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Research Manuscript

Business Intelligence in Management of Knowledge Assets: Co-Word Analysis of Scientific Productions

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Abstract:

This research explores the application of business intelligence in managing knowledge assets using co-word analysis of scientific productions related to "knowledge asset management and business intelligence." Employing content analysis and techniques such as social network analysis, hierarchical clustering, and strategic diagramming, the study analyzes 929 scientific productions from the Web of Science database spanning from the 1990s to 2022. Data was analyzed using Histcite, BibExcel, UCINET, and Excel, with maps created via VOS Viewer and SPSS. Findings revealed average annual growth rates of 28% for publications and 8.9% for impact. Key terms like "big data," "data mining," and "data warehouse" showed the highest frequency, while "management," "system," and "design science" exhibited notable citations. Co-word analysis formed eight clusters of 138 keywords. Hierarchical clustering identified five mature clusters, including business intelligence tools in knowledge management and business process management through knowledge asset management, positioned at the core of the research field. This study provides valuable insights for researchers, educators, policymakers, and organizational managers in the fields of business intelligence and knowledge management. Keywords: Business intelligence, knowledge management, data, information, scientometrics, co-occurrence.

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1. Introduction

In this era, learners and users of capital and knowledge assets have the upper hand, so that new organizations are based on learning and knowledge creation Etzkowitz and Klofsten (2005). This means that organizations try to provide solutions for how to learn and better utilize a variety of important knowledge resources available to them Najafi and *et al.* (2023). In other words, knowledge capital in organizations and business enterprises has always served as a safeguard against turbulent business conditions. Organizations have not only been able to maintain their survival but also gain a competitive advantage through its effective application in their organizational processes Bontis (2007). In this regard, the management of knowledge assets is one of the essential approaches in today's business environment. It involves the processes of producing, evaluating, storing, organizing, sharing, using, and development of various types of organizational knowledge assets to make optimal decisions and achieve maximum productivity Nonaka and Teece (2001). Knowledge asset management has been implemented in different organizations by formulating a strategy and using the necessary tools and technologies (Vasfi *et al.* (2019)). This is despite the fact that after the fourth industrial revolution and the emergence of smart technologies, the use of organizational data as one of the types of knowledge assets has played an important role in organizational and business success Padidarfard and *et al.* (2022). In this context, the concept of business intelligence has emerged and expanded Balouyi and Khosrozadeh Sarasti (2017).

Business intelligence refers to the ability of an organization to collect, store, and analyze organizational data, ultimately creating reports and dashboards aligned with the organization's vision and goals. This process leads to the production of large amounts of information and knowledge, ultimately generating new opportunities for the organization and its managers at different levels Ranjan (2008). In other words, business intelligence is a working framework that includes tools, technologies, and processes to transform data into information and then convert information into the knowledge and insights needed to optimize organizational decision-making (Ranjan (2009); Soleimani and Atefat Doust (2018)). In this way, by using the knowledge gained from data analysis, managers can make better decisions and, as a result, improve the performance of their organizations Khodaei and Karimzadegan Moghadam (2014). In general, business intelligence has been proposed as a new approach in organizational architecture that helps managers make accurate and informed business decisions in the shortest possible time based on the speed of information analysis Hashemi and *et al.* (2018). Business intelligence aligns with the process of producing organizational knowledge and, more broadly, knowledge management within the organization. As mentioned above, by

applying knowledge management processes, the organization generates and utilizes its own knowledge or intellectual capital. Additionally, an organization or business that employs business intelligence technologies, processes, and tools can better meet customer needs, respond to competitive actions, gain more knowledge, learn more, and ultimately increase productivity.

On the other hand, the management of knowledge, recognized as the most strategic asset of organizations, has been utilized since the 1990s as a lifeline and tool for achieving superior performance. The role of business intelligence is to provide the right information to the right person in the right format and at the right time to support a better decision-making process. Currently, both types of information management technologies are widely used as tools for improving organizational performance Saqib and *et al.* (2018).

