Exploring Analytic Hierarchy Process (AHP) Applications in Banking: A Bibliometric Study

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Abstract

Background: A bibliometric analysis was conducted to investigate the prevalence of the Analytic Hierarchy Process (AHP) in academic studies, revealing it to be one of the most widely used methods in multi-criteria decision-making. The AHP structures complex decisions in a hierarchy, facilitating the evaluation of multiple criteria and alternatives. This approach is particularly valuable in situations where quantitative methods are not always applicable or sufficient. **Objectives:** The main aim of this study is to assess the extent of research development on this topic at global and national levels using various performance indicators. **Methods/Approach:** The WoS database was used to obtain the required data. The search revealed 286 research publications on "AHP and banking", of which 79 were analysed to illustrate the potential applications of AHP and hybrid methods**. Results:** The analysis provided a qualitative assessment of bibliometric indicators, highlighting existing trends and future research directions for the (r)evolution of academic progress. According to the selected fields of analysis, a gradual increase in the number of citations, published papers, and research on vertical and horizontal topics within the banking sector was observed. **Conclusions:** The main contribution of this paper is the identification of new research foci and the filling of unresolved gaps in the academic literature. The evidence suggests that the effectiveness of the AHP method has stimulated the development of related research. Future papers should further elaborate on the proposed research areas in collaboration with other disciplines to create a robust research programme and foster innovations.

Keywords: Analytic hierarchy process; banking; qualitative meta-analysis; systematic review; artificial intelligence, AI, AHP.

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Introduction

The Analytical Hierarchy Process (AHP) is a multi-criteria decision-making (MCDM) method that decomposes complex decisions into hierarchical sub-components, thereby facilitating decision-making in complex situations (Zyoud et al., 2017). This method, developed by Saaty in the 1970s, is known as the AHP and is used across various disciplines for its ability to combine quantitative and qualitative criteria (Mukherjee, 2014). The method allows pairwise comparisons of elements to obtain relative priorities, which is helpful in dynamic industries such as banking (Maulida et al., 2023). It is often combined with other methods, such as TOPSIS and fuzzy logic, to improve analytical capabilities and address uncertainty, effectively bridging emotional intuition with logical analysis (Saaty,1994). Despite its drawbacks – such as subjectivity and complexity when dealing with numerous criteria and alternatives – AHP's widespread application underscores its flexibility and usefulness. It integrates subjective evaluations and preferences into a structured format for mathematical analysis.

AHP has so far demonstrated acceptable results in management, strategic planning, operations research, economics, and finance, where it is used for investment valuation, credit risk assessment, and financial portfolio optimisation. This paper aims to provide a comprehensive overview of academic research on the application of the AHP, focusing on identifying and analysing key trends and classifying future research directions. The paper reviews the existing literature on AHP across three fields, identifies key authors and studies, and analyzes their contributions.

Based on the preliminary analysis, the authors have posed the following research questions:

- RQ1. What are the most influential sources, authors, and publications in research on MCDM at the global and national level, particularly in the context of banking?,
- RQ2. What are the most cited papers from the Artificial Intelligence&Machine Learning, Management, and Economics (AIME) fields and what is their contribution?,
- RQ3. What are the main research trends and foci related to AHP in recent publications?,
- RQ4. What research opportunities should be explored to improve the understanding of AHP further?

The authors contribute to the knowledge of AHP by: (1) describing the most influential and renowned authors, journals and papers by analysing the most cited papers to identify the most relevant contributions and authors; (2) highlighting the most relevant and significant research trends in the fields of AIME to demonstrate the utility of developing the AHP method in different disciplines; and (3) identify future research agendas by highlighting practical recommendations and proposing guidelines to improve the effectiveness and applicability of the AHP in different industries based on the literature review conducted. In contrast to previous papers that focus on identifying and integrating AHP methods, this paper identifies a conceptual gap in the AHP's applicability in the banking sector. The comparison of different studies reveals several research directions: the integration of the AHP with advanced technologies (Sipahi et al., 2010; Gottfried et al., 2018; Bai et al., 2019), the adaptation of MCDM to specific industries such as banking or healthcare (Seçme et al., 2009; Agarwal et al., 2018), and the advancement of hybrid models for financial risk management (Park et al., 2022; Castelló-Sirvent et al., 2022).

The paper contributes to the systematisation of the application of the AHP across different fields, identifies key trends and research directions, and fills academic gaps regarding the utility of the AHP in banking from an AIME perspective.

The paper is structured as follows. A comparative bibliographical overview follows the introduction. The second part presents the methods and the research framework used to present the research results. The third part reports on the results. The fourth part provides a discussion and recommendations on AHP applications, identifies gaps in the academic literature that have not yet been addressed, and highlights opportunities to publish high-impact papers that could shape future research agendas. The conclusions offer suggestions for future research directions that could advance scientific progress.

Research motivation: Overview of existing bibliometric research

Four scientific papers from different time periods were analysed as part of the literature search for the bibliometric analysis. A comparative review of the papers led to the following conclusions. All authors provide a comprehensive bibliometric analysis of AHP and related techniques across different contexts, including general applications, banking, and the combination of AHP with TOPSIS/fuzzy-AHP. The analyses are based on Scopus databases and use software tools such as VOSviewer to visualise the results. The identification of important research topics, trends, and the contributions of authors and institutions is common across all papers, whereas only Maulida et al. (2023) present research clusters. All studies recognise the broad applicability of these methods across sectors and contexts, but also acknowledge limitations in data sources and potential biases in the bibliometric approach. The general and substantive characteristics of the observed studies are listed in Table 1. The recommendations for future research in this field are summarised below.

The reviewed papers emphasise the need to extend the application of the AHP across different disciplines and to integrate it with other methods to enhance its analytical capabilities. This need is particularly emphasised by Zyoud et al. (2017) and Mukherjee (2014), and paves the way for interdisciplinarity and hybrid methods. Furthermore, the focus is on integrating AHP with new technologies such as artificial intelligence and big data, as also emphasised by Zyoud et al. (2017) and Mukherjee (2014). Maulida et al. (2023) also emphasise the need to develop methods that enable real-time application of AHP and highlight the importance of technological advancement and automation. Compared to Castelló-Sirvent et al. (2022), who suggest a more detailed investigation of the practical applications of fuzzy-AHP with a view to specific applications and sectoral focus, Maulida et al. (2023) emphasise the need for further research in specific areas of banking. Castelló-Sirvent et al. (2022) focus on developing advanced fuzzy models to address uncertainty, a topic less emphasized in other papers.

Similar to Castelló-Sirvent et al. (2022), this review provides an expanded global perspective on AHP studies and assesses unresolved gaps in the academic literature to identify new trends in the conceptual discourse on AHP. Although we agree with Marczewska et al. (2020) that systematic reviews should provide a detailed and objective insight into the best available knowledge within a given scientific field, this paper was not intended to produce a comprehensive review. We believe that such an approach is challenging to achieve or may be less effective. Given the extensive literature on AHP, we analysed patterns in existing research, with a focus on segmented fields, as suggested by Maulida et al. (2023). We intended to demonstrate the effectiveness of our research activities and assess the current state of knowledge on this topic by deepening existing findings and exploring future directions. We support Marczewska et al.'s (2020) assumption that the diversity of authors ensures balance in knowledge, citations, and sources.

