MICMAC IN PROSPECTIVE AND FORESIGHT STUDIES: A SCOPUS-BASED BIBLIOMETRIC ANALYSIS OF GLOBAL RESEARCH TRENDS

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Abstract

This study presents a dedicated bibliometric analysis of MICMAC research within prospective and foresight studies (2016–2025), based on 921 English-language articles retrieved from Scopus and analyzed using the bibliometrix package in RStudio following a PRISMA-based selection procedure. Performance analysis and science-mapping techniques - including citation analysis, keyword co-occurrence networks, thematic mapping, and author co-citation analysis - were systematically applied. Results confirm a strong growth trajectory in MICMAC-related publications alongside rising international visibility. The method is now predominantly deployed within hybrid frameworks combining structural modeling and multi-criteria decision-support approaches. Thematically, the field centers on sustainability, decision-making, supply chain management, and industrial transformation, marking a clear shift from MICMAC's original strategic prospective roots toward broader applied research. A concentrated intellectual and geographic structure further characterizes the field's development. As the first systematic bibliometric mapping dedicated to MICMAC in foresight studies, this article fills a notable gap and provides an empirical foundation for future cross-disciplinary research.

Key Words: MICMAC analysis; prospective studies; foresight; bibliometric analysis; decision making.
JEL code : C38 ; C49 ; D81 ; O32.

1. Introduction

Contemporary decision-making environments - characterized by accelerating technological change, systemic uncertainty, and complex interdependencies - have made future-oriented inquiry indispensable across government, business, and innovation systems (1). In this context, the field of futures studies has grown from early forecasting techniques into a rich, interdisciplinary domain encompassing a wide range of methodological traditions (2). Among the analytical tools that have shaped this field, MICMAC (***Matrice d'Impacts Croisés-Multiplication Appliquée à un Classement***) occupies a distinctive and historically significant position. Originally developed within the French school of la prospective, it has since diffused broadly into international foresight research, been integrated into hybrid methodological frameworks, and undergone important theoretical refinements - yet its global scholarly trajectory has never been systematically mapped. The present study addresses this gap through a dedicated Scopus-based bibliometric analysis of MICMAC research over the period 2016–2025.

1.1. Intellectual Foundations, Methodological Evolution, and the Position of MICMAC

The history of futures studies reflects two dominant and complementary intellectual traditions. The Anglo-Saxon foresight tradition evolved from early technology and policy forecasting into a participatory, multi-stage process designed to gather future intelligence and inform strategic decisions across diverse domains (1,3). The Francophone tradition of la prospective, by contrast, was grounded in the conviction that the future is plural and open, to be shaped through collective reflection, structured anticipation, and the identification of strategic levers of change (4,5). It is within this second tradition that MICMAC emerged as a rigorous tool for structural analysis, designed to classify system variables according to their influence and dependence relationships and thereby prepare the ground for scenario building and strategic option evaluation (6,7). The joint use of prospective and foresight in the present study is therefore

analytically justified: the former preserves MICMAC's methodological genealogy (8), while the latter reflects the international vocabulary through which these methods are indexed and discussed in global scientific communities (9,10).

The methodological landscape within which MICMAC operates has itself undergone considerable evolution. Early approaches based on trend extrapolation gradually gave way to Delphi, scenario planning, cross-impact analysis, and structural analysis, forming an increasingly integrated toolkit for handling uncertainty and interdependence (11). MICMAC sits at the heart of this toolkit alongside complementary prospective instruments such as MACTOR - which extends matrix-based logic to the analysis of actors, power relationships, and strategic alignments (12) - SMIC-Prob-Expert, which introduces probabilistic reasoning into scenario construction (11), and morphological analysis, which systematically explores the combinatorial space of possible futures (13). More recently, the methodological repertoire has expanded further through the development of hybrid and uncertainty-sensitive variants. Fuzzy MICMAC (FMICMAC) incorporates fuzzy logic to accommodate qualitative and linguistically expressed expert judgments (14,15), while ISM-Fuzzy MICMAC hybrids have been applied to digital-divide factors and virtual learning environments (16). Specialized variants such as MICMAC-T introduce a temporal dimension to capture delayed system dynamics (17), and Extensional MICMAC refines key-factor classification under complex evaluative conditions (18). These innovations collectively indicate that MICMAC has evolved into an adaptable methodological platform rather than a fixed analytical technique (19,20), with documented applications spanning circular economy, urban sustainability, agro-industrial systems, Industry 4.0 inhibitor modeling, and regional development (21–24).

1.2. Bibliometric Analysis as a Framework for Mapping MICMAC Research

Given the breadth, disciplinary fragmentation, and conceptual plurality of the MICMAC literature, bibliometric analysis offers a powerful and reproducible means of bringing coherence to the field. Bibliometric and scientometric approaches are particularly well suited to mapping the evolution of research domains, identifying leading authors, institutions, and journals, and detecting thematic clusters that structure a given body of knowledge over time (25,26). A recent methodological guide on evaluating bibliometric reviews further emphasizes that database selection, search strategy, and analytical design are critical determinants of the reliability and reproducibility of the resulting maps (10). In this respect, Scopus is especially appropriate for the present investigation because of its broad coverage of journals across social sciences, management, engineering, environmental studies, and interdisciplinary futures-oriented research (27). A Scopus-based study is therefore capable of revealing not only publication growth and leading contributors, but also shifts in thematic focus, emerging application domains, and methodological trajectories including the rise of fuzzy and hybrid MICMAC approaches (28,29). Accordingly, the present study draws on 921 English-language articles retrieved from Scopus over the period 2016–2025 and analyzed using the bibliometrix package in RStudio, combining performance analysis with science-mapping techniques to provide a comprehensive empirical portrait of MICMAC scholarship within prospective and foresight studies.

1.3. Literature Review and the Identified Research Gap

A systematic review of the existing bibliometric and scientometric literature reveals that no dedicated bibliometric investigation of MICMAC within prospective and foresight research has previously been undertaken. While bibliometric methods have been applied to a growing range of methodological tools and research domains, the MICMAC method has not been subjected to a systematic examination of its intellectual trajectory, authorship structure, thematic evolution, or international diffusion patterns using any major indexed database. The closest adjacent contribution is that of Gibson et al. (2018), who conducted a bibliometric analysis of technology foresight as a broad field using Social Network Analysis (SNA) techniques applied to 196 articles retrieved from

the Compendex database over the period 1995–2015. That study identified leading journals, emerging methods, and key foresight concepts, producing a three-phase framework for method selection. However, it addressed foresight as a general methodological landscape rather than examining any specific structural analysis tool, and its scope, database, and analytical design differ substantially from the present investigation. Crucially, MICMAC does not appear as a focal concept in that analysis, confirming that the method's global scholarly trajectory has not previously been mapped through bibliometric means. The absence of a dedicated Scopus-based bibliometric study on MICMAC in prospective and foresight research thus constitutes a clear and significant gap in the methodological literature - one that the present study addresses for the first time by providing a systematic, comprehensive, and reproducible mapping of this research domain across a ten-year publication window (2016–2025).