Searching scientific literature through reliable Persian and English databases shows that, in connection with the subject of "management of knowledge assets and business intelligence," various terms and equivalents have been used. A relatively large number of scientific works have been designed and published, investigating this issue from different angles in various fields. However, one of the most widely used techniques for mapping and analyzing the structure of knowledge in studies is the co-occurrence of words — or, in other words, the connection between words used in different parts of scientific literature. Co-occurrence analysis of words, as one of the common techniques in scientometric studies, reveals the topic clusters of a research field, considers its semantic and conceptual relationships, and outlines the structure of knowledge in the investigated field Farshid and *et al.* (2022).

In today's era of knowledge-based and emerging technologies, considering the importance of business intelligence and the management of various knowledge assets on the one hand, and the publication of a relatively large number of related research studies on the other, this research addresses the applications of business intelligence in the management of knowledge assets. This will be achieved by revealing the keywords and significant concepts in related studies within the Web of Science citation database. Identifying the structure of knowledge in this research field will enable policymakers, researchers, and stakeholders to direct their studies and programs in a targeted manner, aligning them with practical issues and advancing with greater awareness, while emphasizing the need to increase the quality of consistent studies in this area. Undoubtedly, the presented view of the structure of knowledge in the desired subject area can provide valuable insights into important and emerging topics, as well as highlight existing gaps in the literature.

Based on the main purpose, which is to explain the application of business intelligence in the management of knowledge assets through the co-word analysis

of scientific literature related to "management of knowledge assets and business intelligence" indexed in the Web of Science database, this study aims to answer the following questions:

1. How has the growth of scientific literature related to "business intelligence and management of knowledge assets" evolved in terms of the number of publications and citations received?

2. What are the most important topics in terms of frequency, impact (measured by citations), and connections in scientific literature related to "business intelligence and management of knowledge assets"? What are the most significant co-word pairs in these publications based on frequency?

3. What clusters and topics have formed based on co-word analysis and social network analysis of scientific literature related to "business intelligence and management of knowledge assets"?

4. What is the hierarchical clustering of the topics in scientific literature related to "business intelligence and management of knowledge assets" based on co-occurrence analysis?

5. In terms of the maturity and development level of the clusters resulting from the co-word analysis, what is the status in the strategic diagram related to the scientific literature on "business intelligence and management of knowledge assets"?

2. Theoretical Framework

The term "knowledge management" was first proposed by Carl Wiig (Wiig (1993)) at a conference held in Switzerland with the financial support of the United Nations and the International Labor Organization. Knowledge management describes the process of locating, organizing, transferring, and using information Duffy (2000). According to Wiig (1993), knowledge management is a conceptual framework that encompasses all the activities and perspectives required for the sustainable optimization of organizational activities. Sousa and Hendriks (2006) argue that knowledge management involves policies, strategies, and techniques aimed at supporting organizational competitiveness by optimizing the conditions necessary to enhance cooperation and productivity among employees. Knowledge management is an integrated approach to identifying, acquiring, evaluating, training, and sharing knowledge at the organizational level Gunjan (2019). It encompasses the processes of collecting, producing, storing, disseminating, and using knowledge

while considering appropriate technologies, organizational structures, and people to solve problems and improve decision-making, ultimately fostering effective learning Dei and van der Walt (2020).

Today, research in the field of knowledge management focuses on knowledge management as an organizational resource, emphasizing the importance of people and organizational culture in supporting the sharing and development of knowledge. This includes creating a favorable environment for formal and informal communication, cooperation, and the transfer of knowledge, which is an essential strategy for implementing knowledge management Nazem and Mukherji (2017). Knowledge management processes are at the heart of knowledge management, and most researchers have identified and studied these processes as a crucial component of their own and others' proposed models and frameworks in various ways. Table 1 presents the processes of knowledge management from the perspectives of different researchers.

Based on the table above and the information provided, knowledge management processes generally include creating, producing, or acquiring knowledge; storing and organizing knowledge; sharing knowledge; and applying and developing knowledge.