Table 1
Comprehensive Analysis of Key Research Trends and Methodologies in Bibliographic Literature

Author(s)	Purpose and objectives	Methods and Methodology	Results	Limitations
Mukherjee (2014)	Provide a detailed bibliometric analysis of AHP/TOPSIS from its beginnings to the present, including the identification of future directions and new trends.	The primary scientific databases use software tools for mapping trends, contributions, and research hotspots based on 61 articles.	Detailed mapping of development and current status. Identification of key topics, influential articles, and important contributions.	Possible biases in data collection due to the selection of databases and the dynamic nature of research trends.
Zyoud et al. (2017)	A comprehensive overview of the application and development of AHP/TOPSIS techniques, publication trends, important research areas, and key contributions.	Bibliometric analysis with data from Scopus/WoS. VOSviewer for the mapping and visualisation of 2086 studies.	Identification of key research clusters and trends, number of publications, prominent authors, institutions, and countries contributing to research.	Dependence on data from specific databases that may not cover all relevant publications.
Castelló-Sirvent et al. (2022)	Review of the development/application of fuzzy AHP in the last 30 years, analysis of publication trends, primary research areas, and contributions.	Bibliometric analysis and VosViewer to visualise trends and important contributions.	Highlighted main research topics, influential authors, geographical distributions, and patterns of collaboration.	Limitations due to specific databases. Rapid field development, with a lack of the latest achievements.
Maulida et al. (2023)	Determine the scope of AHP research development in banking worldwide—mapping of research clusters, identification of trends and gaps.	Bibliometric analysis of 207 Scopus-indexed articles using VOSviewer for keyword and author mapping.	Identification of 6 main research clusters, trends in the number of publications, and key contributions by authors and institutions.	Limited to Scopus, with the option to overlook relevant research from other databases.

Source: Author's according to the Web of Science Core Collection database

However, we identified biases, as the objectivity of systematic reviews can be controversial due to the possibility of contradictory conclusions. Quantitative approaches provide clearer, more precise results and reduce the risk of interpretative bias, as documented in numerous academic studies. Therefore, we proposed a partial application of bibliometric analysis, focusing on specific research questions and analysing key trends, similar to Maulida et al. (2023). Following Marczewska et al. (2020), we omitted data visualisation techniques but allowed for more precise systematisation than in classical meta-analyses.

Methodology

Selection of the database and search terms

To answer the research question, all AHP studies were retrieved from WoS. According to Clarivate (2022) and To (2022), WoS has strict criteria for journal inclusion and is the authoritative bibliometric source for high-quality publications. Its core collection lacks sufficient new, less-established open-access journals in emerging disciplines and conference proceedings. Currently, the WoSCC comprises 21,100 journals across 254 disciplines, totaling about 74.8 million records, which is slightly fewer than Scopus.

To investigate the application of AHP and banking, the following search query was entered into the WoSCC database: ("Analytical Hierarchy Process" or AHP or "Analytical Hierarchical Process" or "Analytic Hierarchy Process (ahp)" or "Analytic Hierarchy Process" or "Analytic Hierarchy" or "Ahp Technique") and bank*. The asterisk was used as a wildcard to expand the search and capture all possible variants of the search terms (Zyoud et al., 2017). The search, conducted on 24 October 2023, yielded 697 papers. The term "AHP and banking" often refers to two distinct concepts, suggesting that papers have explored the application of AHP in different contexts, including banking. This research aimed to analyse the development trends of AHP and to identify future research areas and topics; therefore, the search was not limited in time.

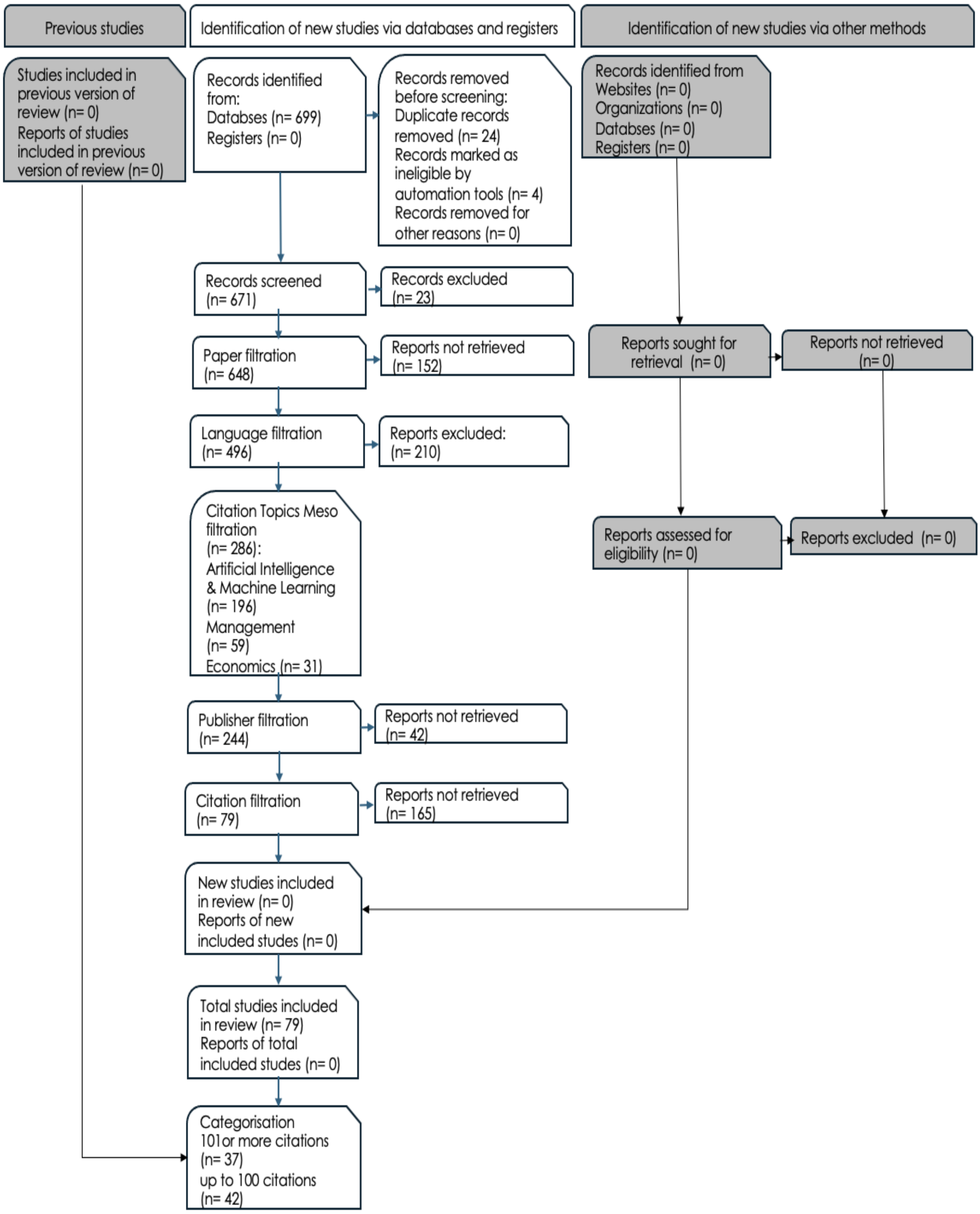
The data were cleaned to ensure the accuracy and reliability of the analysis. The data cleaning included removing duplicates, correcting inconsistencies, and handling missing values. To assess the reliability of the cleansing process, we calculated the correlation between the original and cleansed data sources. The resulting correlation coefficient of 0.96 indicates a high degree of consistency and suggests that the data integrity was maintained during the cleansing process. In the literature review, the authors mainly used two types of indicators for the bibliometric analysis: performance and/or science mapping. Performance analysis assesses the productivity and influence of researchers or institutions based on the number of publications and citations (Farrukh et al., 2020). Science mapping visualises information from the literature and shows the dynamics of research and the structure of the scientific field (Gao et al., 2021). In this study, the focus was on the total number of publications and citations, with the number of publications providing an insight into the volume of published papers and the number of citations reflecting the influence and popularity of journals and articles. The number of citations provides a quick assessment of a journal's influence in a particular field (Gao et al., 2021).

Web of Science offers a wide range of bibliometric analyses, including the total number of citations to an author's papers or journal articles, citations excluding self-citations, the h-index, and analyses of papers by language, year, document type, and authors (Mitrović, 2013). One of the most important bibliometric indicators of a journal's scientific value is the impact factor, which measures the average number of citations a paper receives in a given journal over a given period (Čuljak et al., 2019). The journals in the WoS database are evaluated using the Journal Citation Reports, from which data on each journal's impact factor are derived (Konjevod, 2020).

