "Metaheuristics", "Neural Network [s]", "Stability Analysis", and "Oscillation" are among topics that have attracted significant attention from researchers in the more recent period, as evidenced by their sharp, positive slopes in Figure 2b,c. We also observe sustained, but slower growth in such areas as "Decision [-] Making", "Entropy", "Fractional Calculus", "Optimal Control", "Optimization", and "Stability". In addition, the trendlines shown in Figure 2b,c demonstrate that some research topics have attracted significant attention over the years but have begun to see decline in emphasis in the more recent period. Among these topics are: "Analytic Functions", "Banach Space", "Existence", "Fixed Point", "Fractional Derivative", "Fractional Differential Equations", "Hyers-Ulam Stability", "Laplace Transform", "Maximum Likelihood Estimation", and "Mittag-Leffler Function." Taken together, these findings point to a significant change in the journal discourse that roughly corresponds to the 2019–2020 period wherein topical coverage began to shift away from more traditional themes of applied mathematics, such as "Fixed Point", toward more novel areas of computational sciences, such as "Artificial Intelligence".



(**a**)


ARTIFICIAL INTELLIGENCE
BANACH SPACE
CAPUTO FRACTIONAL DERIVATIVE
CLASSIFICATION
CONVERGENCE
COVID-19
DEEP LEARNING
ENTROPY
EXISTENCE
FINITE ELEMENT METHOD
FIXED POINT
FRACTIONAL CALCULUS
GENETIC ALGORITHM
MACHINE LEARNING
MATHEMATICAL MODEL
MATHEMATICAL MODELING
MAXIMUM LIKELIHOOD ESTIMATION
NONLINEAR EQUATIONS
OPTIMAL CONTROL
OPTIMIZATION
OSCILLATION
PARAMETER ESTIMATION
PARTICLE SWARM OPTIMIZATION
STABILITY
STABILITY ANALYSIS
Frequency
Year
0
20
40
60
80
2016
2017
2018
2019
2020
2021

(**b**)


ANALYTIC FUNCTIONS
CLUSTERING
CONVOLUTIONAL NEURAL NETWORK
DATA ENVELOPMENT ANALYSIS
DECISION MAKING
DECISION-MAKING
DIFFERENTIAL EQUATIONS
DIFFERENTIAL EVOLUTION
FEATURE SELECTION
FRACTIONAL DERIVATIVE
FRACTIONAL DIFFERENTIAL EQUATIONS
HYBRID NANOFLUID
HYERS-ULAM STABILITY
LAPLACE TRANSFORM
MATHEMATICS
MCDM
METAHEURISTICS
MITTAG-LEFFLER FUNCTION
MONTE CARLO SIMULATION
MULTI-OBJECTIVE OPTIMIZATION
NEURAL NETWORK
NEURAL NETWORKS
SIMULATION
STRONG CONVERGENCE
TOPSIS
Frequency
Year
5
10
15
2016
2017
2018
2019
2020
2021

(**c**)

Figure 2. (**a**): Frequency analysis of author-entered keywords. (**b**): Longitudinal analysis of most frequently observed author keywords (1–25). (**c**): Longitudinal analysis of most frequently observed author keywords (26–50). In (**b**,**c**), gray lines and nodes are representative of frequency of keyword use over time. Purple lines indicate 2-year moving averages.

Another important observation from our analysis is that the journal has also been responsive to important contextual issues/events/developments that influence societal progress and well-being. Particularly, our analysis in Figure 2a,b reveals that one of the most frequently used terms in the more recent period is "COVID–19". To understand the context in which the term "COVID–19" has been used in publications in the *Mathematics* journal, in Figure 3, we plot the author-entered keywords that have been most frequently associated with "COVID–19" based on a pairwise frequency count. Figure 3 can be evaluated as a quasi-conceptual network of the term "COVID–19" based on the publications that appeared in the *Mathematics* journal. "COVID–19" has most frequently been associated with "Mathematical Modeling", "Machine Learning", and "Parameter Estimation" as indicated with darker and wider lines in Figure 3.

