

## Bibliometric study of association rule-market basket analysis

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### ABSTRACT

Association rule-market basket analysis (AR-MBA) is a data mining technique for finding distinguished relationship patterns from a collection of items. The application of AR-MBA is also increasingly widespread, starting from retail and hotels to hospitals. So, bibliometrics related to AR-MBA needs to be done to reveal what research opportunities can be later carried out by reviewing and analyzing publications about AR-MBA. 91 bibliographies in 1 decade from 2012-2022 were collected using Harzing's Publish or Perish (PoP). VOSviewer is also employed to map authorship and publication topic trends. This paper is innovative because it identifies trends and future research directions in data mining, specifically in association with AR-MBA. The findings show publication productivity, top authors, types of publications, annual topic trends within a decade, term distribution, most cited and most influential articles, and research gaps that can be opportunities for further research.

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## 1. INTRODUCTION

Data is a valuable resource for organizations, and database management systems are gradually becoming used in numerous small and medium-sized businesses [1]. Data collection is managed using a procedure called a database for easy access. The database has been operating for more than 50 years. It has become primary [2] since the mid-1980s, characterized by the widespread adoption of the relational model worldwide and the dramatic shift in research and development efforts towards the development of new, potent database systems [3]. Recently, data has been stored in various databases in various fields, such as the retail market, the banking sector, and the medical field [4]. However, only some information in the data is helpful to the user. That is why extracting useful information from extensive data is very important. This process of extracting valuable data is known as data mining or the process of knowledge discovery and data (KDD) [5]. Finding and interpreting patterns from data involves many steps, such as selection, preprocessing, transformation, data mining, and interpretation [6]. Data mining itself has several techniques, such as clustering [7], [8], classification [9], [10], singular value decomposition (SVD) [11], [12], association rule mining (ARM) [13], [14].

ARM is a technique that plays an essential role in data mining research to find interesting correlations between a collection of items in a database [3] so that it can provide information that can be used to support decision-making [15]. It has significantly succeeded in many applications, such as market baskets, computer networks, recommendation systems, and healthcare [16]. Market basket analysis (MBA), or association rule learning or affinity analysis, is a data mining technique used in various fields, such as marketing, bioinformatics, education, and nuclear sciences. The main goal of an MBA in marketing is to provide retailers with information to understand the buying behavior of customers, which can assist retailers

in making the right decision [17]. In the retail business, analyzing such information is valuable for mining purchasing patterns that allow retailers to adjust promotions, store layout arrangements [18], [19], temporal visual profiling [20], and serve consumers better [21].

MBA is divided into two types, namely predictive and differential. A predictive MBA is established to predict buyer behavior to find relationships between various products from their market basket. In essence, it seeks to imitate the market to examine what factors influence events by determining cross-selling, considering items purchased in a particular order [22]. Differential MBAs can identify noteworthy outcomes and solve the issue of a potentially high volume of unimportant outcomes [23]. This kind of analysis is suitable for analyzing competition by identifying exciting patterns in consumer behavior. It can be carried out by comparing purchase history across brands, periods, seasons, days of the week, and more.

Various algorithms are available to generate MBA, such as the equivalence class transformation algorithm (ECLAT) [24], [25], the Apriori algorithm [26]–[28], and the FP-growth algorithm [29], [30]. Existing algorithms only process static data and are unable to adapt to changes in the data over time. Then, the proposed algorithm mines the static data and offers an innovative method of accounting for data changes [31]. AR-MBA is widely used. So, research related to AR-MBA is applied in supermarkets and other fields of study [32]. There must be juxtaposed with other methods to create personalized healthcare [33]. MBA is also applied to inventory prediction combined with other methods such as artificial neural networks [34], text segmentation [35], economics [36], and others. MBA can increase hotel revenue by exploring the most attractive and satisfying services and products to encourage existing guests to repeat their stays and recommend the hotel to new potential guests [37].