The potential of business intelligence was recognized in 1958 with the publication of an article by Hans Peter Luhn, an IBM researcher. The article, titled "A Business Intelligence System," described an "automatic system" that was "developed to disseminate information to the various sections of any industrial, scientific, or government organization." Such organizations at the end of World War II needed a way to manage and simplify the increasing amount of technological and scientific data. Luhn defined "intelligence" as "the ability to apprehend the interrelationships of presented facts in such a way as to guide action towards a desired goal," citing Webster's dictionary Sharp (2009). This definition forms the core of business intelligence—a method that enables quick and easy comprehension of vast amounts of data and information to facilitate optimal decision-making Sharp (2009). Luhn's work went beyond simply introducing and presenting concepts; it marked a pivotal turning point in the evolution of business intelligence. In this way, Luhn's research serves as the foundation for many of today's analytical systems. He predicted several cutting-edge trends in business intelligence, including the ability of information systems to learn based on user interests. Today, Luhn is recognized as the "father of business intelligence."

Initially, business intelligence solutions were very expensive; however, in the late 1970s and 1980s, one of the first applications of business intelligence was used for tasks such as inventory management of stock items, tracking a company's assets and liabilities, and processing payroll Kahaner (1997). Additionally, one of the

Table 1: A Summary of Knowledge Management Processes from the Perspective of Different Experts Choi (2002)

Author	The revised sentence is now clearer and maintains a professional toneknowledge management processes
Wiig (1993)	Knowledge production, collection, dissemination and application
Nonaka & Takeuchi (1995)	Sharing hidden knowledge, creating concepts, confirming concepts, building an initial model
Meyer & Zack (1996)	Knowledge acquisition, knowledge refinement, storage, distribution, presentation
Probst (1998)	Knowledge ideal, recognition, acquisition, development, distribution, preservation, use, measurement
McElroy (1999)	Individual/group learning, demand stabilization, information acquisition, knowledge validation, integration
Davenport & Prusak (1998)	Knowledge production, knowledge coding, knowledge transfer
Bukowitz & Williams (1999)	Acquiring knowledge, using knowledge, learning, sharing, creating, maintaining, evaluating
Hicks (2000)	Knowledge creation, knowledge storage, knowledge dissemination, knowledge application.
Alavi & Linder (2001)	Creation, storage of knowledge, transfer and application of knowledge
Dalkir (2005)	Knowledge creation, knowledge dissemination, knowledge acquisition and application.
Obeidat (2017)	Knowledge acquisition, knowledge transformation and knowledge application.

earliest practical applications of business intelligence came from Nielsen, which measured how many people were watching a particular television program at any given time.

Business intelligence, which has been widely used and expanded in the twenty-first century while its complexity has been greatly reduced, is a set of skills, technologies, and application systems used to collect, store, analyze, and provide efficient access to data warehouses. It helps organizations make informed decisions. In other words, business intelligence serves as a tool for gaining a competitive advantage and for monitoring and analyzing the organization's market and customers Quagini and Tonchia (2010). Data analysis encompasses classification, clustering, statistical analysis, mathematical prediction, and intelligent analysis based on neural networks and algorithms.

In general, business intelligence is the process of converting raw data into actionable information and practical management knowledge that helps decision-makers in an organization make faster and better decisions based on accurate information. Organizations and large companies use this tool to generate, report, organize, and visualize data. The components of business intelligence include: data warehouse, data analysis, ETL (extract, transform, and load), and online analytical processing. To implement an effective business intelligence system, it is necessary to consider the following steps:

- Identifying the data and information needed by the organization
- Extracting and collecting data from available sources
- Centralizing and organizing data in the data warehouse
- Identifying and providing appropriate analytical methods and tools
- Producing results and illustrating them Omar and *et al.* (2019).

3. Literature Review

This section first reviews Persian and foreign research related to the topic of "business intelligence and management of knowledge assets." Next, new research will be reviewed using a meta-study and scientometric approach, conducted using content analysis methods or co-occurrence techniques in one of the fields related to the current research.