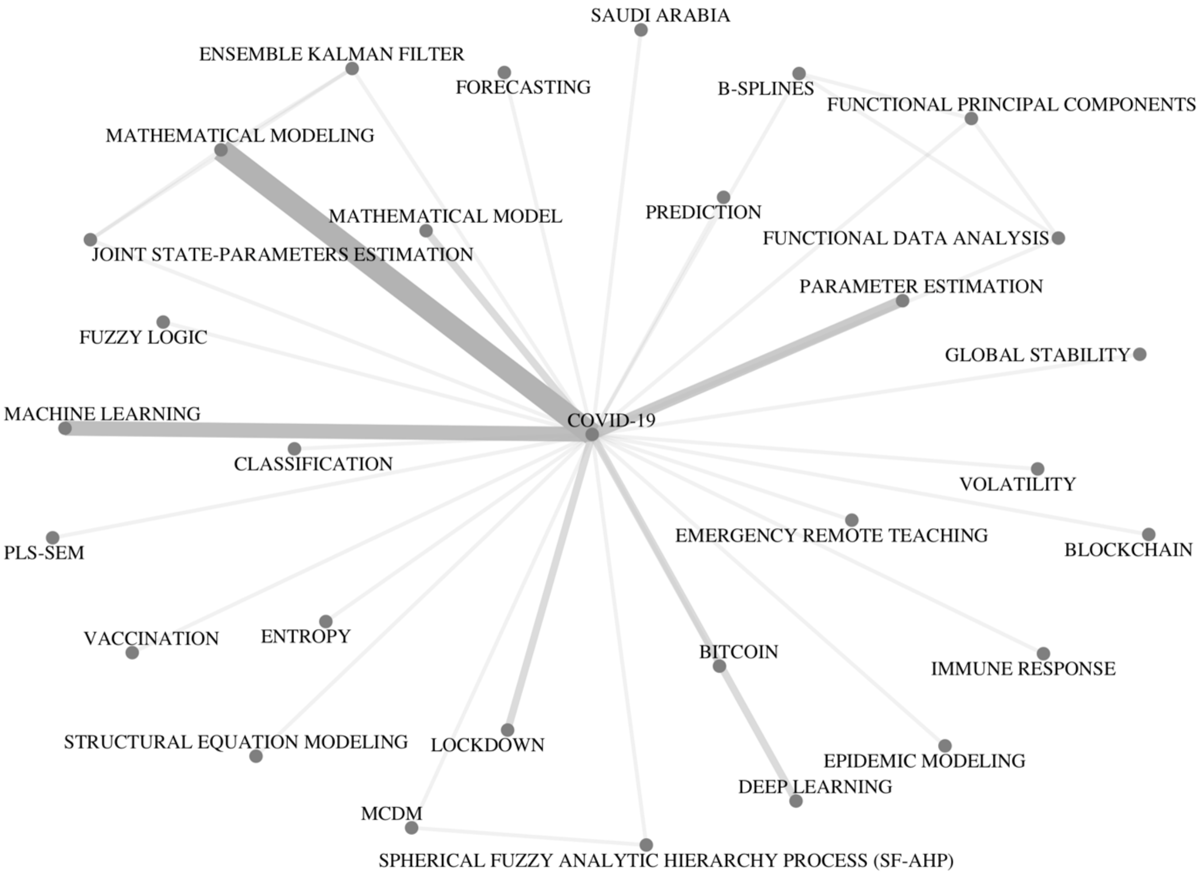
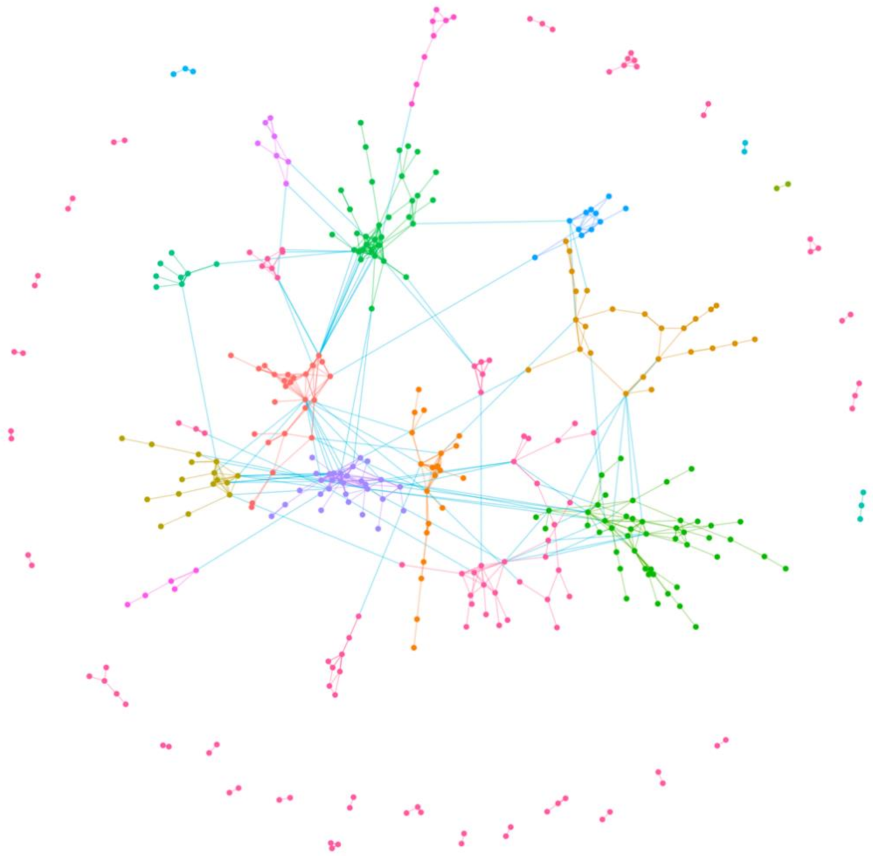


Figure 3. The conceptual network of the term "COVID–19". To plot this graph, we replaced the keywords COVID, COVID-19 EPIDEMIC, PANDEMIC, SARS-COV-2, and CORONAVIRUS with COVID-19, and replaced MATHEMATIC MODELLING with MATHEMATIC MODELING for standardization purpose.