Research related to the bibliometric-based association rule-market basket analysis (AR-MBA) is considered attractive, intending to review and analyze research productivity, authorship, citations, and trending AR-MBA topics. Bibliometric research presents a unique opportunity to contribute to both theory and practice. Leading journals and scholars from diverse subjects have published numerous very influential pieces that explore the subtleties of the evolution of multiple fields and identify emerging patterns using bibliometric techniques [38]. Furthermore, until this research, there has not been any bibliometric study specifically addressing AR-MBA. Therefore, this constitutes a novelty in the study.

This study uses bibliometric analysis to overview the existing literature comprehensively [39]. The survey of bibliographic data through statistical and numerical tools is called bibliometrics [40]. Bibliometric analysis is a quantitative study of bibliographic materials [41]. Bibliometric studies can be used for several purposes, including identifying new trends in the performance of articles and journals, patterns of collaboration, most productive authors, and potential publications [42], research constituencies, and exploring the intellectual structure of a particular domain in the extant literature [43]. The bibliometric methodology has been applied in various research fields such as business [44], [45], health [46], politics [47], and others.

Bibliometric studies related to data mining are also widely applied, such as in text mining [48], data mining algorithms [49], big data analytics [50]–[53], validation models [54], and natural language process (NLP) [55]. Silva *et al.* [56] also carried out a bibliometric study related to association rules to preserve the privacy of confidential information. Dikeç *et al.* [57] also conducted a bibliometric analysis of publications on stigmatization in Turkey according to the association rule. However, bibliometrics related to MBA was carried out when this study was made, even though MBA is an exciting topic and widely applied because it can provide insight to encourage decision-making in determining business strategy.

## 2. BIBLIOMETRIC METHOD

This research utilized the publish or perish (PoP) software as an application for searching bibliographic databases, as seen in Figure 1. Google Scholar is the database source employed for bibliographic searches in the PoP application. Google Scholar was chosen because this database has recently been increasingly used as a bibliometric tool to gather information about the citation impact of individual articles, researchers, or scientific journals, competing with Thomson Reuters' Web of Science and Elsevier's Scopus. The most notable feature of Google Scholar is that its citation count is often much higher than that generated in Web of Science or Scopus [58].

The bibliographic search was explicitly limited to the title and keywords of the sought-after authors, focusing on two words: "association rule-market basket analysis." The search period was confined to the years 2012–2022. The bibliographic search was conducted in February 2023 and yielded 91 bibliographies. The bibliographic search was saved as a CSV file for opening in Excel, then reviewed, supplemented with metadata, and processed. The metadata, referring to Julia *et al.* [59], included the author's name, article title, author's keywords, abstract, year, volume, issue number, pages, affiliation, country, citation count, article link, and publisher. Furthermore, the search results were also saved as an RIS file for mapping using the VOSviewer application.

Bibliometric indicators used in this study [60], represent bibliographic data, such as the number of publications, co-authorships of authors, and citations [61]. Typically, the number of publications measures productivity, and the number of sources measures influence [62]. One of the main aspects of bibliographic analysis is the authorship patterns, especially concerning the types of authors, the nature and degree of collaboration between them, and the collaborative level [63]. Authorship patterns and citations are mapped and analyzed using VOSviewer.

Google Scholar search interface showing search criteria for 'Association Rule-Market Basket Analysis' from 2012 to 2022. The interface includes fields for Authors, Publication name, Title words, and Keywords, along with search buttons and a 'Help' link.

Figure 1. Bibliographic search used PoP

### 3. RESULTS AND DISCUSSION

#### 3.1. Publication research output

The Google Scholar search collected 91 publications on the AR-MBA topic for the last 11 years between 2012-2022. The distribution of publication years is presented in Figure 2, and the types of publications are in Figure 3. There are 91 publications on AR-MBA identified in the Google Scholar database, with 5 (5%) of them published in 2012, 2 (2%) papers published in 2013, 3 (3%) in 2014, 12 (13%) in 2015, 6 (7%) in 2016, 10 (11%) in 2017, papers published in 2018 and 2019 have the same number, which is 7 (8%), in 2020 as many as eight articles are published (9%), 2021 with 18 (20%) and 2022 with 13 (14%). Most were published in 2021.