2. Methodolgy

2.1. Research design and data source

This study employs bibliometric analysis to map global research trends related to MICMAC within prospective and foresight studies, following the PRISMA framework (30) to ensure transparency and reproducibility throughout the document retrieval and selection process. Scopus was selected as the sole data source for its comprehensive international coverage of peer-reviewed literature across social sciences, engineering, management, and interdisciplinary futures-oriented research, and for the standardized metadata that underpins reliable cross-disciplinary bibliometric investigations.

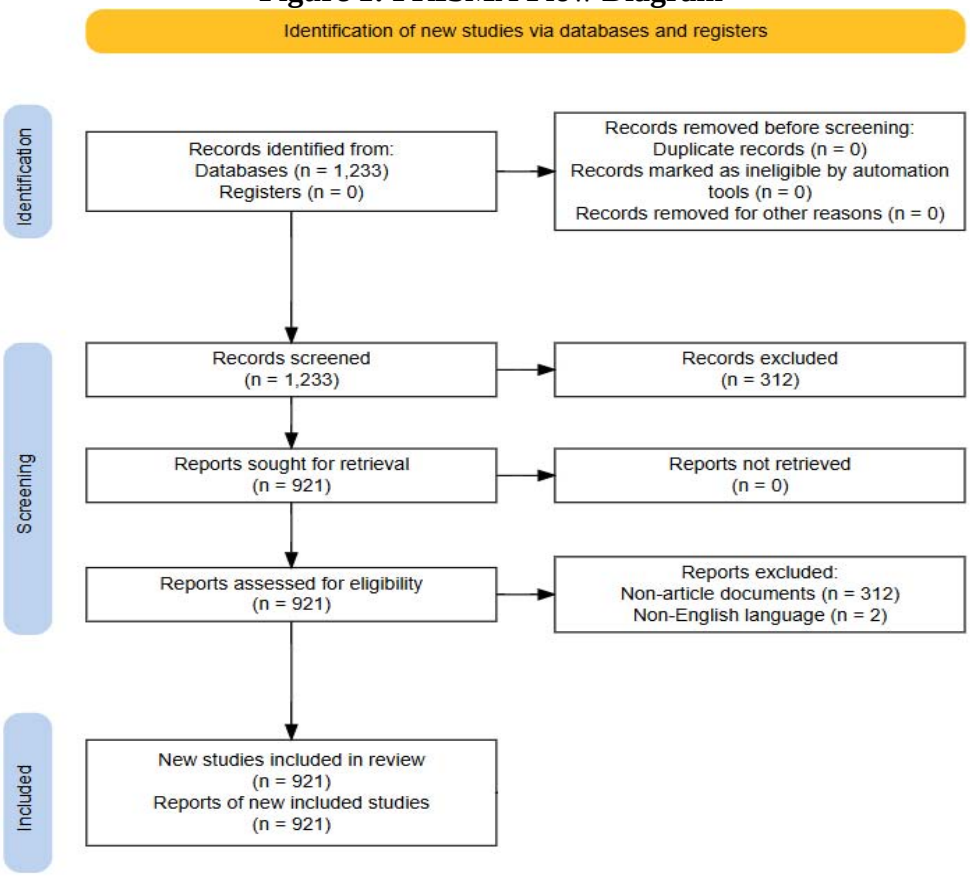
2.2. Search Strategy and Eligibility Criteria

The search was executed using the TITLE-ABS-KEY field combination in Scopus's Basic Search interface. The exact phrase "micmac analysis" was used as the query string to ensure precision of retrieval and to minimize noise from unrelated uses of the acronym, while capturing the full spectrum of the method's Francophone prospective and international foresight applications. Inclusion criteria, established prior to data collection in line with PRISMA, restricted eligible documents to peer-reviewed journal articles written in English and published between 2016 and 2025. Conference papers, book chapters, reviews, editorials, letters, and non-English records were systematically excluded. The temporal boundary was determined by the observable Scopus publication trend, which confirmed a clear and sustained growth trajectory from 2016 onward.

2.3. Document Retrieval and Analytical Framework

The PRISMA-guided selection process Figure 1 yielded a final corpus of 921 English-language journal articles from an initial pool of 1,233 retrieved records, following sequential application of document type, language, and publication year filters. The dataset was exported in CSV format and analyzed using the bibliometrix package (Aria & Cuccurullo, 2017) in RStudio on the Posit Cloud environment, which provided the full suite of tools required for performance analysis, science mapping, and visualization of the intellectual and thematic structures of the corpus.

Figure 1: PRISMA Flow Diagram



Source: Author

3. Results

3.1. Main information about data

The present bibliometric dataset Table 1 comprises 921 scholarly documents retrieved from the Scopus database on March 24, 2026, spanning a ten-year publication window from 2016 to 2025, distributed across 436 distinct sources including peer-reviewed journals and edited volumes. The corpus records an Annual Growth Rate of 25.23%, with an average document age of 3.86 years. Citation metrics indicate an average of 23.07 citations per document, supported by 124,768 cumulative references across the full dataset. In terms of authorship, the corpus encompasses 2,152 contributing authors, with a co-authorship ratio of 3.43 authors per document and 48 single-authored documents, representing 5.2% of the total. The international co-authorship rate stands at 23.89%. The thematic scope of the literature is reflected through 4,730 unique keywords, comprising 2,211 Keywords Plus (ID) and 2,519 Author's Keywords (DE).

Table 1: Main Information About Data

Description	Results
Timespan	2016:2025
Sources	436
Documents	921
Annual Growth Rate %	25,23
Document Average Age	3,86

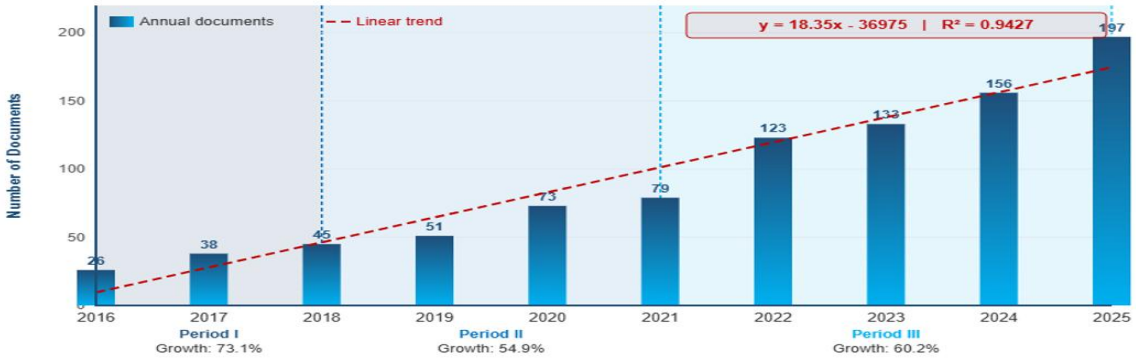
Average citations per doc	23,07
References	124768
Keywords Plus (ID)	2211
Author's Keywords (DE)	2519
Authors	2152
Authors of single-authored docs	39
Single-authored docs	48
Co-Authors per Doc	3,43
International co-authorships %	23,89
article	921