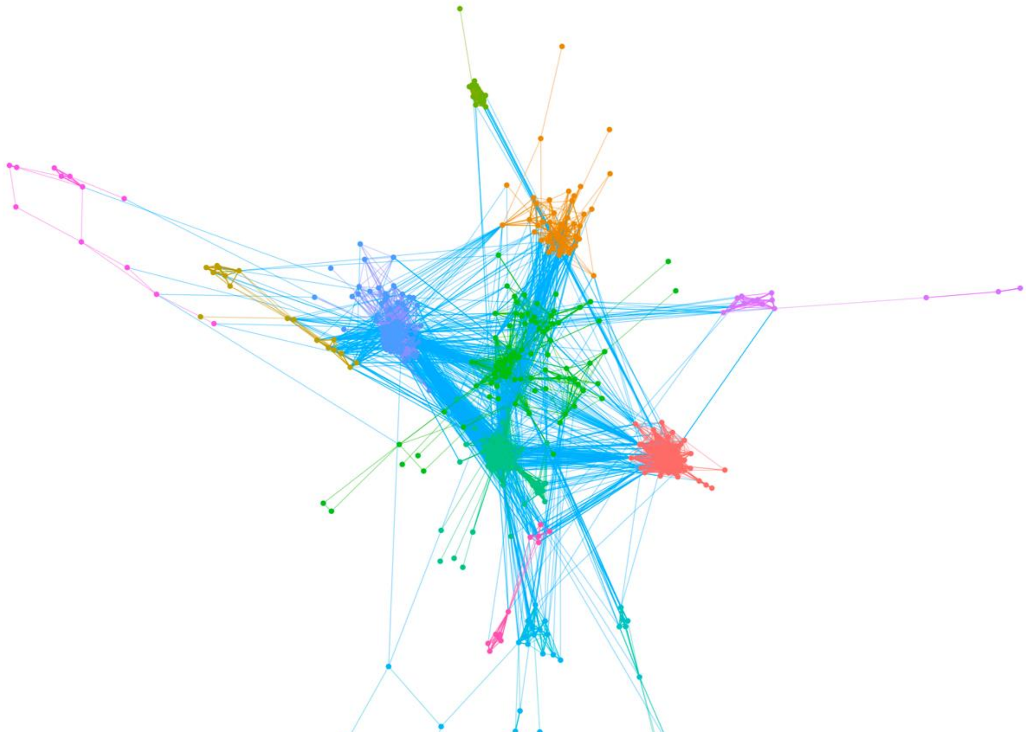
3.2. Bibliographic Coupling Analysis

Next, we conducted a bibliographic coupling analysis. For brevity, we limit the analysis to the most recent period (2022); however, Figure 4a,b provides a visual representation of the community structure of the *Mathematics* journal for the 2016–2022 period. (To add visual clarity to plots, we only included communities that had more than two members in the years 2016, 2017, 2018, and 2022 (given the relatively lower number of published papers in these years) and more than five members in the years 2019, 2020, and 2021.) Overall, we observe more integrated and connected work in the journal throughout the period 2019–2021 as evidenced by the within- and cross-community relationships shown in these figures. Bibliographic coupling occurs when articles have shared references and the goal of the analysis is to identify clusters of research that coalesce around similar themes/topics [3,9]. As a result, stronger within and between community relationships would entail greater convergence within and among topics that are otherwise disconnected from one another. This is likely to be the case when disparate research streams begin to mature and move toward becoming a more synthesized, integrated, and coherent scientific field. In Figure 4a,b, we observe this type of co-evolution among literature substreams represented in the *Mathematics* journal.



(**a**)

(**b**)