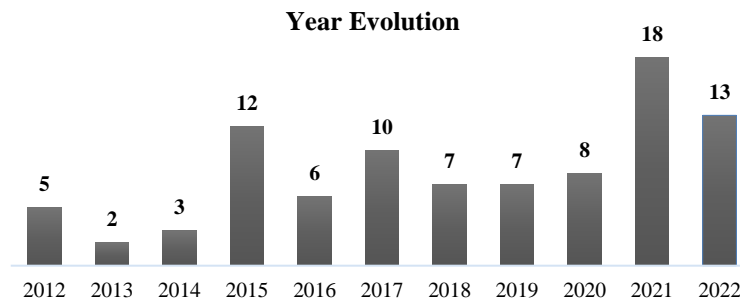


Figure 2. Year evolution

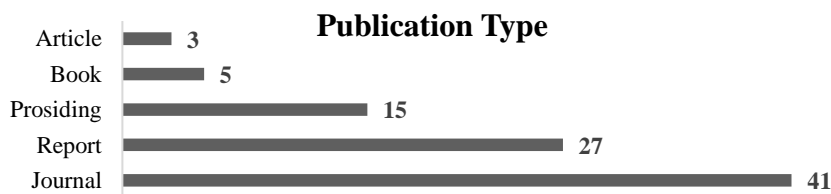


Figure 3. Publication types

In addition, these publications are divided into five types, namely journals which dominate the number of publications with 41 (45%), while 27 (30%) are reports, 15 (16%) proceedings, 5 (6%) books, and 3 (3%) articles. However, out of 41 journal publications, only 22 were classified as international journals with English introductions.

### 3.2. Authorship pattern

Authorship of a scientific article has been attributed to the given author unchallengedly. Applying the authorship attribution method allows us to feature specific segments of an article to individual authors to analyze scientific authorship at a more fine-grained level [64]. Collaboration among authors is essential in research production [65], [66]. Arya and Sharma [67] found that the main factors in research productivity are collaborative research and authorship. Bibliometric studies have shown that collaborative writing achieves popularity over time, and more papers are published in collaboration rather than through individual efforts [68]. According to Garg and Padhi [69], this collaboration pattern can be divided into four writing groups, namely single collaboration, two, multi (3 and 4), and mega (5 and above). The trend of authorship in this study is shown in Table 1.

Table 1. Authorship collaboration pattern

Authorship pattern	Number of contribution	Percentage (%)
Single author	55	60.44
Two authors	14	15.38
Multi-authors	17	18.68
Mega authors	5	5.50

Next, co-authorship mapping is carried out using VOSviewer software. This mapping discovers the author's collaborative patterns and productivity in writing publications related to specific topics [61]. The results of the co-authorship mapping on AR-MBA topics can be seen in Figure 4. Figure 4 shows a yellow circle with the author's name. Adjacent circles indicate the existence of collaboration between the primary authors. Eight principal authors emerged from 91 publications, including Adewole, K.S., Akintola, A.G., Batta, G., Ganguly, A., Azhra, F.H., Badrul, M., Dowd, K., Rizki, Z.U. It indicates that the authors have published their writing in more than two documents.