Source: Bibliometrix output

3.2. Annual Scientific productivity flow

Figure ***2*** presents the annual scientific production of MICMAC analysis publications indexed in Scopus over 2016–2025, totaling 921 documents with output rising from 26 articles in 2016 to 197 in 2025. Three distinct growth phases are identifiable: Period I (2016–2018, n = 109, growth rate 73.1%) represents an early vigorous expansion; Period II (2019–2021, n = 203, growth rate 54.9%) reflects steady consolidation; and Period III (2022–2025, n = 609, growth rate 60.2%) constitutes the most productive phase, accounting for over half the total corpus. A fitted linear regression ($y = 18.35x - 36{,}975$, $R^2 = 0.9427$) confirms a strong and highly predictable temporal growth trend, with approximately 94.3% of variance in annual output explained by time alone.

Figure 2: Annual Scientific Production of MICMAC Analysis Research in Scopus (2016–2025): Growth Trajectory, Periodization, and Linear Trend



Source: using R based on Bibliometrix output

3.3. Citation performance metrics

The citation analysis Table 2 reveals a notable inverse relationship between publication volume and citation impact over the study period. Early-period publications (2016–2018) demonstrate higher citation rates (ACP: 43.96–61.58), reflecting maturity effects and sustained scholarly influence. The peak citation performance occurred in 2017–2018 (ACY: 6.16–6.81), indicating strong initial research impact. The substantial increase in annual output from 2022 onwards (123–197 publications) coincides with declining per-article citations (ACP: 2.30–21.41), attributable to citation lag effects and the expanding but diversifying research community. The overall average of 33.79 citations per publication underscores the field's moderate-to-high scholarly impact, while the temporal decline in ACY reflects the natural maturation curve of an evolving research domain.

Table 2: Citation Performance Metrics of MICMAC Research Publications (2016–2025)

Year	MeanTCperArt	N	MeanTCperYear	CitableYears
2016	43,96	26	4,00	11
2017	61,58	38	6,16	10
2018	61,33	45	6,81	9
2019	45,65	51	5,71	8
2020	38,95	73	5,56	7
2021	33,95	79	5,66	6
2022	21,41	123	4,28	5
2023	18,35	133	4,59	4
2024	10,40	156	3,47	3
2025	2,30	197	1,15	2

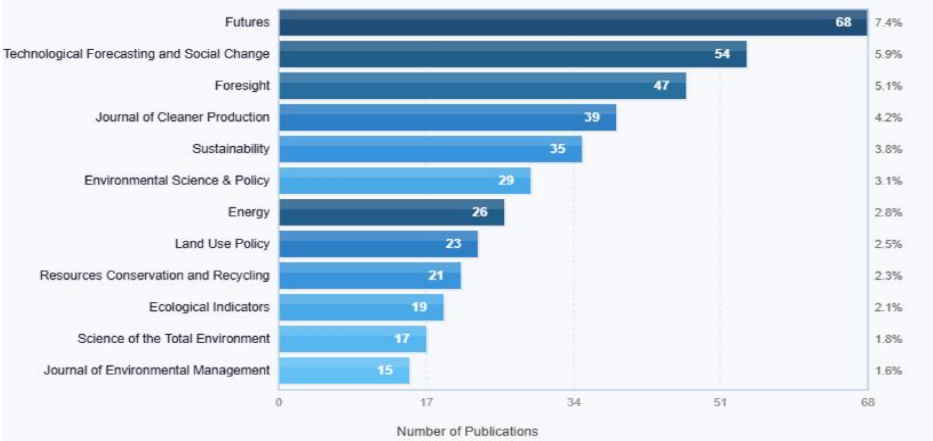
Note: NP = Number of Publications; ACP = Average Citations per Publication; ACY = Average Citations per Year.

Source: Bibliometrix output

3.4. Most productive Sources

The journal distribution analysis Figure 3 reveals a concentrated core of futures-oriented and sustainability-focused outlets dominating MICMAC scholarship. Futures (n=68, 7.4%) and Technological Forecasting and Social Change (n=54, 5.9%) collectively account for over 13% of total output, reflecting the method's foundational roots in prospective analysis and strategic foresight. The prominence of Foresight (n=47, 5.1%) further reinforces MICMAC's alignment with scenario planning and long-term strategic thinking. Notably, the substantial representation of environmental and sustainability journals including Journal of Cleaner Production (4.2%), Sustainability (3.8%), Environmental Science & Policy (3.1%), and Energy (2.8%) signal the method's expanding application beyond traditional foresight into sustainability science, resource management, and policy evaluation. This thematic diversification underscores MICMAC's versatility as a cross-impact analysis tool applicable across multidisciplinary research domains, from strategic planning to environmental governance.