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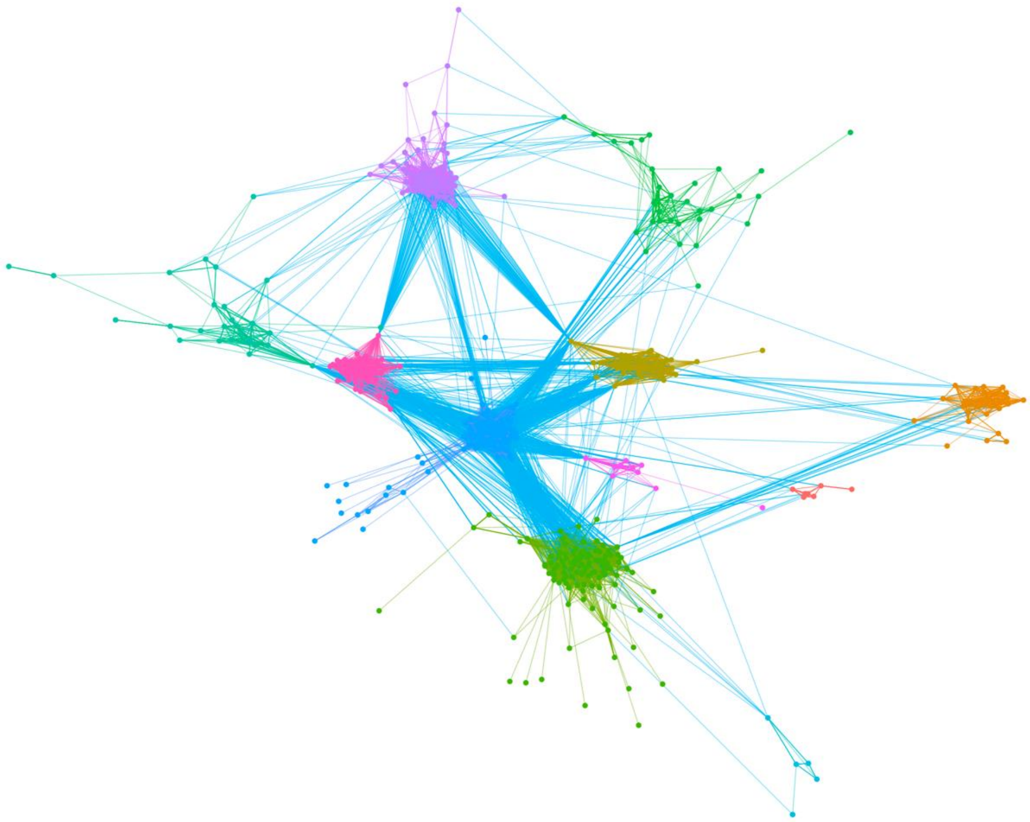
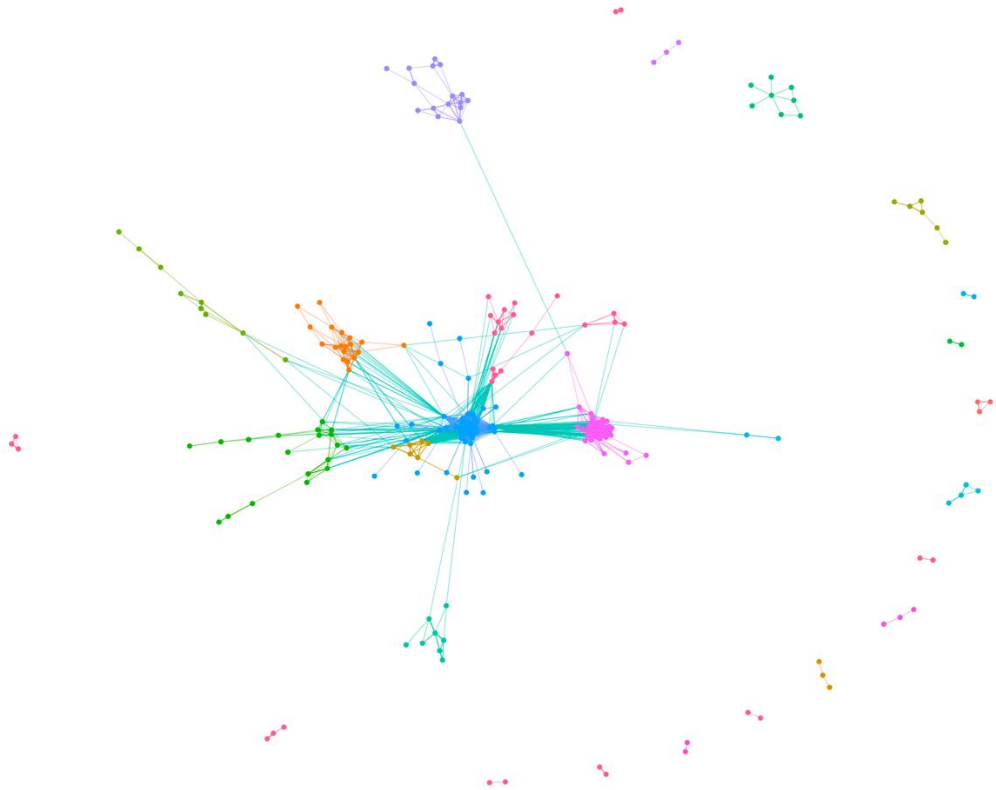
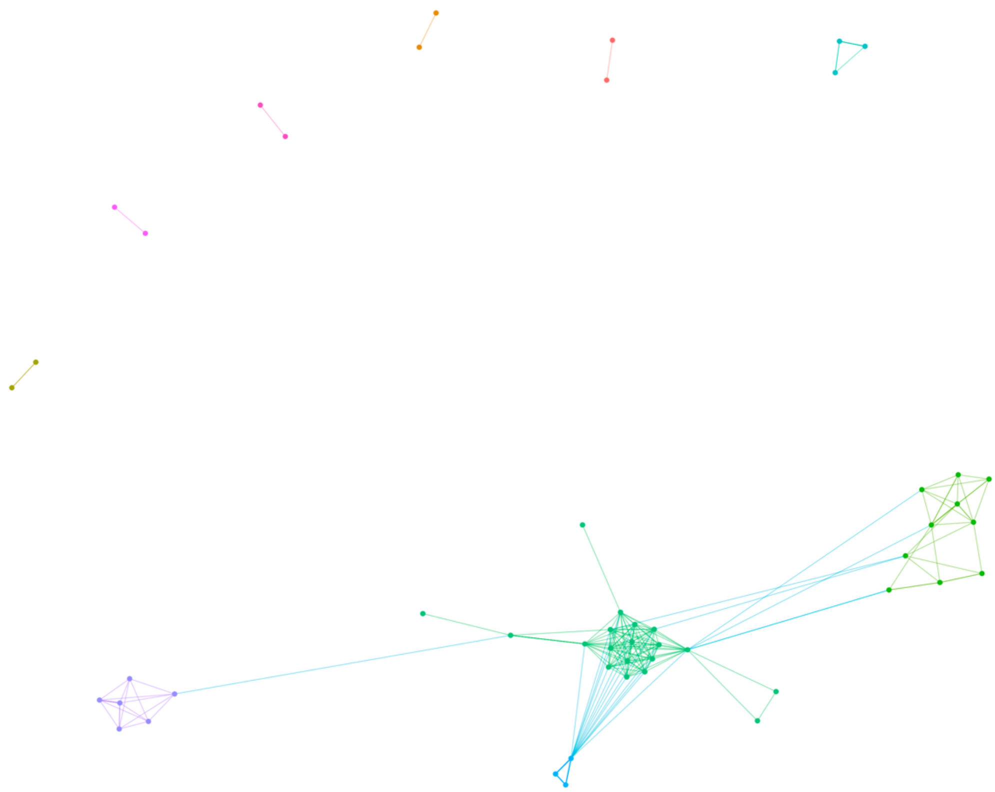