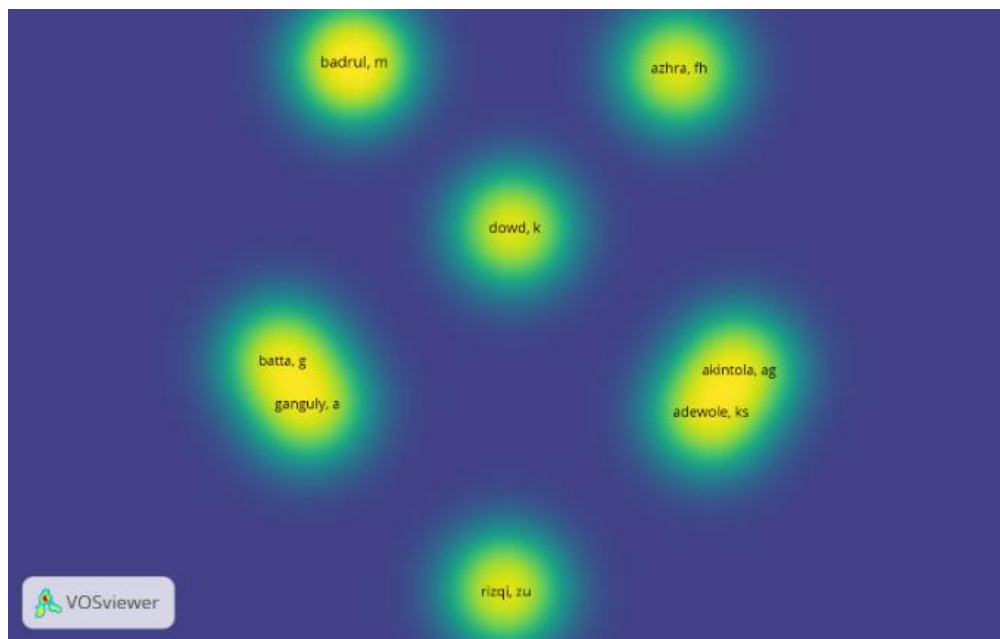


Figure 4. Collaboration of author mapping

### 3.3. Citation

Out of 91 documents, there were 804 citations in total, with 73.09 citations per year and an average number of citations per paper of 8.84. The article "A primer to frequent itemset mining for bioinformatics," written by Naulaerts *et al.* [70] and published in a briefing in the bioinformatic journal, is identified as the most cited publication. Since publication, his articles have been cited 150 times, with an average annual citation of 18.75. Some of the documents that are also frequently cited with a minimum of 12 sources can be seen in Table 2.

### 3.4. Topic trends

One method for mapping the recognized published records is bibliometric analysis. It is commonly acknowledged as an alternate technique for analyzing important and in-depth subjects to evaluate and forecast research using issue trends [80]. This analysis provides further insight into trending topics [81] regarding AR-MBA topics over a decade. This topic trend analysis was introduced to the title and abstract of the paper using VOSviewer so that a mapping is formed, as shown in Figure 5.

Table 2. Frequently-cited writings

R	C	Author and year	C/Y
1	150	Naulaerts <i>et al.</i> [70]	18.75
2	123	Waitzkin [71]	15.38
3	103	Raorane <i>et al.</i> [3]	9.36
4	54	Beal <i>et al.</i> [72]	13.5
5	38	Gray and Vogel [73]	5.43
6	31	Nengsih [74]	3.88
7	26	Abdulsalam <i>et al.</i> [1]	2.89
8	25	Batta <i>et al.</i> [75]	2.78
9	15	Tang <i>et al.</i> [76]	2.5
10	14	Schütze [77]	2.33
11	13	Pence <i>et al.</i> [78]	4.33
12	12	Falato <i>et al.</i> [79]	3