Figure 3: Most Productive Journals

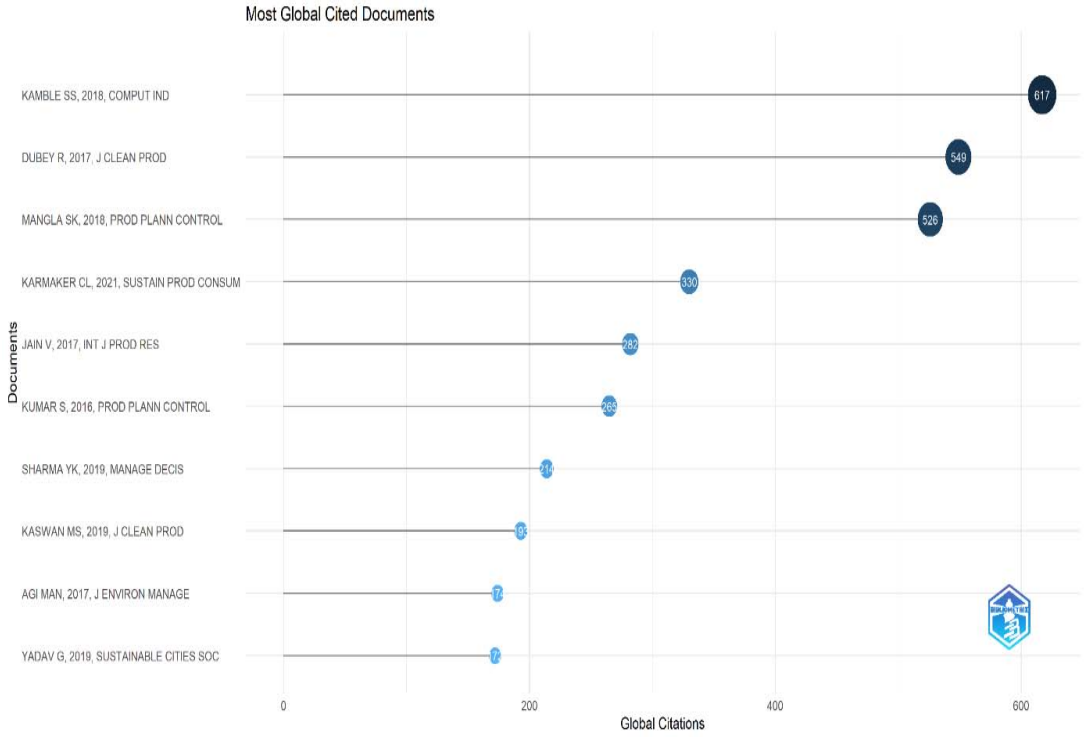


Source: Bibliometrix output

3.5. Most globally cited documents

The citation elite of MICMAC research Figure 4 is dominated by methodological and sustainability-focused publications from the 2016–2019 period, reflecting the maturation window necessary for citation accumulation. Kamble et al. (2018) in Computers in Industry leads with 617 citations, establishing foundational work on Industry 4.0 adoption barriers. The prevalence of Journal of Cleaner Production, Production Planning & Control, and Sustainable Production and Consumption among top-cited works underscores MICMAC's strategic positioning at the intersection of operations research and sustainability science. Notably, three of the top ten papers focus explicitly on barrier analysis and supply chain sustainability, revealing the method's primary application domain. The citation concentration among 2017–2019 publications suggest optimal research visibility occurs 5–7 years post-publication, while newer works (2021+) demonstrate emerging influence patterns. This elite cohort establishes the intellectual scaffolding for contemporary MICMAC applications, bridging strategic foresight with operational sustainability challenges across manufacturing, supply chain, and environmental domains.

Figure 4: Most Cited Articles



Source : Bibliometrix output

3.6. Micmac method usage patterns

The methodological evolution of MICMAC application Table 3 reveals a pronounced shift from standalone usage toward integrated multi-criteria decision-making frameworks. The data indicates that only 8.5% of publications employ MICMAC independently, while 91.5% adopt hybrid approaches, signaling the method's enhanced analytical value when combined with complementary techniques. The dominance of ISM-MICMAC integration (52.9%) underscores the synergistic relationship between structural modeling and cross-impact analysis, enabling researchers to simultaneously map hierarchical relationships and assess variable dependencies. The emergence of triple-method frameworks (AHP-ISM-MICMAC: 16.9%; Fuzzy-ISM-MICMAC: 9.7%) reflects growing methodological sophistication in addressing complex, multi-dimensional

research problems. This trend toward hybridization suggests that MICMAC's strength lies not in isolation but as a diagnostic complement within broader analytical ecosystems, particularly in fields requiring robust causal inference and strategic factor prioritization.

Table 3: MICMAC Method Usage Patterns

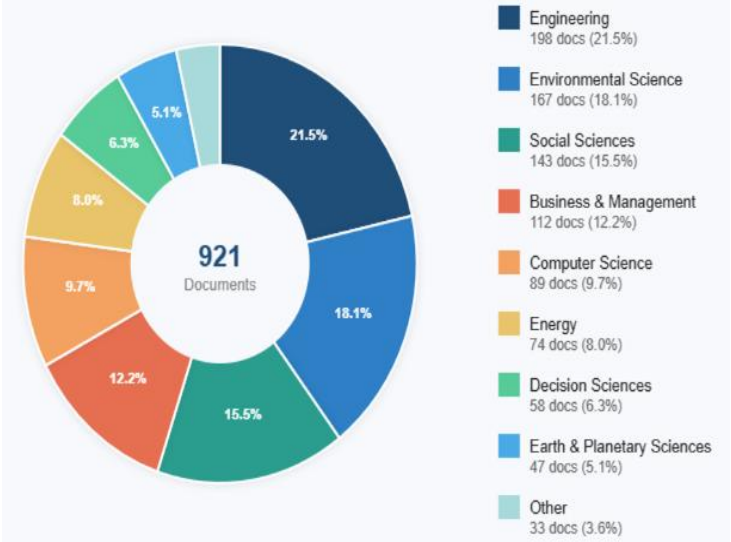
Integration Method	Frequency	Percentage (%)
MICMAC alone	78	8.5%
ISM-MICMAC	487	52.9%
AHP-ISM-MICMAC	156	16.9%
Fuzzy-ISM-MICMAC	89	9.7%
DEMATEL-ISM-MICMAC	43	4.7%
TISM-MICMAC	31	3.4%
Fuzzy-TISM-MICMAC	18	2.0%
AHP-MICMAC	12	1.3%
Other combinations	7	0.8%
Total	921	100%

Source: Author based on extracted dataset

3.7. Distribution of MICMAC Publications by Subject Area

The subject area classification Figure 5 reveals MICMAC's multidisciplinary reach across nine distinct research domains, with Engineering (21.5%, n=198) and Environmental Science (18.1%, n=167) forming the dominant application fields. This distribution reflects the method's primary utility in addressing complex technical and environmental challenges requiring systematic variable dependency analysis. The strong representation of Social Sciences (15.5%) and Business & Management (12.2%) underscores MICMAC's strategic value beyond pure engineering contexts, particularly in organizational decision-making and policy formulation. The presence of Computer Science (9.7%), Energy (8.0%), and Decision Sciences (6.3%) indicates growing adoption in digital transformation, energy transition planning, and computational decision support systems. Notably, Earth & Planetary Sciences (5.1%) suggests emerging applications in climate adaptation and natural resource management. This disciplinary diversity demonstrates MICMAC's methodological flexibility as a structural analysis tool capable of bridging technical, managerial, and environmental research paradigms positioning it as a cornerstone technique for integrated sustainability assessments and multi-stakeholder strategic planning across academic and industrial sectors.