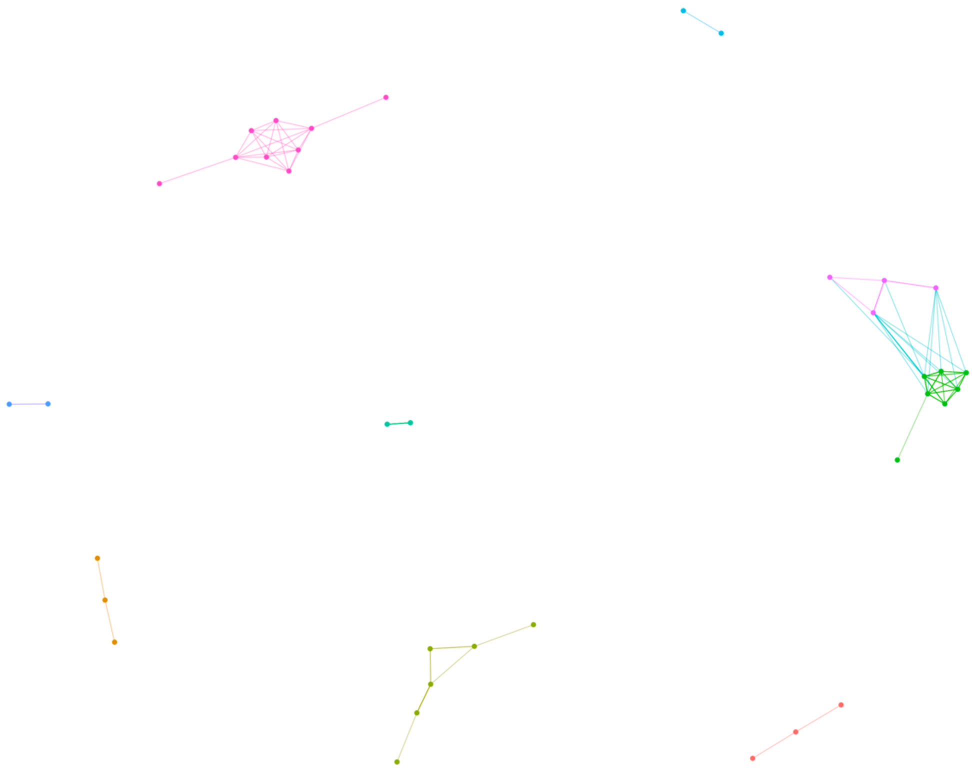
(**d**)



(**e**)



(**f**)



(**g**)

Figure 4. (**a**): Bibliographic coupling graph for 2022. (**b**): Bibliographic coupling graph for 2021. (**c**): Bibliographic coupling graph for 2020. (**d**): Bibliographic coupling graph for 2019. (**e**): Bibliographic coupling graph for 2018. (**f**): Bibliographic coupling graph for 2017. (**g**): Bibliographic coupling graph for 2016. Cluster membership is indicated by color.

In terms of the specific communities identified, the five largest communities in the bibliographic coupling network in the year 2022 are Community #4 (47 publications), Community #8 (33 publications), Community #7 (30 publications), Community #2 (25 publications), and Community #9 (25 publications). To understand the content of these research clusters better, we conducted a keyword frequency analysis. The most frequently observed author-entered terms in Community #4 are: “Machine Learning”, “Deep Learning”, “Anomaly Detection”, “Convolutional Neural Network”, “Data Augmentation”, “Deep Neural Network”, “Generalized Finite Difference Method”, “Intelligent Transport Systems”, “Natural Language Processing”, “Singular Boundary Method”, and “Transfer Learning”. This suggests that one of the major areas of emphasis in the *Mathematics* journal, consistent with our cumulative results reported in Figure 2a–c, is topics pertinent to artificial intelligence. Community #8 consists primarily of articles that focus on “Fractional Calculus”, “Banach Spaces”, “Caputo Fractional Derivative”, “Fixed Point”, “Fractional Differential Equations”, and “System Identification”. Comparatively, “Data Hiding”, “Meta-Heuristics”, “Optimization”, “Particle Swarm Optimization”, and “Taguchi Method” are among the most frequently used keywords in Community #7. Our analysis also shows that “Entropy”, “Financial Markets”, “Monte Carlo Simulation”, “Quantile Regression”, and “Random Walk” are the most frequently occurring keywords in Community #9. The analysis shows that the clusters identified by the community-finding algorithm have distinct research themes that focus on specific areas of computational programming/analysis and applied mathematics. We expect these areas to remain important to researchers in these domains for the foreseeable future and predict increased cross-pollination across fields, given the structural changes observed in the journal during the 2019–2021 period with greater occurrence of cross-community ties.

One of the most important implications of this change is that more novel ideas that advance our cumulative understanding of computational programming/analysis and applied mathematics are likely to emerge from these cross-pollinating lines of work that integrate knowledge embedded in distinct knowledge repositories. Indeed, research in network science [21] would suggest that scientific work that integrates knowledge across otherwise disconnected fields is likely to put forth more novel and creative ideas that will significantly advance our understanding of theory and practice. Therefore, we consider the co-evolution of the communities observed in the *Mathematics* journal highly encouraging for future research in computational programming/analysis and applied mathematics, as they point to increased collaborative and integrative work across subdisciplines.