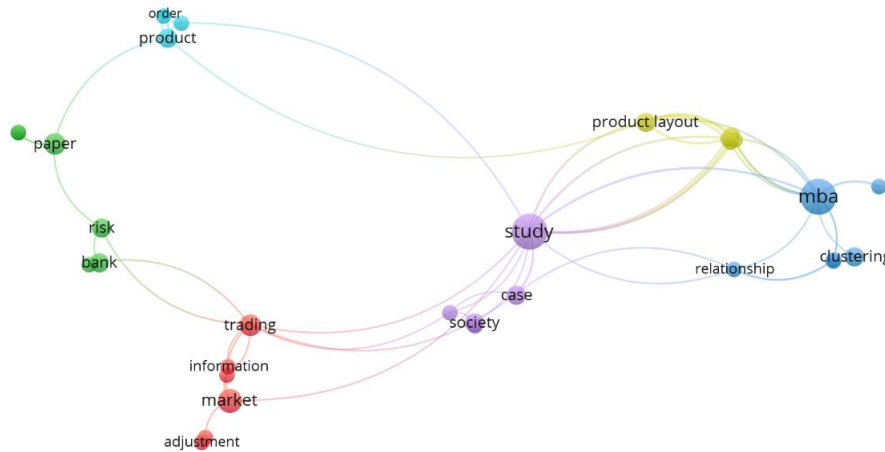


Figure 5. Co-occurrence map of titles and abstracts

Based on the titles and abstracts of a total of 91 documents, there are 630 keywords found with 70 thresholds with minimum keyword occurrences of 2 in the document. Then, the relevance value of the 70 terms is calculated. Based on this score, the most relevant terms will be selected by 60% of the total terms. The results are then made into several clusters. In this case, the clusters formed are 6, with detailed terms for each cluster shown in Table 3.

Table 3. Detailed terms for each cluster

Cluster	Terms
1	Adjustment, article, information, market, price discovery, trading
2	Artificial Intelligence, bank, paper, risk, stress, team sport
3	AR-MBA method, association rule market basket analysis, clustering, marketing strategy, MBA, relationship
4	CG mart, layout analysis, Kampar district, product layout
5	Case, field, society, study, wealth
6	Case study, order, product, researcher

In Figure 5, the clusters are distinguished by color: red for Cluster 1, green for Cluster 2, cerulean blue for Cluster 3, yellow for Cluster 4, soft purple for Cluster 5, and sky blue for Cluster 6. A larger circle size in the mapping can indicate the terms that mostly appear in publication titles and abstracts. The larger

the circle, the more frequently appeared terms. These terms include "MBA" and "study," with 11 times occurrence. Meanwhile, "risk," "price discovery," and "intrusion detection" are considered to be rarely-appearing terms. Then, the distribution of the year of publication based on the occurrences of the term is shown in Figure 6.

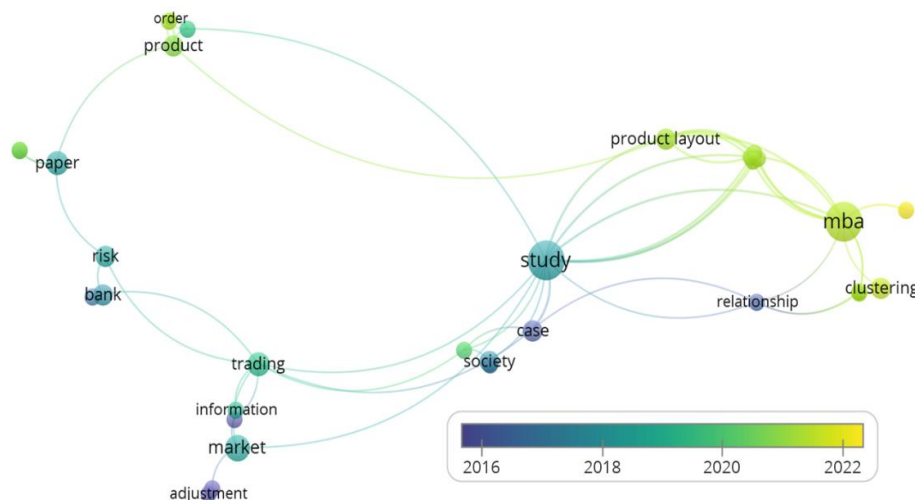


Figure 6. Overlay visualization of titles and abstracts

#### 4. CONCLUSION

This research presents AR-MBA bibliometric analysis, a data mining method widely used to obtain attractive business strategies. Through this bibliometric analysis, research patterns can be identified for a decade, offering future research opportunities. It is revealed that out of 91 publications, more than 60% are written by one author. So that further AR-MBA research can be carried out by involving more collaborative writing. The complexity of scientific research requires collaborative writing. Apart from that, several unique topics, yet less prominent, were also found, and it would be interesting to integrate them massively with the AR-MBA in the future. These topics include “risk,” “price discovery,” and “intrusion detection.” Furthermore, further study could use Scopus or WOS databases to obtain a comprehensive view of emerging trends in issues related to AR-MBA. It could utilize a broader range of bibliometric indicators.

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