Najafi Yazdi (2012) examined the components of business intelligence (knowledge management and business processes) and their impact on the performance of companies in the Yazd Science and Technology Park. The variables of knowledge management strategies, knowledge management processes, and business processes

were defined as independent variables, while organizational performance served as the dependent variable in the research model. The results indicated that knowledge management strategies do not affect organizational performance; however, there is a positive and significant relationship between knowledge management processes, business processes, and business intelligence with organizational performance. Ranjbar and *et al.* (2013) investigated the relationship between knowledge management strategies and business intelligence at the Exir pharmaceutical factory in Borujerd through descriptive correlational research. The results of the regression analysis revealed a direct and significant relationship between the variables of knowledge acquisition, knowledge response, knowledge distribution, and knowledge management strategy and business intelligence. Balouyi and Khosrozadeh Sarasti (2017) explored the relationship between business intelligence, knowledge management, and the decision-making types of managers in the commercial department of Mazandaran Province. The findings confirmed a significant relationship between business intelligence, knowledge management, and the decision-making types of these managers. Additionally, the relationship between the components of business intelligence and knowledge management with the decision-making types of managers was also confirmed. Soleimani and Atefat Doust (2018) examined the effect of business intelligence on organizational decision-making, considering the mediating role of data quality and the context of business intelligence at the Qom Kosar store. The results demonstrated that business intelligence has a positive and significant effect on organizational decision-making, both directly and indirectly, through the mediating variables of data quality and business intelligence context. Shokri and Ghazizadeh's research (2018) investigated the effect of business intelligence as a knowledge management tool on improving key performance indicators using a system dynamics approach in investment holdings. The simulation results with Vensim software indicated a significant effect of business intelligence and knowledge management on key indicators of organizational performance, including net profit, return on investment, and economic growth. Rastegar and Hakaki (2020) aimed to investigate the effect of knowledge management infrastructural capabilities on business intelligence, with open innovation as a mediator. Their research showed a positive and significant relationship between open innovation and business intelligence. It was also found that the infrastructural capability of knowledge management affects business intelligence both directly and indirectly through open innovation, with approximately one-third of the total effect of knowledge management infrastructural capabilities on business intelligence being indirectly explained by open innovation. Jedali and jedali (2021) investigated the effect of knowledge management on improving innovative behaviors, with business intelligence serving as a mediator at the Sepah

Bank of Tabriz. The findings indicated that knowledge management, through business intelligence, positively influences the innovative behavior of employees.

Abusweilem and Abualoush (2019) investigated the effect of knowledge management processes, including knowledge production, knowledge sharing, knowledge use, and business intelligence—encompassing online analytical processing and data mining—on the performance of organizations in Maskan Bank branches in Jordan. The results showed a positive relationship between knowledge management processes and organizational performance. Additionally, the components of business intelligence positively affected organizational performance. Moscoso-Zea and *et al.* (2019) presented a hybrid information infrastructure for business intelligence and analysis, as well as knowledge management, based on an educational data warehouse and an enterprise architecture repository. This infrastructure enables the digitization of knowledge and the visualization and analysis of various organizational components, such as people, processes, and technology. The proposed infrastructure is grounded in research and has been created to conduct various experiments analyzing educational data and academic processes, facilitating the creation of explicit knowledge using different algorithms and methods of educational data mining, learning analytics, online analytical processing, and organizational architecture analysis. Bouaoula and *et al.* (2019) demonstrated that monitoring internal and external environments involves collecting, retrieving, managing, and disseminating large amounts of data and information. Organizations can perform these complex tasks efficiently through knowledge management. A valuable tool of knowledge management, business intelligence consists of a set of coordinated measures for searching, processing, and distributing information that can support an organization's competitiveness. This study identified four business intelligence variables affecting organizational competitiveness: information search, information processing, information usefulness, and information security. The findings showed that search, usefulness, processing, and security are positively correlated with business intelligence, and the strength of the relationship between business intelligence and each variable is significant. Furthermore, the results indicated that the elements of business intelligence can explain more than 38% of the changes in organizational competitiveness. In the following sections, research will be reviewed using a meta-study and scientometric approach, focusing on studies conducted in fields related to the present research.

Moomivand and *et al.* (2022) researched the field of commercialization by analyzing 3,101 articles published from 1990 to 2022, providing valuable insights for research managers and scholars. The concepts of innovation, performance, governance, entrepreneurship, knowledge, industry, enterprise, research and development, and technology were the most frequently used keywords in commer-

cialization research. The co-occurrence network of the entire vocabulary revealed the intertwining and strong connections between the concepts in this field. The research areas of management, business, and fossil fuels accounted for the most studies under the title of commercialization during the research period. The time trend indicates that commercialization research has shifted from engineering fields to management and business fields, suggesting that the softer aspects of commercialization have received more attention in recent years. Additionally, the comparison of research clusters related to Iran with international studies highlighted the absence of the governance cluster in research originating from Iran.