3.3. Topic Modeling Analysis

Finally, we complement our bibliographic coupling analysis with a topic modeling analysis using the Latent Dirichlet Allocation algorithm included in the *topicmodels* package in R [22]. As discussed elsewhere [23,24], the LDA algorithm identifies terms/words that constitute a topic and the topics that constitute a document. We use article abstracts as input in the LDA algorithm and specify five topics to extract the terms/words associated with each of these topics to interpret the scholarly discussion that is taking place in the *Mathematics* journal in the most recent period (i.e., sample year 2022). Our results are shown in Figure 5. The LDA algorithm allows us to calculate “beta” scores that indicate per-topic-per-term probabilities, that is, “the probability of that term being generated from that topic” [24] (p. 92). To conduct the topic modeling analysis, we first tokenized all of the abstracts of the articles published in 2022, then removed stop words (e.g., in, for, at) and common terms that are observed in abstracts but do not describe an area of study (i.e., “result”, “study”, “paper”, “provide”, “obtain”, “example”, “theory”, “approach”, “model”, “propose”, “research”, “introduce”, “compare”, “finally”). In Figure 5, we limit the number of terms in each topic to 30 words with highest beta in each topic.

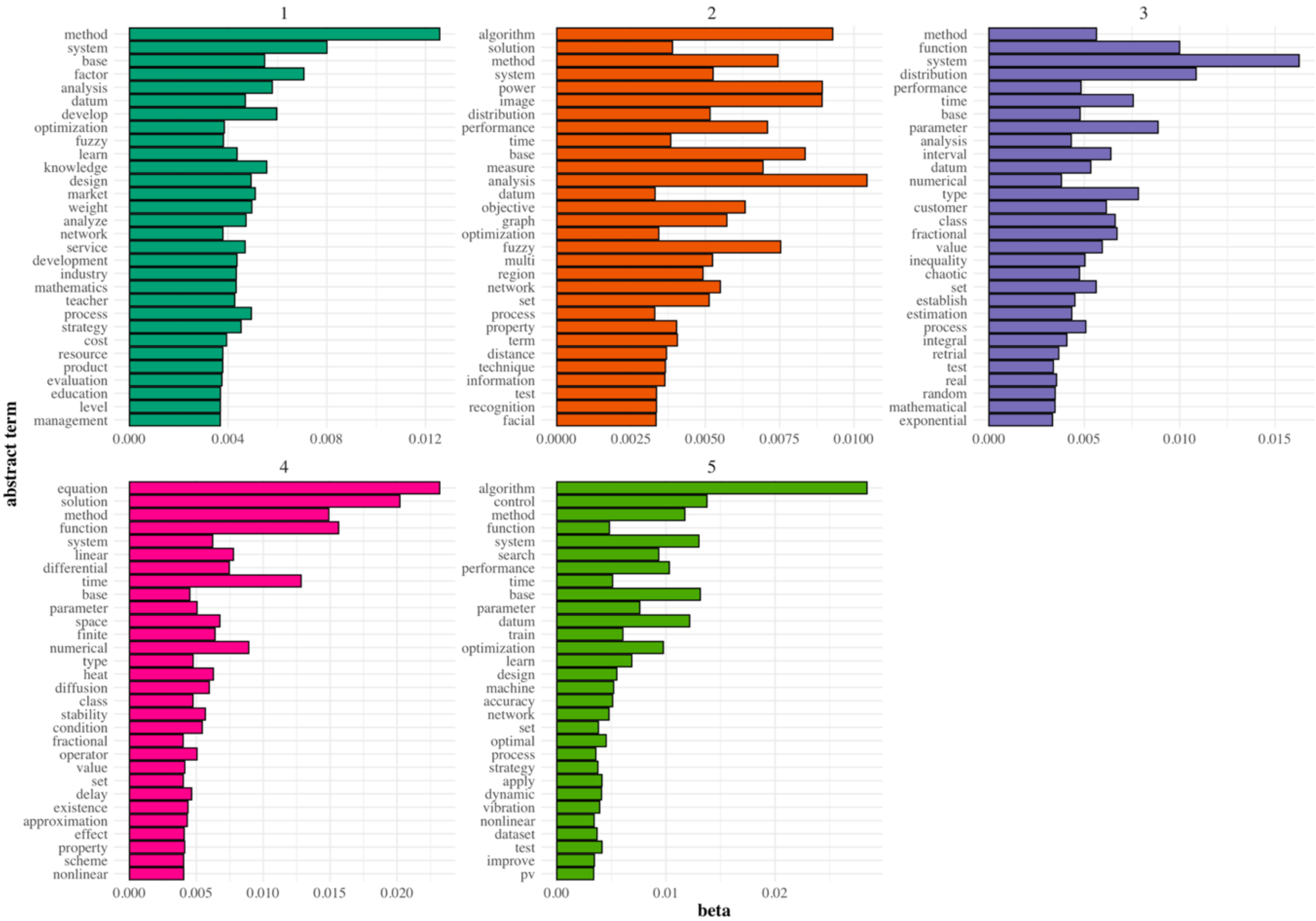


Figure 5. LDA topic modeling analysis using article abstracts. Topics extracted are represented by numbers 1–5 as indicated at the top of each plot facet and by distinct colors.