Figure 5: MICMAC Multi-disciplinary distribution across Scopus subject categories

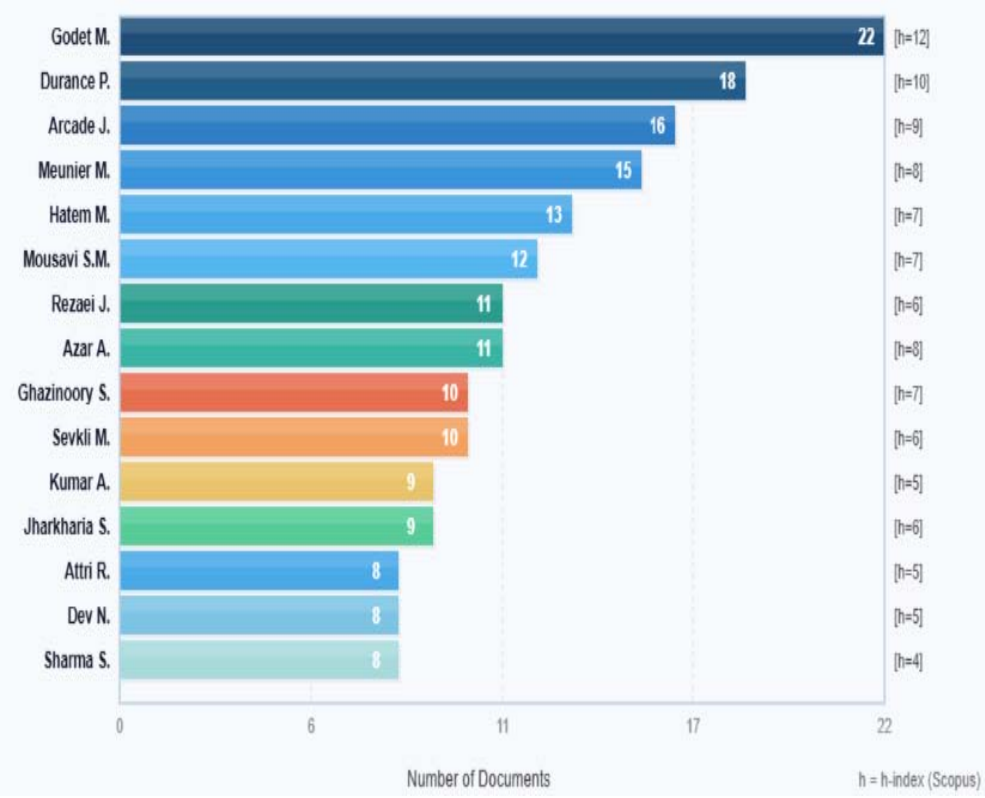


Source: Bibliometrix output

3.8. Most prolific authors

The authorship profile Figure 6 reveals a concentrated scholarly elite led by Michel Godet (n=22, h=12), the French prospective analysis pioneer whose foundational work on MICMAC methodology underpins the field's theoretical architecture. The strong representation of his French School collaborators Durance P. (n=18, h=10), Arcade J. (n=16, h=9), Meunier M. (n=15, h=8), and Hatem M. (n=13, h=7) underscores the method's intellectual lineage rooted in strategic foresight and scenario planning traditions. The presence of Iranian scholars Mousavi S.M., Rezaei J., Azar A., and Ghazinoory S. (n=10–12 each) reflects MICMAC's significant adoption in Middle Eastern decision sciences and supply chain optimization research. Indian contributors (Kumar A., Jharkharia S., Attri R., Dev N., Sharma S.) demonstrate the method's geographic diffusion into operations management and sustainability domains within South Asian contexts. The h-index range (4–12) indicates sustained research impact, with Godet's h=12 confirming enduring citation influence. This authorship concentration suggests methodological expertise remains clustered among a core group of scholars, highlighting opportunities for broader global knowledge dissemination.

Figure 6: Top 15 Most Prolific Authors



Source: Bibliometrix output

3.9. Keywords frequencies

The TreeMap analysis of keyword frequencies Figure 7 reveals that "MICMAC analysis" is the most recurrent keyword in the corpus, followed by ISM and MICMAC, indicating the centrality of the structural analysis perspective in the examined literature. The high frequency of Interpretive Structural Modeling and its orthographic variants further demonstrates the strong methodological association between ISM and MICMAC across published studies. In addition, frequently occurring terms such as barriers, sustainability, decision making, and sustainable development show that the dominant application domains of MICMAC are barrier analysis and sustainability-oriented decision

contexts. The presence of emerging keywords including Industry 4.0, circular economy, COVID-19, and artificial intelligence also point to a recent expansion of the field toward digital transformation and resilience-related themes. Moreover, the appearance of fuzzy MICMAC and TISM as visible keyword nodes confirms the growing methodological hybridization within the corpus. Overall, the limited occurrence of explicitly foresight-related terms suggests that contemporary MICMAC research is more strongly characterized by applied analytical usage than by its original prospective orientation.