Research Process Design

The overall design of the research process is shown in Figure 1, following the PRISMA flow diagram.

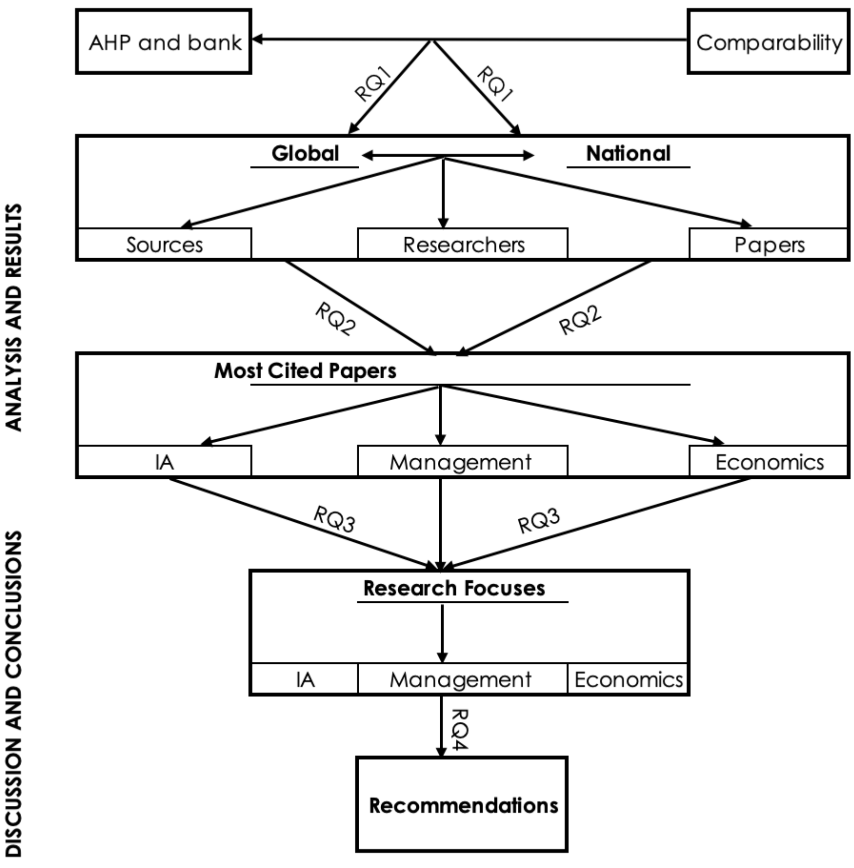
Figure 1
PRISMA 2020 Flow Diagram Template for Systematic Review Process Overview



Source: Author's illustration according to Page et al. (2021)

Of the 697 papers found in the WoSCC database with the selected keywords, 482 were journal articles, 5 were book chapters, 23 were early access papers, 153 were conference proceedings, and 8 were review papers. The majority of the papers, totalling 648, were written in English; the remaining papers were in Chinese and Czech (4 each), Russian (2), and one each in Portuguese and Spanish. Only English-language papers were selected for further analysis, reducing the total number to 496. Filtering by "Citation Topics Meso" and WoS categories reduced the number of papers to 286: 196 articles in the field of AI&ML (label 4.61), 59 in the field of Management (label 6.3), and 31 in the field of Economics (label 6.10). According to Clarivate, Citation Topics are algorithmically derived citation clusters based on a three-level hierarchical document-level classification developed by CWTS, Leiden. Macro and meso topics are manually labelled based on content, while micro topics are algorithmically labelled according to the most significant keyword. The citation topics are derived from citation relationships, not from the documents' content, so the labels are not always meaningful. Each topic has a fixed numerical prefix for precise identification. The remaining papers were not included in the analysis because they had already been covered by other studies, such as Zyoud et al. (2017), which emphasise the dominance of engineering research.

Figure 2
Detailed Conceptual Framework for Research Questions and Analysis



Source: Author's illustration.

Sixty-eight publishers published the research papers. Based on a selection criterion of at least two articles, 26 publishers with a total of 244 papers were selected. The papers were then filtered by citation count, resulting in the selection of 79 papers: 25 in AI & ML and Economics, and 29 in Management. According to Zyoud et al. (2017), the fields selected in this study are among the top 6 on the Top Twenty Prevalent Areas of Interest list. The distribution of papers across the WoS categories is nearly even, enabling more precise categorisation. The papers were then divided into two groups: 42 papers with fewer than 100 citations, representing the latest trends, and 37 papers with more than 100 citations, labelled as the most frequently cited papers. This approach makes it easier to understand the authors' common themes and approaches, as illustrated in Figure 1, which serves as the basis for the Conceptual Research Framework in Figure 2.

Operationalization of the dataset

When operationalising the data in the WoSCC database, the Leiden algorithm is used to identify datasets. The Leiden algorithm, developed by Traag et al. (2019), improves on the Louvain algorithm for detecting communities in networks and optimises modularity using the Constant Potts model. According to Newman (2004), Traag et al. (2019), and Anuar et al. (2021), the algorithm consists of three key phases: Modularity Optimisation, Partition Refinement, and Community Aggregation. The algorithm starts with modularity optimisation, similar to the Louvain algorithm, by moving nodes between communities to maximise modularity. Newman (2004) defines a community as a group of nodes c_i to which vertex i is assigned. The proportion of nodes within communities, i.e., those that connect vertices, is defined as:

$$\frac{\sum_{ij} A_{ij}\delta(c_i, c_j)}{\sum_{ij} A_{ij}} = \frac{1}{2m}\sum_{ij} A_{ij}\delta(c_i, c_j), \qquad (1)$$

Where the δ-function $\delta\,(u, v)$ is 1 if $u = v$ and 0 otherwise, and $m = \frac{1}{2}\sum_{ij} A_{ij}$ is the number of edges in the graph. If we preserve the degrees of vertices in network, but otherwise connect vertices together at random, then the probability that an edge exists between vertices i and j is $k_i k_j/2m$, where k_i is the degree of vertex i. Modularity Q measures the quality of the network's community structure. For a network $G = (V, E)$, where V is the set of nodes and E is the set of edges, modularity is defined as:

$$Q = \frac{1}{2m}\sum_{ij}\left[A_{ij} - \frac{k_i k_j}{2m}\right]\delta(c_i, c_j), \qquad (2)$$

where A_{ij} is the adjacency matrix, which is 1 if there is an edge between the nodes i i j, 0 otherwise; k_i and k_j are the degrees of nodes i j; m is the number of edges; c_i is the community of node i; $\delta(c_i, c_j)$ is the Kronecker delta function: 1 if both nodes i i j belong on the same community, zero otherwise. Anuar et al. (2021) find that higher modularity values indicate better communities, with modularity values always remaining below 1. When modularity is less than 1, each node represents an individual community. In the second phase, the Leiden algorithm refines the community partitions to ensure their internal connectivity, i.e., that each node can reach any other node within the same community by following only nodes within that community. This is achieved by redefining the communities based on node connectivity, which the Louvain algorithm does not address. In the final phase, the formed communities are treated as individual nodes in a new aggregated network, where the nodes represent the communities from the previous iteration and the edges between the nodes aggregate the weights of the edges between the communities. According to Traag et al. (2019), CPM optimises a function that considers community density with a constant degree of incentive as:

$$H = \sum_{c}\left[|E_c| - \gamma\frac{|E_c^{\max}|}{|V_c|}\right] \qquad (3)$$

where H Hamiltonian (system energy), c is the community, $|E_C|$ is the number of edges within community c, γ is the resolution parameter (which controls the size of communities), $|E_c^{max}|$ is the maximun number od possible edges within community c,

$|V_c|$ is the number of nodes within community c. Higher resolutions yield more communities. Lower resolutions yield fewer communities, as with the resolution parameter for modularity.