Liang and Liu (2018) reviewed research related to "big data" and "business intelligence" using bibliometric methods from 1990 to 2017 in the Web of Science database. The findings showed that computer science and management information systems are the two main disciplines driving research related to big data and business intelligence. Keywords such as "data mining," "social media," and "information systems" were highly frequent, while "cloud computing," "data warehouse," and "knowledge management" received more emphasis after 2016.

In research, Lopez-Robles and *et al.* (2018) conducted a conceptual and structural analysis of the publication of intelligence in business studies from 2011 to 2017. Considering that the journal under review provides an open platform for the publication of original research articles, in terms of bibliometric performance, the amount of literature it has covered has shown a noticeable increase in recent years. This increase coincides with the growth of the research area in other fields of knowledge, such as computer science, information science, business management, marketing, and education. The most frequently used topics were business intelligence, big data, competitive intelligence, information management, and social networks.

Zou and *et al.* (2019) reviewed research in the field of business intelligence in the Web of Science during the years 1997-2017, analyzing 876 published articles. Among the keywords related to business intelligence, "cloud computing" had the strongest link. De las Heras-Rosas and Herrera (2021) reviewed studies in the field of competitive intelligence in the Web of Science between 1985 and 2021. Data analysis showed that interest in this topic is relatively new, and the most central topic in the sample is innovation. The published works had an upward trend, and the subjects of innovation and position recognition (orientation) were at the top of the topics.

The literature review shows that many studies have been conducted using different approaches and methods to examine knowledge management and business intelligence from various aspects. However, in general, those studies differ from the current research in terms of methodology, purpose, or study population. In this

regard, the present research has explained the application of business intelligence in the management of knowledge assets based on the co-word analysis of scientific productions related to "management of knowledge assets and business intelligence" indexed in the Web of Science database.

4. Methodology

The current research is descriptive-analytical and, based on its objective, is applied research with a scientometric approach using content analysis methods and techniques such as co-word analysis, social network analysis, hierarchical clustering, and strategic diagramming. Content analysis is one of the research methods used to systematically and objectively describe the content obtained from various communications (Zeighami and *et al.* , 2008). The co-word analysis technique used in this research is one of the techniques within the content analysis method. The statistical population of the current research consists of studies related to business intelligence and the management of knowledge assets in the Web of Science database from 1994 to 2022. To retrieve relevant records, various terms and combinations used in scientific production were identified using thesauruses, specialized dictionaries, scientific texts, and the opinions of experts, focusing on the topic of "business intelligence and the management of various types of knowledge assets." Subsequently, Boolean operators and phrase searches were employed through the following search strategy in the topic field (including title, abstract, keywords, and text) to retrieve related studies in the form of various scientific documents, resulting in 929 records in plain text format from the Web of Science Core Collection.

TS=(("Knowledge manag*" OR "knowledge creat*" OR "knowledge product*" OR "knowledge generat*" OR "knowledge acquisition" OR "knowledge storage*" OR "knowledge shar*" OR "knowledge transfer*" OR "knowledge exchang*" OR "knowledge disseminat*" OR "knowledge utiliz*" OR "knowledge extract*" OR "shar* of knowledge" OR "Experience* documenta*" OR "documenta* of experience*" OR "Knowledge retriev*" OR "knowledge organiz*" OR "knowledge organis*" OR "Discover* of knowledge" OR " knowledge Discover*" OR "creat* of knowledge" OR "product* of knowledge" OR "generat* of knowledge" OR "acquisition of knowledge" OR "storage* of knowledge" OR "transfer* of knowledge" OR "exchang* of knowledge" OR "disseminat*of knowledge" OR "utiliz* of knowledge" OR "extract* of knowledge" OR "retriev* of Knowledge" OR "organiz* of knowledge" OR "organis* of knowledge" OR "Experience* manag*" OR "Knowledge Representat*" OR "tacit knowledge" OR "implicit knowledge" OR "learn* lesson*" OR "lesson* learn*" OR "explicit knowledge" OR "Codified