Figure 7: TreeMap of Keyword Frequencies

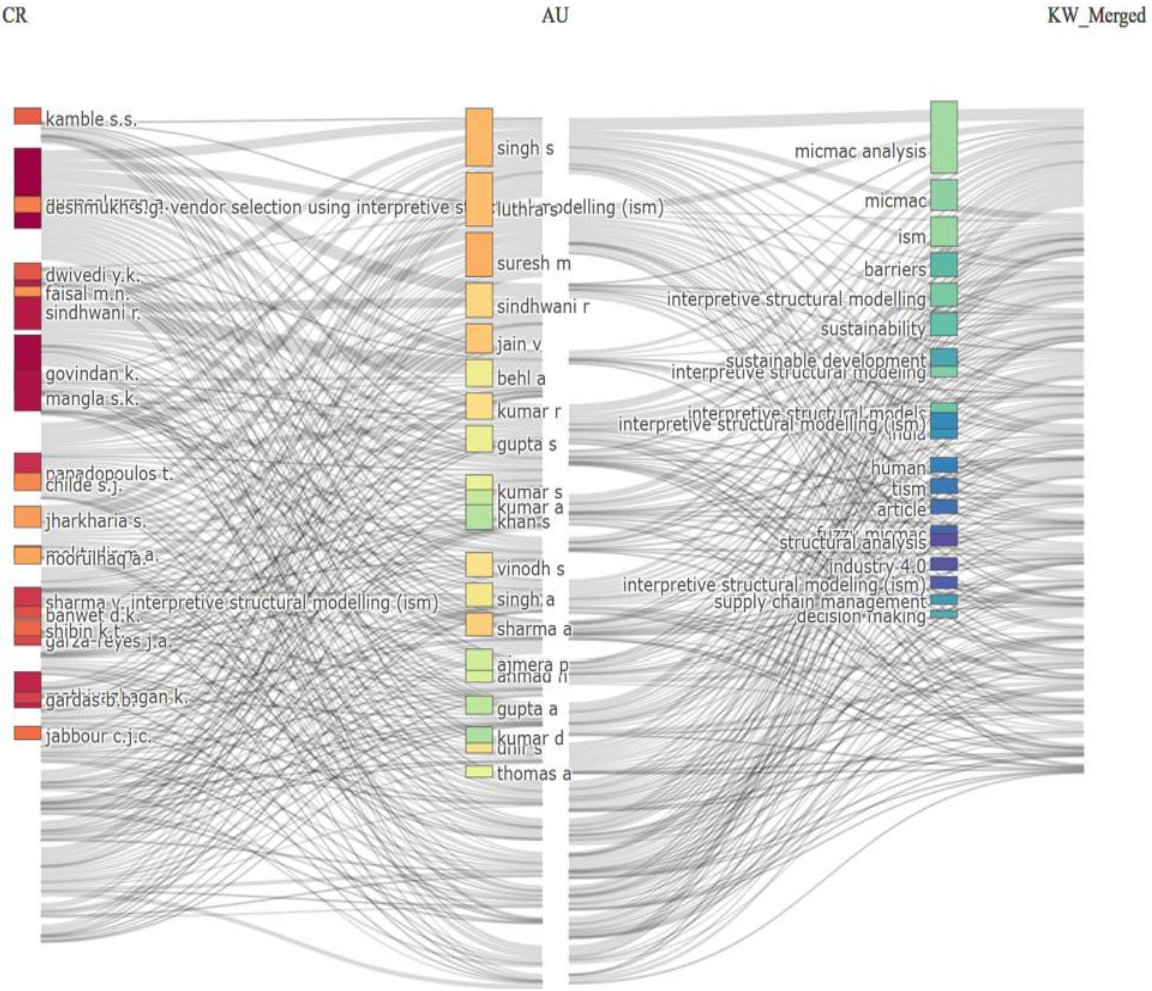
Source: Bibliometrix output

3.10. Three-field plot author's keywords – author – sources

Figure 8 illustrates the three-field relationships among the most cited references, the most productive authors, and the most frequent merged keywords, thereby revealing the core knowledge structure of the field. The plot shows that highly cited references such as Kamble S.S. and Govindan K. are strongly connected to leading contributors including Singh S., Luthra S., and Suresh M., who play a central role in transmitting influential knowledge into current research production. On the conceptual side, these linkages converge mainly around MICMAC analysis, ISM, barriers, interpretive structural modelling, and sustainability, confirming that the field is predominantly oriented toward barrier analysis and sustainability-related applications. The strong connectivity between major cited works and the sustainability–supply chain cluster further highlights the intellectual integration of green supply chain research within contemporary MICMAC studies. Overall, the figure reveals a tightly interconnected structure in which a limited

set of cited works, influential authors, and recurrent concepts collectively shape the field's dominant research profile.

***Figure 8*: Three-Field Plot Linking Cited References (CR), Authors (AU), and Keywords (KW)**

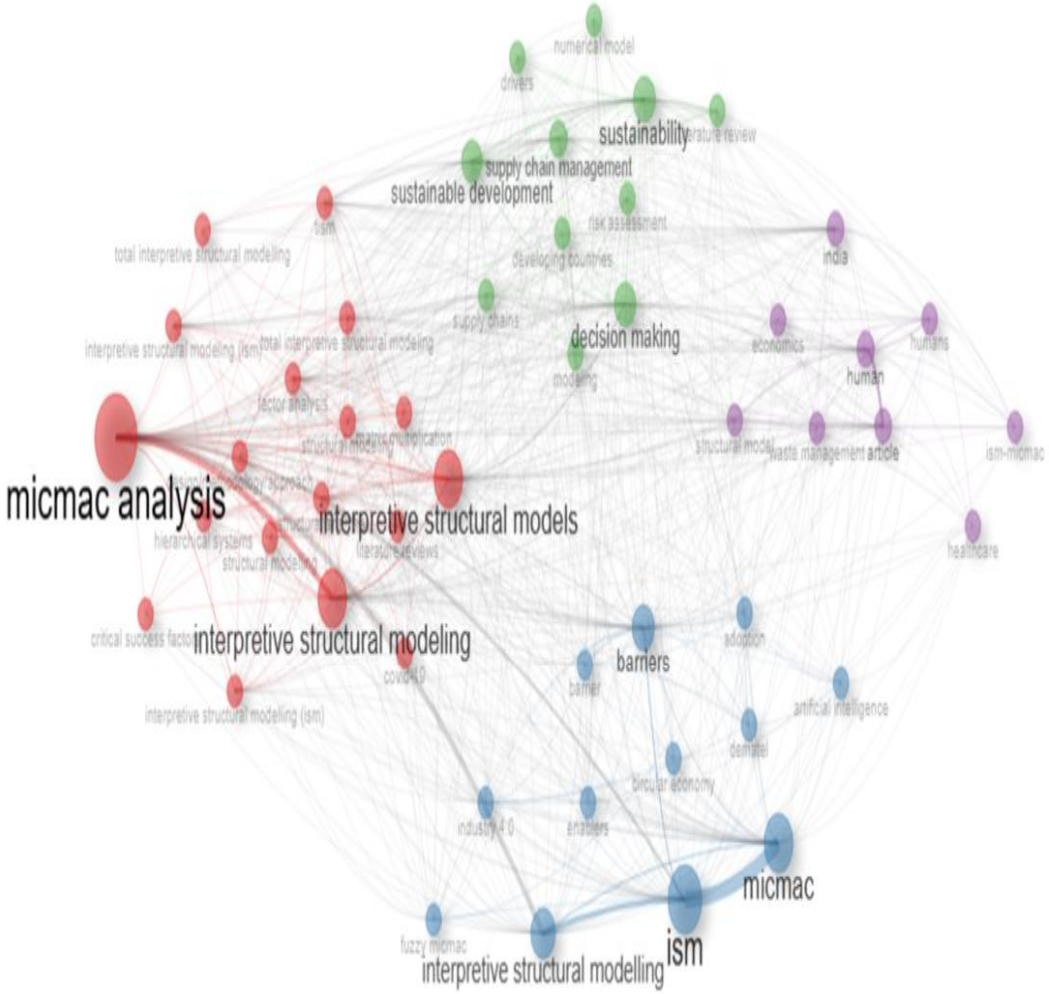


Source: Bibliometrix output

3.11. Co-occurrence network

Figure 9 presents the keyword co-occurrence network and reveals four major thematic clusters structuring the corpus. The first cluster, centred on "micmac analysis," groups the core methodological vocabulary of the field, including interpretive structural modeling, interpretive structural models, factor analysis, and critical success factors, highlighting the strong anchoring of MICMAC within the structural analysis tradition. A second cluster, organized around "ism" and "micmac," brings together applied methodological terms such as barriers, enablers, fuzzy MICMAC, Industry 4.0, circular economy, and DEMATEL, reflecting the field's applied orientation in barrier analysis and technology-related studies. The third cluster, led by "sustainability" and "decision making," captures the environmental and managerial application domain through links with supply chain management, sustainable development, and risk assessment. Finally, a more peripheral cluster connects contextual terms such as India, human, healthcare, and waste management, indicating specialized application settings. Overall, the network suggests that MICMAC research is conceptually dominated by structural, applied, and sustainability-related themes, while explicitly foresight-oriented concepts remain marginal.