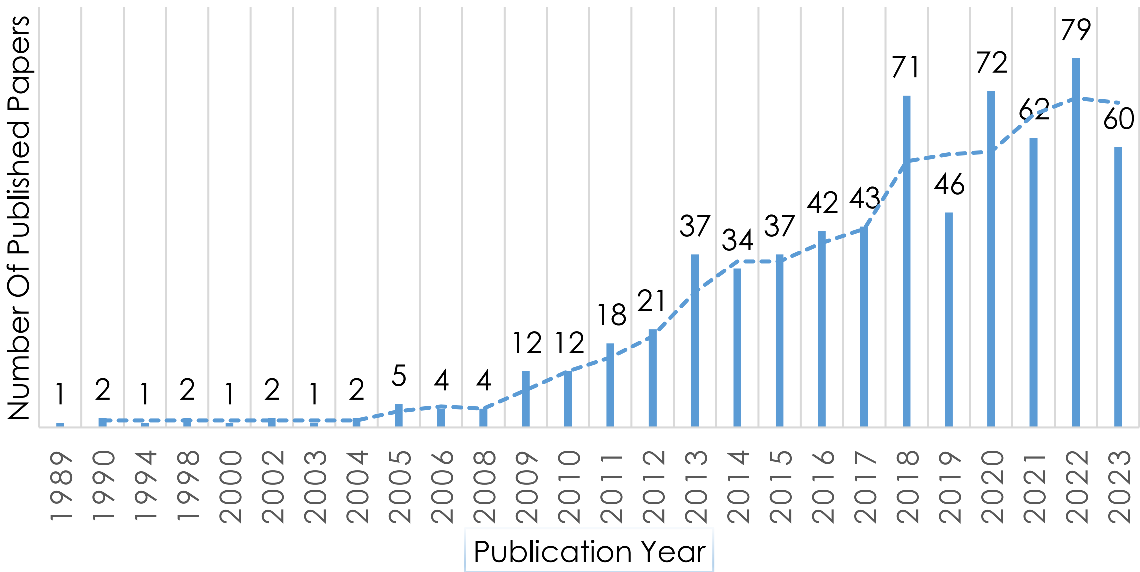
This process is repeated, improving modularity optimisation by refining the partition and aggregating communities, yielding more stable, higher-quality community detection than the Louvain algorithm.

Results

Descriptive analysis

The descriptive analysis identifies annual scientific production, the geographical distribution of scientific productivity, and the classification of publishers. Classification criteria include publisher size, specialisation, access to publications, and affiliation with professional and academic institutions. The following categories of publishers were identified: (1) large commercial publishers, (2) open access publishers, (3) professional and technical organisations, (4) university and academic publishers, and (5) small specialised publishers.

Figure 4.
Yearly Trends in Scientific Publications



Source: Author's illustration according to WoSCC

According to Figure 4, the oldest paper included in the study was published in 1989, titled "Using the Analytic Hierarchy Process for Bank Management: Analysis of Consumer Bank Selection Decision," by Javalgi et al., and thus significantly later than Saaty (1976). According to the authors (1989), bank decision-makers use the AHP to integrate customer preferences into the service offering and thus determine the bank's relative market position. An empirical analysis in an urban area demonstrated the suitability of the AHP for management decision-making, strategic planning, and the marketing mix.

The papers were published continuously, with the number of publications increasing sharply after 2012, which can be linked to the stabilisation following the global financial crisis. Until 2009, no more than five papers were published annually; by 2012, this number increased to 20, and over 86% of research papers were published after 2012. Most papers were published in 2022, with 79, while 60 were published by October 2023. In terms of the number of published articles, Turkey is the most prolific country, with 45, followed by Taiwan (39) and India (34). Other countries with more than 10 articles are Iran (34), China (29), the USA (21), Vietnam (16), Spain (11), and the UK (10), in contrast to Zyoud et al. (2017). English is still the universal language of science, but Chinese has gained importance, particularly in the last decade. Croatia is also represented on the list with five contributions. Large commercial publishers, such as Elsevier and Springer Nature, dominate, accounting for 154 articles. Open access publishers such as *MDPI* are also strongly represented, with 21 papers. Professional and technical organisations, such as IEEE, have published 10 papers, while university and academic publishers, such as the Croatian Operational Research Society, have published fewer. Smaller and specialised publishers contributed 26 papers. According to Zyoud et al. (2017), Iran and Turkey are globally influential in the field of decision sciences, including information systems, operations research, and statistics. The analysis of leading journals that have contributed to the development of AHP yields results similar to those of Zyoud et al. (2017).

Overview of the most cited papers

Table 2 lists papers from the WoS database with more than 100 citations, whose importance was confirmed by the impact factors of the journals in which they were published, in the fields of AI and ML, and Management. The most cited paper, Sipahi et al. (2010), published in the journal *Management Decision* (IF 5,589), has 313 citations, which emphasises its significant impact on the field. This study examines more than 600 related papers from 2005 to 2009, of which 232 were selected for further analysis. The study highlights the widespread use of the AHP across environmental management, agriculture, energy, transport, construction, and healthcare, with notable applications in logistics, finance, marketing, management, and the military.

Papers published in the journal *Expert Systems with Applications* (IF 8,665) rank second, third, and fourth in terms of citations (244,199,191), reflecting the current research trends and the field's importance. Wu et al. (2009) introduce a fuzzy-MCDM model for evaluating bank performance that combines BSC-fuzzy-AHP with SAW, TOPSIS, and VIKOR methods. Seçme et al. (2009) employ the FMCDM model with FAHP-TOPSIS to evaluate bank performance and emphasise the importance of financial and non-financial indicators. Park et al. (2002) developed a k-NN algorithm, extended with the AHP method, to refine classification in corporate contexts. Peng et al. (2011) design a fusion approach for a weighted MCDM ranking of algorithms, while Huang et al. (2004) use the Delphi method-AHP to identify and prioritise key risks in ERP projects. Akkaya et al. (2015) use fuzzy AHP and MOORA to rank sectors, identifying technology, software/IT, and finance as the most favourable. Ginevičius (2011) introduces the Factor Relationship to improve the determination of criterion weights in multi-criteria methods. Kim et al. (2009) created a CRM scorecard that integrates AHP to prioritise CRM practices in a Korean bank with a sophisticated CRM strategy.

Croatian research in AHP

Among the researched papers, notable articles by authors published in journals of Croatian publishers are systematised in Table 2. Primorac et al. (2021) investigate the application of AHP to decision-making in operational risk management at banks and emphasise the importance of evaluating alternatives and decision criteria. Ristanović et al. (2023) extend AHP with fuzzy AHP to account for uncertainty and complexity in decision-making. The results of both studies emphasise that external factors are crucial, especially in times of crisis, and recommend the use of international standards and internal control tools for effective risk management. Kadoić et al. (2021) use MCDM-AHP to rank the best public hospitals in Croatia, evaluating hospital quality based on 20 criteria.

Articles in the *Croatian journal Operational Research Review* document the application of AHP and the Technology Acceptance Model to evaluate business planning software tools and the cost-effectiveness of ATMs, providing helpful guidance for educational institutions. Hell et al. (2013) analyze the functionality of business planning software tools and offer recommendations for educational institutions based on student evaluations. Županović et al. (2015) explore the cost efficiency of automated deposit services at ATMs. They use TAM-AHP to analyse user attitudes and determine priority locations, and provide guidelines for optimising costs and benefits.