knowledge" OR "knowledge codificat*" OR "experience* transfer*" OR " transfer* of experience*" OR "experience* transmission" OR "knowledge transmission" OR "learning experience*" OR "experience* shar*" OR "shar* of experience*" OR "teaching experience*" OR "knowledge documentat*" OR "document* of knowledge" OR "experience* exchang*" OR "exchang* of experience*" OR "experience* disseminat*" OR "disseminat* of experience*" OR "experience* utilize*" OR "experience* extract*" OR "utilize* of experience*" OR "extract* of experience*" OR "data manag*" OR "data shar*" OR "data transfer*" OR "data exchang*" OR "data disseminat*" OR "shar* of data" OR "transfer* of data" OR "exchang* of data" OR "disseminat*of data" OR "data transmission" OR "information manag*" OR "information shar*" OR "information transfer*" OR "information exchang*" OR "information disseminat*" OR "shar* of information" OR "transfer* of information" OR "exchang* of information" OR "disseminat*of information" OR "information transmission") AND ("Business Intelligence*" OR " Business-Intelligence*"))

After retrieving the relevant records, the data were analyzed using different software based on the goals and questions of the research. The stages and steps of conducting the research are presented below.

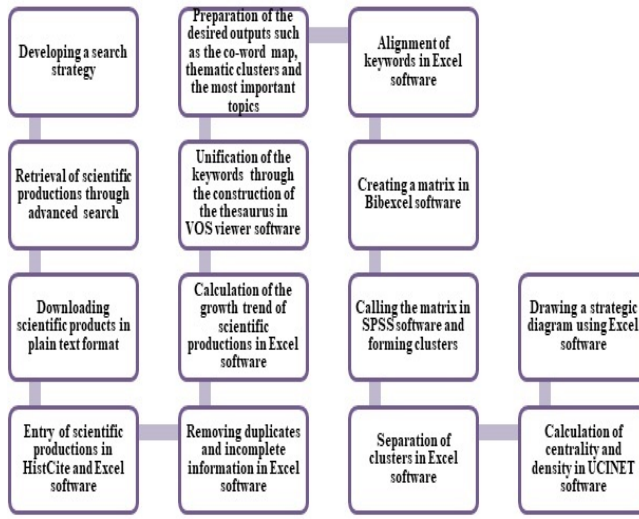

Figure 1: The Diagram (stages and steps) of conducting research.

According to Figure 1, HistCite and Excel software were used to answer the first question; Bibexcel and VOS Viewer software were used to answer the second and third questions; and UCINET, SPSS, and Excel software were used to answer the

fourth and fifth questions. VOS Viewer and SPSS software contain data analysis algorithms such as clustering algorithms, which are used to analyze scientific data and extract patterns and relationships, as well as natural language processing algorithms, which are used to analyze and understand scientific texts and textual data. Additionally, VOS Viewer and UCINET software utilize network analysis algorithms and neural network algorithms.

It should be noted that in the questions related to co-occurrence analysis, during the pre-processing stage of the data, keywords were controlled and homogenized using a thesaurus. Similar and identical keywords, as well as plural and singular forms, were standardized, and non-specialist keywords were removed from the entire set of extracted keywords.

To perform a co-word analysis, hierarchical clustering is typically used. Hierarchical clustering can identify the clusters associated with each keyword and illustrate the relationships between them. For this reason, hierarchical clustering was conducted using SPSS software. In the hierarchical clustering technique, each smaller branch resembles a part of a larger branch, and ultimately, all of these branches are connected to the trunk of the tree in a hierarchical manner (Soheili and *et al.* (2019)). It is important to note that in the first hierarchical diagram, each topic is treated as a branch. Then, the most similar elements are grouped together, and these initial categories form small clusters. Finally, when the similarities decrease, the smaller clusters are combined to form a larger cluster. However, in some clusters, certain keywords may not be semantically related to the content of the cluster. The possibility of this occurring in co-word analysis is common, as these unrelated keywords tend to have low frequency and do not significantly impact the results compared to the main keywords of the cluster. In this diagram, the height of each cluster indicates the points at which two clusters are combined, and the red vertical lines represent the interpretation indicators, which are drawn based on the opinion of a subject expert Soheili and *et al.* (2016). To carry out and conclude the co-occurrence analysis of the keywords, the necessary requirements should be prepared, such as the co-occurrence matrix, which is then converted into the correlation matrix. To prepare the matrix, keywords with a minimum frequency of 4 were selected, resulting in a square matrix of 123×123. The diagonal cells of the matrices were set to zero, and then these normal matrices were converted into correlation matrices. Finally, the clustering of concepts was drawn based on SPSS statistical software (version 26). In the next step, the strategic diagram of thematic clusters was created. To draw the strategic diagram, separate matrices were formed for the keywords of each cluster obtained through the hierarchical diagram. The centrality and density of the clusters were then calculated using UCINET software, and a strategic diagram was generated.