Figure 9: Co-occurrence Network

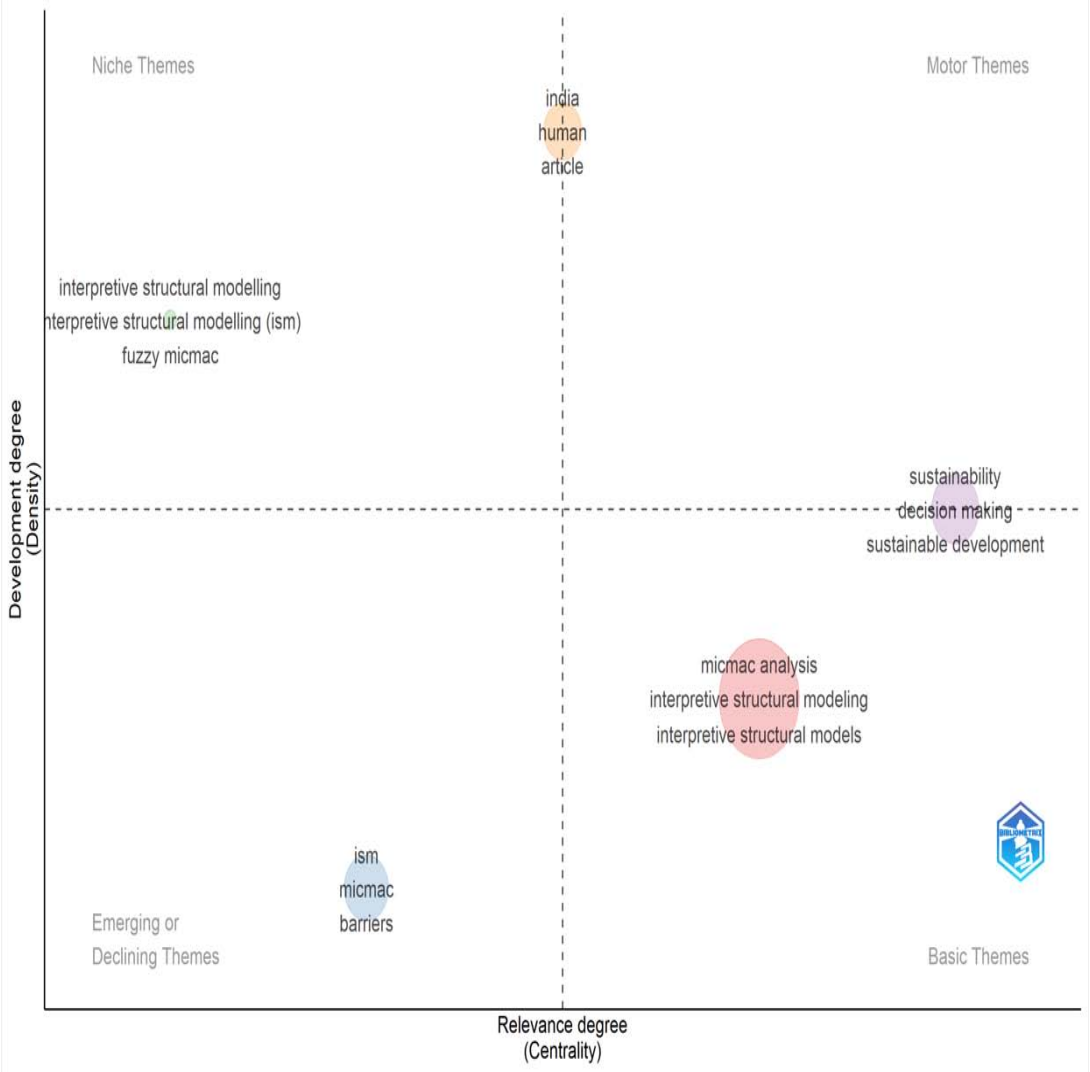


Source: Bibliometrix output

3.12. Thematic evolution

Figure 10 presents the thematic map of the corpus by positioning keyword clusters according to their centrality and density, thereby revealing their structural importance and degree of development within the field. The motor themes quadrant is dominated by sustainability, decision making, and sustainable development, indicating that these themes constitute the most developed and influential drivers of contemporary MICMAC research. In contrast, micmac analysis, interpretive structural modeling, and interpretive structural models appear as basic themes, reflecting their strong centrality to the field despite their relatively limited internal conceptual consolidation. The niche themes quadrant includes interpretive structural modelling, fuzzy MICMAC, and related ISM variants, suggesting the presence of coherent but still peripheral methodological specializations. Meanwhile, ism, micmac, and barriers are located within the emerging or declining themes quadrant, indicating comparatively low thematic development despite their frequent occurrence. Overall, the map suggests that sustainability-oriented and decision-support applications now occupy the conceptual core of the field, surpassing MICMAC's original prospective orientation in both relevance and maturity.