Table 2
Comprehensive overview of most cited papers, publications from Croatia, and the latest research trends

Publisher	Most Cited Papers	Papers Published in Croatia	Most Recent Papers
1	Park et al. (2002) $^{8,665}_{199}$ Huang et al. (2004) $^{4,80}_{157}$ Wu et al. (2009) $^{8,665}_{244}$ Seçme et al. (2009) $^{8,66}_{191}$ Kim et al. (2009) $^{8,890}_{101}$ Sipahi et al. (2010) $^{5,58}_{313}$ Peng et al. (2011) $^{8,673}_{163}$ Ginevičius (2011) $^{8,673}_{106}$ Akkaya et al. (2015) $^{8,6}_{11}$		Roy et al. (2023) $^{1,634}_{19}$ Kaur et al. (2023) $^{0,588}_{6}$ Sharaf et al. (2023) $^{3,732}_{4}$ Wang et al. (2023) $^{4,578}_{4}$ Paltayian et al. (2023) $^{0,587}_{2}$ Jegerson et al. (2023) $^{2,915}_{2}$ Çalik et al. (2023) $^{2,019}_{1}$ Bhuvaneskumar et al. (2023) $^{0,89}_{1}$ Kamvysi et al. (2023) $^{10,972}_{0}$
2		Kadoić et al. (2021) $^{4,614}_{3}$	Opreana et al. (2023) $^{2,592}_{2}$ Liang et al. (2023) $^{4,518}_{0}$
3			Nguyen (2023) $^{3,860}_{0}$
4		Akkaya et al. (2014) $^{8,665}_{110}$ Županović et al. (2015) $^{0,9}_{0}$ Primorac et al. (2021) $^{0,86}_{7}$ Ristanović et al. (2023) $^{n/}_{0}$	Akdemir et al. (2023) $^{n/a}_{0}$

Note: 1 Large commercial publishers; 2 Open access and specialist publishers; 3 Professional and technical organisations; 4 University and academic publishers; 5 Smaller, specialist and regional publishers. Within specific categories and years, the published papers are shown as $\text{Author(s)}\,^{\text{IF}}_{\text{NoC}}$, where IF stands for the Impact factor and NoC for the Number of Citations.
Source: Author is according to WoSCC.

Key influential papers in the field of AI&ML

This area of analysis includes papers with fewer than 100 citations, as shown in Table 3. Yurdakul et al. (2004) developed a model for bank credit assessment that evaluates the credibility of manufacturing firms based on long-term profitability, using AHP to determine creditworthiness accurately. One year later, the same authors (2005) developed a manufacturing performance measurement model using AHP for criteria weighting and TOPSIS for ranking.

Table 3
In-Depth Analysis of Most Cited Papers in AI&ML

1						2	4
Elsevier	**Taylor**	**Wiley**	**Springer**	**Emerald**	**DeGruyter**		
Artificial Intelligence & Machine Learning							
Yurdakul et al. (2004)							
	Yurdakul et al. (2005)						
Ishizaka et. al. (2013)							
García et al. (2014) Mandic et al. (2014)							Celen et al. (2014)
Gottfried et al. (2018)							
Bai et al. (2019)							

Note: 1 Large commercial publishers; 2 Open access and specialist publishers; 3 Professional and technical organisations; 4 University and academic publishers; 5 Smaller, specialist and regional publishers. Source: Authors' work according to WoSCC.

Çelen (2014) evaluates the impact of normalisation procedures on the results of the MADM method using FAHP weights and TOPSIS to assess the financial performance of Turkish deposit banks. Similarly, Mandic et al. (2014) propose a fuzzy multi-criteria model to evaluate the financial performance of banks in Serbia, using FAHP to determine criterion prioritisation and TOPSIS to rank banks. Ishizaka et al. (2013) apply FHAP to manage valuation uncertainty and illustrate the selection of current accounts for students. Gottfried et al. (2018) investigate biogas as a factor for reducing emissions in the Chinese sector and achieving climate targets by analysing the criteria for private investment using SWOT-AHP-TOWS analysis, identifying priorities for banks (interest rates), insurance companies, and pension funds (equity investments), and developing strategies to encourage. García et al. (2014) address agribusiness site selection using AHP to evaluate the optimal location for new agri-food warehouses, while Bai et al. (2019) assess the credit risk of farmers using fuzzy-rough set theory and C-means clustering, achieving a prediction accuracy of 81.16%.

Key influential papers in the field of management

Table 4 presents the most influential papers in management. Rebai et al. (2016) developed a model to evaluate bank performance based on sustainability and demonstrated its effectiveness using three French banks. Raut et al. (2017) introduced the BSC-FAHP-TOPSIS framework to assess sustainability in Indian banks and emphasised the need to understand CSR. Lin (2013) emphasised customer service as a critical factor in evaluating mobile banking. Tu et al. (2020) examined the development of the green bond market in Vietnam to finance environmental projects. They found that an adequate legal framework and monetary policy measures are crucial for supporting low-carbon initiatives.

Table 4
In-Depth Analysis of Most Cited Papers in AI&ML, Management, and Economics

1						2	4
Elsevier	**Taylor**	**Wiley**	**Springer**	**Emerald**	**DeGruyter**		
			Management				
				Awan et al. (2011)			
				Garg et al. (2013)			
Lin (2013)		Calabrese et al. (2013)					
			Zeidan et al. (2015)				
Rebai et al. (2016)							
		Raut et al. (2017)					
Agarwal et al. (2018)							
Acuña-Carvajal et al. (2019)							
Tu et al. (2020)							
			Chien et al. (2022)				

Note: 1 Large commercial publishers; 2 Open access and specialist publishers; 3 Professional and technical organisations; 4 University and academic publishers; 5 Smaller, specialist and regional publishers. Source: Authors' work according to WoSCC.

Chien et al. (2022) used FAHP-FTOPSIS to identify challenges in implementing green activities and to recommend further research methods to overcome policy barriers. Zeidan et al. (2015) introduce a sustainability-oriented credit scoring system to enhance profitability in Brazil's agricultural sector. Calabrese et al. (2013) suggest the model to improve competitiveness in banking and understand cultural change and commitment to CSR. Muhammad Awan et al. (2011) employ a modified SERVQUAL scale to assess service quality and satisfaction in Pakistani banks and identify five key dimensions. Garg et al. (2012) recommend using the ANP to examine critical success factors in customer banking organisations. Agarwal et al. (2018) investigate perceptions of innovation in the Indian healthcare sector using Voice of Customer-AHP methods, identifying critical customer factors and opportunities for entrepreneurship. Acuña-Carvajal et al. (2019) craft a strategic planning model for a Colombian bank using fuzzy logic.

Key influential papers in the field of economics

Table 5 presents the most influential papers in the field of economics. Wanke et al. (2016) employed a three-stage approach based on the CAMELS system to evaluate ASEAN banks. Fuzzy-AHP-TOPSIS and neural networks were integrated, focusing on capital, asset quality, management, earnings, liquidity, market risk, and Islamic finance principles to achieve greater efficiency. Shahzad Bukhari et al. (2013) studied corporate governance in Pakistani Islamic banking. They used AHP to emphasise the importance of the Board of Directors and the Shari'ah supervisory board for audit and transparency. Azadeh et al. (2011) combined AHP and DEA to optimise employee productivity in a private bank. AHP was used to convert qualitative employee performance indicators into quantitative indicators, while DEA was used to rank organisational efficiency.

Table 4
In-depth analysis of most cited papers in economics

		1				2	4
Elsevier	**Taylor**	**Wiley**	**Springer**	**Emerald**	**DeGruyter**		
			Economics				
			Azedah et al. (2003) Dinc et al. (2003)				
Azadeh et al. (2011)							Mahdiloo et al.(2011)
			Jablonsky (2012)				
				Shahzad Bukhari et al. (2013)			
Wanke et al. (2016)							
	Cvetovska et al. (2017)		Jatoth et al. (2017)				
					Pop et al. (2018)		
						Alidrisi et al. (2019)	

Note: 1 Large commercial publishers; 2 Open access and specialist publishers; 3 Professional and technical organisations; 4 University and academic publishers; 5 Smaller, specialist and regional publishers. Source: Authors' work according to WoSCC.