Our results indicate that Topic #1 consists of terms such as "Method", "System", "Base", "Factor", "Optimization", "Fuzzy". Topic #2 is comprised of "Algorithm", "Analysis", "Power", "Image", and "Method", among others. Terms such as "Function", "System", "Distribution", "Parameter", and "Time" are among those with top beta scores in Topic #3. We observe that the terms "Equation", "Solution", "Method", "Function", "Linear", and "Differential" are among those that make up Topic #4. Finally, the terms "Algorithm", "Control", "Method", "System", "Search", and "Performance" are among those with top beta scores in Topic #5. Overall, this analysis provides additional insights into the discourse that is taking place in the *Mathematics* journal, by efficiently identifying the topics that are being discussed among researchers publishing in the journal. As our results indicate, the LDA algorithm does not assign a particular term to a topic exclusively, rather it calculates the probability that a term is produced by a topic, and as such, a term can be associated with more than one topic at varying levels of probability [19]. Overall, our findings from the topic modeling analysis are complementary to the bibliographic coupling and keyword analyses.

4. Discussion

In this study, we report findings of a bibliometric analytic review of the *Mathematics* journal to provide a comprehensive understanding of the historic evolution and current thematic structure of the journal to editors, reviewers, and authors. The number of yearly publications has grown at a substantive rate since 2016, with the highest growth rates in 2018 and 2019. Our analysis also revealed that, to date, China and Spain are among the top contributing countries to the *Mathematics* journal. Our findings indicate that the journal has been moving toward becoming a more cohesive publication outlet as evidenced by increased within- and between-community ties shown in the bibliographic coupling graphs since 2016. We consider this type of cross-pollinating work across related fields highly encouraging for new knowledge generation and diffusion. Another important finding is the rapid transition in the discourse of the journal from more traditional applied mathematics concepts to those pertinent to advanced computational sciences, such as deep learning, machine learning, and neural networks. This is an important shift in attention as knowledge pertinent to artificial intelligence has implications for a wide spectrum of scientific fields and applications across a plethora of industries. We find these structural and thematic changes encouraging developments in the journey of the *Mathematics* journal and hope that our bibliometric review provides additional clarity and stimulates novel and interesting research in the future.

Our analysis incorporated time-series data from 2016 to 2022. However, it would be interesting and fruitful for future research to expand on our findings with additional analyses that focus on uncovering the structural and thematic changes in *Mathematics*, once significant new knowledge has been accumulated through new publications in the journal. Preceding work has shown that longitudinal analysis of journals encompassing decades of publication data can help inform future work [25]. We also conducted our bibliographic coupling analysis using more limited 2022 data to better understand the discourse in the journal in the present day and shed light on future research [10]. However, we encourage future research to assess the thematic evolution of the field on a longitudinal basis using periodic data that encompasses a wider time span. It would be interesting to observe the resiliency of subcommunities of research over time as they come in and out of existence as discourse in the applied mathematics discipline evolves.

We also did not evaluate individual studies in our review as the scope and aim of our review is to focus on the overall performance and thematic structure of the *Mathematics* journal rather than discuss individual contributors per se. However, we encourage future research to combine bibliometric tools with a narrative review to engage with researchers at a more micro level, discussing the contributions made by specific articles in each research substream and elaborating on how these articles have inspired research in the journal and advanced the field. Moreover, while our application of the LDA algorithm to the article abstracts represents an important contribution, it is focused on a single topic modeling technique and the number of topics chosen to be extracted is by no means complete. Thus, future research can rely on additional topic modeling algorithms and apply them to not only abstracts but also other data that can be extracted from the main body of published research in the journal (e.g., articles' methods sections) to assess discourse at a more granular level. The scope of bibliometric analysis can also expand to incorporate additional techniques, such as co-citation analysis, to evaluate more historic data [3]. Finally, while our focus was on the *Mathematics* journal, it would be interesting to conduct additional analysis that evaluate the journal's thematic structure along with other similar journals in the field for a comparative assessment. It is our hope that this study serves as an important template, among other important preceding work, for future research in the areas of bibliometric and network analyses of scientific journal data.

5. Conclusions

In this study, we reported findings from a bibliometric review of the *Mathematics* journal. Our findings indicate that the *Mathematics* journal is a rapidly growing publication outlet that publishes an increasingly more connected and cohesive set of scientific reports in the field of applied mathematics, and more recently, in the domains of artificial intelligence, neural networks, and machine learning. Consistent with prior research on bibliometric reviews, we provided a performance report of the journal and charted a science map for journal editors and researchers. We consider the yearly progress made in the *Mathematics* journal highly encouraging for the development of a platform where researchers can introduce novel ideas that focus on diverse issues in the aforementioned areas of applied mathematics and computational sciences. The journal's global reach that encompasses a varied set of affiliate institutions and countries is also highly encouraging for comprehensive representation of varied theoretical and empirical approaches, diverse samples, and novel ideas that will push future research in applied mathematics, computational sciences, and artificial intelligence forward. We hope that our systematic analysis of recent developments in the *Mathematics* journal provides a foundation for such research to build on. We also hope that our study contributes to the dissemination of bibliometric techniques in the field of applied mathematics and encourages future research that incorporates relational methods (i.e., network analysis) to uncover how new scientific knowledge is developed and diffused.