Figure 10: Thematic evolution



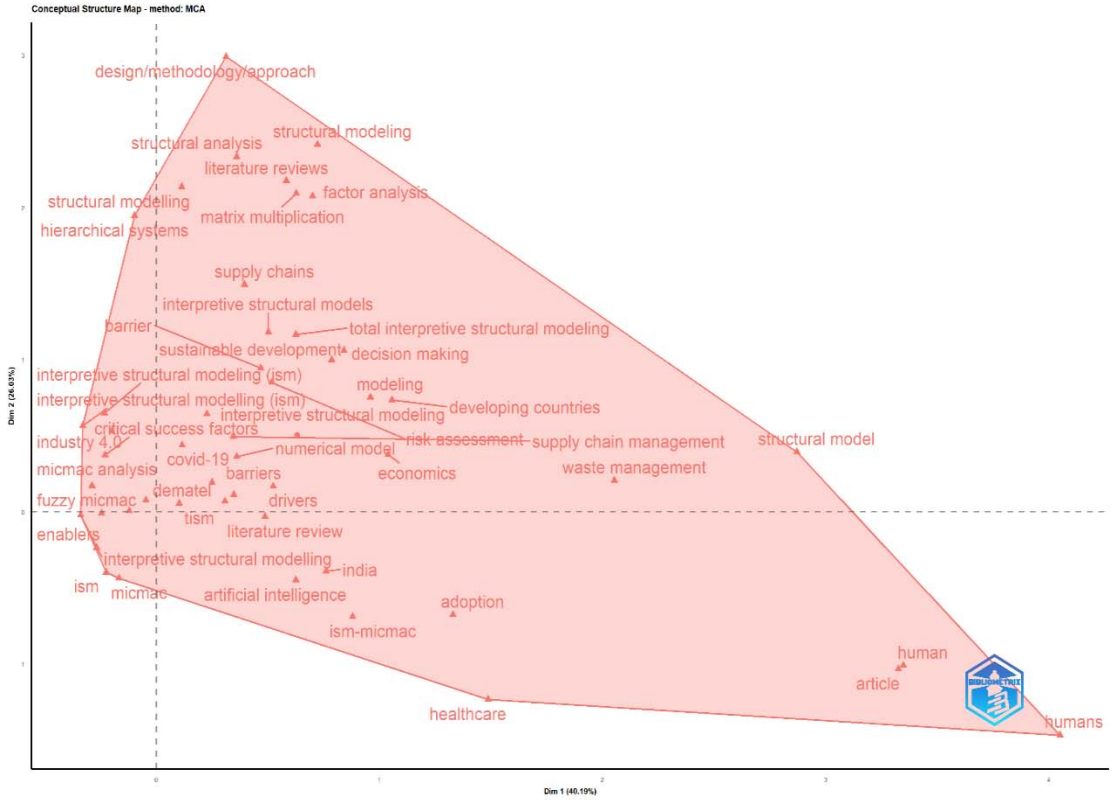
Source: Bibliometrix output

3.13. Conceptual structure – factoial approach

Figure 11 presents the conceptual structure map generated through Multiple Correspondence Analysis (MCA), which captures the field's conceptual architecture across two principal dimensions explaining 66.22% of the total variance. The first dimension reflects the main conceptual divide between a method-oriented core, characterized by terms such as micmac analysis, fuzzy MICMAC, ISM, DEMATEL, and Industry 4.0, and a more application-oriented periphery associated with supply chain management, waste management, and other domain-specific contexts. The second dimension distinguishes between a predominantly methodological and epistemological pole, represented by terms such as design/methodology/approach, structural analysis, and factor analysis, and a more empirical application pole including healthcare, artificial intelligence, adoption, and India. The overall distribution of keywords indicates that the conceptual space of the field is structured around two major tensions: methodology versus application, and theoretical reflection versus empirical implementation. In addition, the peripheral positioning of

terms such as human, humans, and article suggests that these function mainly as indexing artefacts rather than as substantive thematic contributors.

Figure 11: The Conceptual Structure Map



Source: Bibliometrix output

4. Discussion

The findings of this bibliometric analysis indicate that MICMAC research has undergone a marked transition from a relatively specialized methodological niche into a rapidly expanding and increasingly diversified field of application during the period 2016–2025. The sustained increase in annual scientific production, together with the strong temporal trend observed across the dataset, suggests that this development is not episodic but rather reflects a stable process of consolidation within the broader landscape of prospective and foresight-related research. In this sense, MICMAC can no longer be regarded as a marginal analytical technique; instead, it has emerged as an established methodological instrument with relevance across multiple disciplinary and applied domains.

A central outcome of the analysis is the clear transformation in MICMAC's practical identity. Although the method originated within the French school of la prospective and was initially designed to support structural analysis for scenario building and long-term strategic reflection, the current literature shows a much stronger orientation toward operational and application-driven uses. The conceptual and thematic analyses consistently position sustainability, decision making, barriers, supply chain management, and industrial transformation at the centre of the field. This indicates that MICMAC is now employed primarily for structuring complex variables, identifying key drivers and constraints, and supporting prioritization in decision contexts, rather than functioning mainly as an explicit foresight tool in the classical sense.

Another major finding concerns the predominance of hybrid methodological designs. The results show that MICMAC appears only rarely as a standalone technique, whereas integrated

combinations with ISM, AHP, DEMATEL, TISM, and fuzzy approaches account for the overwhelming majority of the corpus. This pattern reflects a broader methodological shift in which researchers increasingly seek composite analytical frameworks capable of addressing hierarchy, interdependence, causality, weighting, and uncertainty simultaneously. From this perspective, MICMAC's contemporary value lies less in isolated variable classification and more in its complementary role within broader decision-support architectures. The growing prevalence of such integrations also suggests that the method has adapted successfully to the demands of complex, multi-dimensional research problems.

The study also reveals a concentrated intellectual and geographic structure. Knowledge production is shaped by a relatively limited set of highly cited works, productive authors, and institutionally dense regional networks, while international collaboration remains present but uneven. The visibility of South Asian and other regionally clustered research communities indicates that MICMAC has been strongly appropriated within specific applied contexts, particularly those related to sustainability, industrial systems, and operations management. However, this concentration also points to an imbalance in the global diffusion of the method, suggesting that important opportunities remain for broader uptake in underrepresented regions facing complex policy, governance, and development challenges.

The conceptual structure of the field further confirms that MICMAC research is cumulative rather than fragmented. Across the keyword frequency analysis, co-occurrence network, thematic map, and MCA-based conceptual structure map, the field appears to be organized around a stable methodological core composed of MICMAC, ISM, and associated structural analysis terminology, surrounded by a more dynamic applied periphery. This periphery includes themes such as circular economy, healthcare, artificial intelligence, Industry 4.0, and waste management, which demonstrate the method's growing adaptability across new empirical contexts. At the same time, the limited presence of explicit foresight and prospective terminology in dominant thematic clusters suggests that MICMAC's practical expansion has progressed more rapidly than its conceptual reconnection to its original futures-oriented foundations.

The citation patterns also provide an important interpretive insight. Earlier publications show substantially higher citation averages than more recent ones, despite the accelerating growth in annual output. While this outcome is partly explained by citation lag, it also indicates that influence within the field remains concentrated around a relatively small set of foundational contributions. Such a pattern is characteristic of maturing research domains in which production expands quickly, thematic diversity increases, and participation broadens, while intellectual authority continues to rest on an established core literature.

5. Conclusion

This study provides the first dedicated bibliometric analysis of MICMAC research within prospective and foresight studies over the period 2016–2025 and offers a comprehensive picture of the field's intellectual, thematic, and methodological evolution. The findings demonstrate that MICMAC has moved beyond its original position as a specialized structural analysis tool within the French prospective tradition to become a widely used analytical approach across diverse disciplinary and applied contexts. The sustained growth in publication output, together with the expansion of subject areas and application domains, confirms that MICMAC now occupies an increasingly visible place in contemporary research on complex systems and strategic decision environments.

The study further shows that the field is characterized by a strong tendency toward methodological hybridization, with MICMAC most often integrated with complementary approaches such as ISM, AHP, DEMATEL, TISM, and fuzzy techniques rather than used as a standalone method. Conceptually, the literature is increasingly organized around themes such as sustainability, decision making, barrier analysis, supply chain management, and industrial

transformation, while explicitly foresight-oriented terminology remains comparatively limited. This indicates that the practical development of MICMAC has been driven more by operational and applied problem-solving needs than by its original futures-oriented foundations.

At the same time, the results reveal that MICMAC scholarship remains shaped by a relatively concentrated intellectual and geographic structure, with influential authors, highly cited studies, and active regional research networks playing a decisive role in defining the field's current profile. Overall, the study confirms that MICMAC has evolved into a mature, adaptable, and globally relevant analytical framework. Future research should therefore focus not only on extending its empirical applications, but also on strengthening its conceptual reconnection with scenario building, strategic foresight, and the broader logic of prospective inquiry.

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Data availibility

Data for this study are available upon request

Competing interest

Not applicable

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

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