Pop et al. (2018) analysed non-performing loans in Romanian banks using the GMM and introduced new qualitative variables, including risk management metrics and the Aggregate Priority Vector. Cvetkoska et al. (2017) evaluated the efficiency of Komercijalna Banka AD Skopje branches using DEA window analysis validated by the AHP-DEA model. Jablonsky (2012) devised a ranking model for efficient units in DEA models applied to Czech banks using AHP target programming. Jatoth et al. (2017) presented data envelopment analysis methods for evaluating the performance of cloud services in light of user preferences. Dinc et al. (2003) utilised DEA and input-output analysis to investigate the efficiency of the regional sector. They proposed a decision-making framework that combines quantitative tools with qualitative factors through AHP. Alidrisi et al. (2019) applied DEA models to assess the efficiency of petrochemical companies in Saudi Arabia and integrated them with AHP-MDS methods to validate the results. Building on a previous paper, Mahdiloo et al. (2011) used DEA to measure customer value in an Iranian manufacturing company. They ranked it by profitability using the BCC, Assurance Region, and Cross-Efficiency Evaluation models.

Discussion

Reflections and paths into the future for AI&ML

Four categories of MCDM-AI applications were identified: finance, risk management, service personalisation, and specific industries. These categories are linked by methodological frameworks, interdisciplinary approaches, and the integration of advanced technologies, enabling broad application across different contexts. Each category provides directions for future research to improve existing methods and their practical application.

The first category focuses on the synergy between MCDM and AI in financial decision-making. The cohesion of these methods is crucial for optimising processes such as bank selection, financial performance evaluation, and risk management in financial institutions, as outlined by Aydogmus et al. (2023), Akdemir et al. (2023), and Opreana et al. (2023). Future development should focus on models that combine MCDM and AI to dynamically adapt financial strategies to changing market conditions. Such models would use real-time data to continuously adjust weighting criteria, thereby enabling better decision-making in the financial sector. At the same time, the automation of decision-making processes through AI and the development of machine-learning-based systems for analysing large datasets and predicting market trends in real time represent future research directions. The application of AI in the creation of personalised investment portfolios would use MCDM to optimise resource allocation across risk, return, and liquidity.

Operational risk management is becoming increasingly complex due to global uncertainties (cyber threats, economic crises, regulatory changes), which emphasises the importance of AI in this context. AI plays an important role in identifying, analysing, and managing risks, as emphasised by Ristanovic et al. (2023) and Pekkaya et al. (2023), especially when combined with MCDM methods for risk assessment in the banking sector. Future research should focus on developing AI systems for risk prediction and anticipatory risk management using historical data and machine learning techniques. Further potential lies in the synergy between AI and blockchain technology in operational risk management, data security, and transparency. In addition, research should be conducted into how AI-MCDM can optimise credit risk assessment processes and enable users to achieve more accurate assessments.

With the growing demand for personalised financial services, AI is becoming increasingly important for analysing large amounts of customer data and for customising services to specific customer needs, as discussed by Kamvysi et al. (2023), Roy et al. (2023a), and Sharaf et al. (2023). The studies show the potential for the further development of AI systems that offer personalised financial advice. New research could focus on developing AI models that analyse customer data using the MCDM method to provide targeted financial advice, as well as on systems for the automatic management of personal finances in real time. In addition, AI systems capable of predicting financial behaviour could further personalise financial services, increasing their relevance and efficiency.

The final category encompasses the application of MCDM methods across industries outside the financial sector, including logistics, energy, and social capital valuation. The fusion of methods enables decision-making tailored to the specifics of each industry, as shown by Liang et al. (2023), Çalik et al. (2023), and Sharaf et al. (2023). Future research should aim to adapt MCDM methods to improve performance in logistics, especially in global supply chains, and to harmonise economic, social, and environmental criteria for sustainability assessment of energy projects. In addition, special attention could be given to applying MCDM to assess social capital in SMEs, with a focus on quantifying social networks, reputation, and other intangible resources.

Reflections and paths into the future for management

The analysis of the collected contributions has highlighted four categories in the digital age. Each category provides an insight into current challenges and guidelines for future research.

The first category addresses the challenges and opportunities related to digital transformation, digital readiness assessment, technology adoption, and change management among users and employees. Jegerson et al. (2023) examine factors influencing the adoption of digital mobile payments, while Anggrain et al. (2022) and Okfalisa et al. (2021) assess SMEs' readiness for digital transformation through intelligent decision-support systems. Paltayian et al. (2023) developed a decision-making framework for e-banking by combining QFD and AHP to improve service quality. Future research directions should include analysing the impact of working arrangements, such as remote work, on organisations' digital readiness and hybrid working models. It is crucial to recognise the role of AI in automating processes, while accounting for ethical considerations and the impact on employment. Key considerations include how AI can increase efficiency and reduce costs, and how employees' digital literacy impacts the success of digitalisation initiatives, with a focus on education and support for the effective use of digital technologies.

The second category structures studies on integrating sustainable practices and social responsibility into management strategies to improve organisations' competitiveness and reputation, with a focus on innovation and user experience as key components of sustainable management. Bhuvaneskumar et al. (2023) evaluate the performance of socially responsible companies using the FAHP-TOPSIS-Altman Z-score to assess financial stability and sustainability. Chien et al. (2022) investigate the barriers to green innovation in SMEs, while Ngo et al. (2022) examine the innovativeness of banks under uncertain conditions and emphasise the importance of innovation for sustainable management. New research could explore the principles of the circular economy to improve sustainability and social responsibility, as well as innovative business models that reduce waste and increase resource efficiency. Particular attention should be paid to analysing the impact of ESG standards on long-term stability and competitiveness in the global market, as well as the role of social media in promoting sustainable practices and increasing corporate transparency, thereby improving organisations' image and social responsibility.

The third category brings together research on the impact of HR strategies on organisational effectiveness, particularly in MNCs and across different cultural contexts. Studies examine the adaptation of HR strategies to different cultural and economic environments to improve organisational effectiveness (Jha et al., 2022). Agrawal et al. (2022) apply the AHP-TOPSIS-DEMATEL approach to evaluate the success of e-services in the digitalisation of organisations. Albugami (2022) describes the impact of HRM on customer loyalty towards banking technologies, emphasising the importance of employee satisfaction and engagement. Future research directions should explore the role of emotional intelligence in managing workforce diversity and promoting inclusivity, the impact of HR analytics on real-time decision-making, and the relationship between flexible benefits and employee retention.

The fourth category includes research on innovation, digitalisation, and security in the financial sector, covering the optimisation of digital channels and the use of new technologies (e.g., FinTech solutions). Rezaei et al. (2022) use data mining to improve the omnichannel customer experience in banking. Wang (2023) compares verification techniques in FinTech using an extended technology acceptance model/fuzzy-AHP, with a focus on security and user trust. Nguyen (2023) develops an integrated e-wallet selection model tailored to the needs of users of digital financial services. Roy et al. (2023b) explore the MCDM model for the evaluation of m-banking applications to help digital banks better optimize services to users' needs, while Zhu et al. (2022) present a framework for measuring user experience in Chinese mobile banking applications and emphasize the importance of integrating UX into the development of FinTech technologies. Future academic studies should include analyses of blockchain technology applications to improve the security of financial transactions, research on user perceptions of the security of FinTech applications, and the development of advanced predictive models for risk management in digital banking.

Reflections and paths into the future for economics

Research in economics and finance is divided into several categories, each with specific topics, methods, and objectives, but with clear links that contribute to a broader understanding of financial systems and economic development. The common goal of these categories is to optimise financial processes and support economic growth.