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References

1. Mathematics. About Mathematics. Available online: https://www.mdpi.com/journal/mathematics/about (accessed on 2 May 2022).
2. Mathematics. Journal History. Available online: https://www.mdpi.com/journal/mathematics/history (accessed on 2 May 2022).
3. Zupic, I.; Čater, T. Bibliometric Methods in Management and Organization. *Organ. Res. Methods* **2015**, *18*, 429–472.
4. Bilgili, H.; Johnson, J.L.; Bilgili, T.V.; Ellstrand, A.E. Research on Social Relationships and Processes Governing the Behaviors of Members of the Corporate Elite: A Review and Bibliometric Analysis. *Rev. Manag. Sci.* **2021**, 1–55. https://doi.org/10.1007/s11846-021-00505-5.
5. Nerur, S.P.; Rasheed, A.A.; Pandey, A. Citation Footprints on the Sands of Time: An Analysis of Idea Migrations in Strategic Management. *Strateg. Manag. J.* **2016**, *37*, 1065–1084.
6. Ramos-Rodríguez, A.R.; Ruíz-Navarro, J. Changes in the intellectual structure of strategic management research: A bibliometric study of the Strategic Management Journal, 1980–2000. *Strateg. Manag. J.* **2004**, *25*, 981–1004.
7. Nerur, S.P.; Rasheed, A.A.; Natarajan, V. The Intellectual Structure of the Strategic Management Field: An Author Co-citation Analysis. *Strateg. Manag. J.* **2008**, *29*, 319–336.
8. Podsakoff, P.M.; MacKenzie, S.B.; Podsakoff, N.P.; Bachrach, D.G. Scholarly influence in the field of management: A bibliometric analysis of the determinants of university and author impact in the management literature in the past quarter century. *J. Manag.* **2008**, *34*, 641–720.
9. Donthu, N.; Kumar, S.; Mukherjee, D.; Pandey, N.; Lim, W.M. How to conduct a bibliometric analysis: An overview and guidelines. *J. Bus. Res.* **2021**, *133*, 285–296.
10. Wickham, H.; Averick, M.; Bryan, J.; Chang, W.; McGowan, L.; François, R.; Grolemund, G.; Hayes, A.; Henry, L.; Hester, J.; et al. Welcome to the Tidyverse. *J. Open Source Softw.* **2019**, *4*, 1686. https://doi.org/10.21105/joss.01686.
11. Pedersen, T.L. Tidygraph: A Tidy API for Graph Manipulation. R Package Version 1.2.0. **2020**. Available online: https://CRAN.R-project.org/package=tidygraph (accessed on 26 July 2022).
12. Aria, M.; Cuccurullo, C. Bibliometrix: An R-tool for Comprehensive Science Mapping Analysis. *J. Informetr.* **2017**, *11*, 959–975.

13. Pedersen, T.L. Ggraph: An Implementation of Grammar of Graphics for Graphs and Networks. R package Version 2.0.5. 2021. Available online: https://CRAN.R-project.org/package=ggraph (accessed on 26 July 2022).
14. Rinker, T.W. *Textstem: Tools for Stemming and Lemmatizing Text Version 0.1.4*; 2018. Available online: http://github.com/trinker/textstem (accessed on 26 July 2022).
15. Silge, J.; Robinson, D. Tidytext: Text mining and analysis using tidy data principles in R. *J. Open Source Softw.* **2016**, *1*, 37.
16. Robinson, D. Widyr: Widen, Process, then Re-Tidy Data. R Package Version 0.1.4. 2021. Available online: https://CRAN.R-project.org/package=widyr (accessed on 26 July 2022).
17. Zeileis, A.; Grothendieck, G. Zoo: S3 Infrastructure for Regular and Irregular Time Series. *J. Stat. Softw.* **2005**, *14*, 1–27. https://doi.org/10.18637/jss.v014.i06.
18. Garrappa, R. Numerical solution of fractional differential equations: A survey and a software tutorial. *Mathematics* **2018**, *6*, 16.
19. Kamran, T.; Samreen, M.; UL Ain, Q. A generalization of b-metric space and some fixed point theorems. *Mathematics* **2017**, *5*, 19.
20. Kumar, S.; Ahmadian, A.; Kumar, R.; Kumar, D.; Singh, J.; Baleanu, D.; Salimi, M. An efficient numerical method for fractional SIR epidemic model of infectious disease by using Bernstein wavelets. *Mathematics* **2020**, *8*, 558.
21. Hargadon, A.B. Brokering Knowledge: Linking Learning and Innovation. *Res. Organ. Behav.* **2002**, *24*, 41–85.
22. Grün, B.; Hornik, K. Topicmodels: An R Package for Fitting Topic Models. *J. Stat. Softw.* **2011**, *40*, 1–30. https://doi.org/10.18637/jss.v040.i13.
23. Hannigan, T.R.; Haans, R.F.; Vakili, K.; Tchalian, H.; Glaser, V.L.; Wang, M.S.; Kaplan, S.; Jennings, P.D. Topic Modeling in Management Research: Rendering New Theory from Textual Data. *Acad. Manag. Ann.* **2019**, *13*, 586–632.
24. Silge, J.; Robinson, D. *Text Mining with R: A Tidy Approach*; O'Reilly Media: Sebastopol, CA, USA, 2017.
25. Donthu, N.; Kumar, S.; Pattnaik, D. Forty-five years of Journal of Business Research: A bibliometric analysis. *J. Bus. Res.* **2020**, *109*, 1–14.