The first category harmonises papers that use advanced analytical methods to improve the financial efficiency and stability of banks and optimise financial models. Anjum et al. (2021) investigate the impact of different volatility models on VaR estimates in the banking sector. Babacan et al. (2020) combine the AHP and DEA to analyse bank efficiency, providing deep insights into key performance areas. Kumar et al. (2020) apply AHP to assess the financial performance of commercial banks, which is directly related to Mârza et al. (2021), who use AHP-fuzzy methods to assess the degree of financial and digital inclusion. Arman et al. (2021) and Shakouri et al. (2020) also use DEA to analyse efficiency in the financial sector, focusing on model optimisation and evaluation of the banking sector. Varga et al. (2020) apply the CAMEL-Similarity Analysis to evaluate the performance of Islamic banks, while Krematzis et al. (2022) develop a framework for ranking banks using interval and cross-efficiency in the DEA system. Andrade et al. (2020) use MCDM to analyse the performance of television programmes, and Milovic et al. (2021) analyse the impact of macroeconomic stability on global competitiveness. Future research should focus on developing new hybrid models by combining different MCDM methods with advanced statistical techniques to increase the accuracy and reliability of financial efficiency assessments, integrating AI-MCDM to automate and improve decision-making processes within financial institutions, and incorporating external macroeconomic factors.

The second category examines the relationships between economic reforms, financial development, and urbanisation, and how these factors improve the business environment and economic growth. The papers highlight the importance of systematic reforms and strategic plans to adapt to economic change and optimise the business environment and urban development. They also show how financial development and urbanisation can synergistically promote economic growth. Ekel et al. (2022) examine the costs of the business environment and offer guidelines for economic reforms that improve it and stimulate economic growth. Han et al. (2020) identify the synergy between financial development and new forms of urbanisation and show how this link can serve as a lever for economic growth. Future studies should consider the long-term impact of economic reforms on the business environment and competitiveness in the context of global economic conditions. There is a need to analyse the impact of urban development and sustainable development strategies on improving the business environment, with a focus on climate change adaptation and environmental protection. The analysis of the impact of digitalisation and technological innovation on improving the business environment, with particular attention to emerging countries and the integration of new technologies, is also crucial.

The third category of research focuses on financing SMEs and improving their access to financial resources. The papers emphasise the need for specialised financial models and strategies that provide SMEs with better access to finance, a crucial factor for their growth and sustainability. Furthermore, the importance of precise financial models and strategic financial decisions that support the development of these companies is emphasised. Liao et al. (2022) investigate the optimisation of SME financing using dynamic system models, analyse differences between theoretical and actual loan amounts, and propose solutions to optimise financing. Kaur et al. (2023) use fuzzy AHP to investigate the bank selection criteria for SMEs and identify key factors for accessing financial resources. Mehta et al. (2022) methodically address the exit strategies of venture capital firms, with a particular focus on financial decisions and strategies that affect SMEs. The development and implementation of FinTech solutions that facilitate access to finance for SMEs, including crowdfunding, peer-to-peer lending, and blockchain technologies, represent an important direction for future studies. There is a need to consider the impact of various government measures (subsidies, tax incentives, credit programmes) on SME financing, with a focus on their long-term effectiveness. Special attention should be paid to developing sector-specific financial models that account for the challenges and opportunities of SMEs.

A Comparative Study of Disciplinary Approaches

AI&ML focuses on developing advanced algorithms and applying artificial intelligence to business processes. This technology offers high precision and the potential for automation, but challenges include algorithmic biases and ethical dilemmas that require high technological readiness and careful data management. The combination of MCDM-AI leads to more accurate decisions under conditions of uncertainty, which are crucial for the financial sector by reducing the time needed for option evaluation and tailoring financial products to users. However, integrating AI-MCDM can be challenging for smaller financial institutions due to the high cost and the need for specialised skills. Automation and personalisation enabled by AI raise privacy and security concerns. Although AI enables risk prediction and loss mitigation, integration with blockchain technology further increases data security. Implementing AI systems is complex and requires significant investment, with success dependent on the quality of the available data. Adapting MCDM to industries increases their value but requires a deep understanding of the sector's needs and significant investment in R&D. Research could therefore be extended to sectors such as healthcare and smart cities, where personalisation and big data analysis could be important drivers of change.

Management addresses the broader context of organisational change, HRM, and sustainable business practices. Benefits include broad applicability across organisations and a holistic approach to adapting to technological innovation, while challenges include slower adaptation to technological change. Digital transformation is becoming increasingly critical as the economy becomes increasingly digital, requiring research focused on the impact of technology on organisational structures and change management. Rapid technological development can render research obsolete, while integrating technological platforms increases complexity and costs. Global challenges such as climate change highlight the importance of sustainability, while research on ESG standards can help organisations compete; however, measuring actual impact remains challenging, and differences in CSR practices further complicate the development of universal models. Human resource management is critical to a company's efficiency, and research on HRM has shown that personalised approaches increase employee engagement. Future research could focus on developing hybrid models that combine digital tools with human resources to increase employee productivity and engagement. Using AI technologies to adapt and personalise people management approaches could be key to improving work efficiency.

Economics focuses on financial institutions and the business environment through economic reform, particularly macroeconomic policy and economic growth. The benefits of this field include improving the business environment and supporting economic growth, while political instability and the complexity of long-term planning are unavoidable obstacles. The first category provides an analysis of financial institutions using MCDM, thereby increasing valuation accuracy and, in combination with AI and ML, further enhancing analytical capabilities and precision. Methods such as AHP-DEA-CAMEL require a high level of expertise, and modelling bias can occur if the data are misused. The second category of research can significantly impact political and economic strategies by improving the business environment at a broad scale through the synergy between financial development and urbanisation, thereby promoting sustainable growth. However, the impact of reforms and urbanisation often becomes visible only after a longer period, making it difficult to assess success. The focus on SME financing can stimulate economic growth, but it also increases the risk for investors due to high default rates and sector-specific needs, leading to financing inequalities.

Critical analysis of the application of the AHP in dynamic systems

The application of the Analytic Hierarchy Process shows considerable potential for multi-criteria decision-making but also has severe limitations that call into question its effectiveness and relevance, especially in dynamic and complex sectors such as banking, textiles, IT, education, and finance. AHP provides a structured framework for analysing and decision-making based on the hierarchical structuring of criteria and alternatives, but specific challenges often constrain its practical application.

The Analytic Hierarchy Process plays an important role in improving decision-making and business processes in banking through various applications. For example, it enables precise assessment of SMEs' and other borrowers' creditworthiness, thereby ensuring more accurate lending decisions. Roy and Shaw (2023b) have developed an AHP-TOPSIS model for this purpose, thereby increasing the reliability of credit scoring. In addition, the method is used to evaluate banks' overall performance by integrating financial and non-financial indicators. Seçme et al. (2009) applied a combination of AHP and Fuzzy TOPSIS to analyse the performance of banks in the Turkish financial sector. In the area of risk management, Primorac et al. (2021) developed a multicriteria decision-making model to optimise operational risk decisions in banking. In the context of sustainability, the method was used to support initiatives such as green projects and low-emission investments. Raut et al (2017) integrated the Balanced Scorecard with AHP to assess the sustainability of banks. It also helps banks to prioritise strategic initiatives and strengthen competitiveness, as Agarwal et al. (2018) show in their analysis of key success factors in banking strategies. In evaluating banking technologies, such as mobile banking, Lin (2013) analysed qualitative aspects of services to identify the most important features. The method also helps to optimise branch and ATM locations to ensure maximum efficiency and customer satisfaction. Županović et al. (2015) documented the successful application of this approach in their study. At the same time, combining AHP with other methods, such as DEA, enables a detailed analysis of bank performance. Babacan et al. (2020) emphasise that such integration provides deeper insights into key areas, such as cost efficiency and profitability, and allows banks to be ranked according to predefined criteria. These analyses help financial institutions to set strategic goals and allocate resources more effectively. Risk assessment, especially when combined with artificial intelligence, enables detailed analysis of historical data and the prediction of potential risks. Ristanović et al (2023) highlight the potential of this approach for predictive risk management, especially in the context of global threats such as cyberattacks and economic instability. The method is also used to create personalised investment portfolios by optimising resource allocation based on risk, return, and liquidity. The synergy with AI simplifies the analysis of large amounts of data and enables the customisation of financial services to individual user needs. It also plays a crucial role in digital transformation, especially in improving the quality of digital banking services. Paltayian et al. (2023) emphasise that combining this method with tools such as QFD can significantly improve the user experience and security of digital platforms.

Despite its advantages, implementing the method requires sophisticated technical systems, which is a challenge for banks with limited technical resources. In addition, the hierarchical structure of the method can sometimes be too slow for real-time analysis, limiting its adaptability to dynamic changes in financial markets. Regulatory requirements and technical barriers further complicate its application in the banking sector and hinder its wider implementation in decision-making processes. These restrictions also apply to other sectors. In the textile industry, the method has proven helpful in supplier selection, enabling adaptation to different demand scenarios. However, the reliance on subjective evaluations makes the accuracy of the results difficult to assess (Ramos et al., 2024). In education, it helps teachers to select learning resources, but often ignores broader pedagogical perspectives and specific contextual requirements (Leon et al., 2023). In the IT sector, it has been used to optimise business processes through simulation modelling, but the complexity of integrating the method with other tools often limits its practical applicability (Serhiienko et al., 2024). In finance, artificial intelligence (AI) and big data have already proven to be key technologies for improving economic forecasting, decision-making, and personalising financial services. These technologies enable financial institutions to analyse large amounts of data, adapt strategies, and automate business processes, as Wójcik-Czerniawska and Grzymala (2024) show.

The subjectivity of judgments in determining the weighting coefficients for the criteria remains one of the main limitations of the AHP. While the method uses structured pairwise comparisons to minimise bias, the results are often influenced by subjective judgements of decision-makers, which affect the reliability of decisions (Čančer et al., 2017; Ramos et al., 2024). This limitation is particularly pronounced in industries with high dynamism, where subjective judgements may not reflect actual priorities or current market conditions. In addition, the increase in the number of criteria and alternatives significantly increases the time and resource requirements of the analysis, potentially leading to lower accuracy and consistency in results (Serhiienko et al., 2024). The complexity of the method often discourages its use, especially in contexts where quick and adaptable decisions are required. In addition, many key criteria, such as reputation, trust, and innovativeness, are not easily measurable, further undermining the credibility and practicability of AHP analyses

(Wójcik-Czerniawska et al., 2024; Pejić Bach et al., 2020). Moreover, AHP results are often context-specific and difficult to generalise to broader settings. Such limitations further reduce the method's applicability in global and complex environments, where more universal and flexible methodological adaptations are required (Ramos et al., 2024; Serhiienko et al., 2024).

Proposed solutions to improve the AHP include technological and methodological innovations to reduce subjectivity and increase certainty and transparency in financial decision-making. The development of hybrid models that integrate AHP, AI, and blockchain could significantly improve the method's reliability. Blockchain provides data immutability, which is critical for accurate risk assessment and operational process management. In addition, advanced software tools to automate pairwise comparisons could reduce subjectivity and speed up analysis, thereby increasing the method's efficiency (Ramos et al., 2024). The integration of AHP with fuzzy logic and simulation models would enable more precise analysis of complex systems and qualitative criteria and expand its applicability (Čančer et al., 2017). Standardising processes and training decision-makers in applying AHP could reduce variability in results and improve consistency (Leon et al., 2023; Serhiienko et al., 2024). In addition, multi-criteria simulations would enable the analysis of long-term impacts and improve the method's adaptability to dynamic environments, especially in sectors characterised by rapid technological change (Serhiienko et al., 2024; Wójcik-Czerniawska et al., 2024). Despite these advances, the successful application of AHP requires a more detailed approach to adapting the method to users' specific needs and contexts. The lack of clear guidelines for standardisation continues to limit its universality. A critical approach to improving the method in conjunction with technological innovation is essential to maintain its relevance in modern decision-making systems. Without such advances, AHP risks becoming less relevant in meeting the complex demands of today's industries and markets.

Research Limitations

Bias in qualitative meta-analyses can arise from excluding certain studies, affecting the analysis's completeness and representativeness. Using papers from the WoSCC database ensures access to high-quality scientific papers, but it also carries risks. A limited search may exclude papers from less influential journals, grey literature, or non-English languages, leading to selection bias. Papers outside a specific time period or not yet indexed in WoSCC may also be omitted, missing recent evidence. Selective bias occurs when studies with insignificant results or contradicting theories are excluded, leading to biased conclusions. Additionally, linguistic and cultural biases may favour Anglo-Saxon papers, overlooking contributions from other regions. To mitigate bias, it is advisable to use additional databases, including grey literature, and broaden the search strategy. Transparent documentation of the search process helps identify and reduce biased sources.

Conclusions

The most influential sources and researchers in the field of MCDM include papers from leading scientific journals with high citation rates. In Croatia, research is fundamental in banking and finance, where studies emphasise the importance of evaluating alternatives and decision criteria, especially during crises. The most cited papers in AIME fields apply AHP and related methods to analyse and support decision-making under complex conditions and integrate them with advanced algorithms to achieve more accurate and reliable decisions in the areas of financial performance, risk management, and strategic planning.

Recent trends include combining AHP and AI to improve the accuracy and efficiency of decision-making. In Management, research focuses on adapting methods to specific industries and conditions of uncertainty, whereas in Economics, topics such as macroeconomic policy and economic growth dominate. AI-driven automation reduces the time required to evaluate options, but it also raises high costs and ethical concerns. Digital transformation in Management requires research to help organisations adapt to rapid technological change, while in Economics, political instability can hinder long-term planning. In Management, research focuses on methods tailored to industry needs and conditions of uncertainty, while in AI, the focus is on developing hybrid models that combine MCDM and AI to improve risk management and optimise business processes.

The comparison of the fields shows different approaches to process optimisation, with each field emphasising specific aspects of its context. AI&ML drives innovation through technological precision and automation; Management ensures adaptability and sustainability; Economics explores broader economic implications with a focus on macroeconomic impact. Each field faces unique challenges: ethical issues in AI & ML, organisational adaptation in Management, and political stability in Economics.

The future application of AHP and combined methods in the banking sector seems promising, with several main directions that could further improve decision-making processes. Integration with artificial intelligence (AI) and machine learning (ML) enables more sophisticated models for analysing risk, predicting creditworthiness, and tailoring services to the customer. AI improves AHP efficiency by automating criterion assessment, while AHP provides a structured approach to interpreting complex results. Real-time optimisation is becoming increasingly necessary as banks demand real-time decisions. AHP and combined methods, integrated with advanced data processing systems, enable large amounts of information to be analysed quickly, which is crucial in rapidly changing market conditions. The combination with big data technologies brings additional benefits, as AHP becomes an effective tool for analysing and decision-making in complex systems. Combining big-data analysis techniques improves the precision of risk and investment models. The use of AHP in sustainable finance is becoming increasingly important as awareness of sustainability grows and investment assessments based on environmental, social, and governance (ESG) criteria become possible. Future methods could include valuations that combine AHP with models to assess the impact of sustainable initiatives.

The development of hybrid models is also on the horizon, given the need for more accurate assessments. Hybrid models that combine AHP with other multi-criteria methods, such as TOPSIS, VIKOR, or DEA, enable better classification and optimisation of investment decisions and the assessment of the efficiency of banking operations. The automation of decision-making and digital transformation in the banking sector will continue to benefit from AHP. Automated decision-making platforms using AHP can improve the accuracy of risk assessment and customise financial products to users' preferences. Integration with blockchain technology increases the security and transparency of decision-making processes. AHP, when combined with blockchain, can be helpful for risk management and supply chain optimisation in financial services. The use of AHP and combined methods in banking will continue to increase as new technologies develop and the demand for complex, informed decisions grows. Banks will invest in systems that provide more accurate assessments and optimise business processes, while integration with digital tools will further improve efficiency and customisation of services for customers.

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