This diagram illustrates the interrelationships and correlations between different thematic clusters. In the diagram, the horizontal axis typically represents centrality (the degree of cluster correlation), while the vertical axis represents density (the degree of internal communication within each cluster).

5. Findings

In this section, the research findings are presented as answers to the research questions.

Answer to the First Research Question: What is the growth trend of scientific productions related to "business intelligence and the management of knowledge assets" in terms of the number of scientific productions and received citations?

By conducting an advanced search in the Web of Science database using the search strategy mentioned in the methodology and employing HistCite software, 929 scientific productions from 1992 to 2022 were identified (search and retrieval date of scientific productions: September 2, 2022). These productions have been indexed in the mentioned database, receiving 404 local citations (LCS) and 9,320 global citations (GCS). The figure below illustrates the growth trend of scientific productions related to "business intelligence and the management of knowledge assets" in terms of the number of productions and received citations per year.

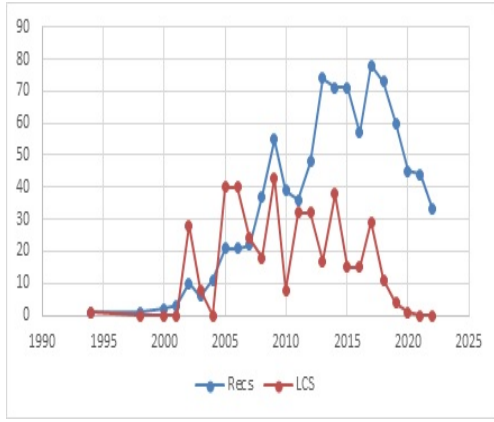

Figure 2: The growth trend of scientific productions related to "business intelligence and management of knowledge assets" in terms of the number of productions and citations

In general, Figure 2 shows the upward trend in the acceptance of the combination of business intelligence and knowledge management in terms of the publication and impact of scientific productions. Among the examined years, 2017 had the

highest number of studies, with 78 publications, while the 1990s had the lowest, with only one work. In total, the average annual growth rate of publications in this field is 28%, and the annual growth rate of scientific products published has fluctuated between -40% (minimum) and 235% (maximum) since the 1990s. On the other hand, among the years under review, 2017 had the highest number of received citations in this field, with 1,025 global citations, while 2009 had the highest number of local citations, with 43. The average annual growth rate of the impact of these studies is 8.9%, and the annual growth rate of the impact in this field has fluctuated between -86% (minimum) and 630% (maximum) since 1992.

Answer to the Second Research Question. What are the most important topics in terms of frequency, impact (receiving citations), and links in scientific productions related to "business intelligence and management of knowledge assets"? What are the most important co-word pairs based on frequency?

At this stage, to identify the top topics in terms of co-occurrence, impact (citation), and links in scientific productions related to business intelligence and knowledge asset management, the scientific records extracted from the Web of Science were entered into VOS Viewer software. Following the co-word analysis of 2,848 keywords extracted from the scientific productions, and applying homogenization of keywords with a co-occurrence threshold of 5, the most important topics were identified based on co-occurrence indicators, impact (citations received), and links, as well as the most significant co-word pairs (Table 2).

Among the keywords extracted from scientific productions related to business intelligence and management of knowledge assets, after the main searched keywords, as shown in Table 2, the keywords "big data, data mining, and data warehouse" and "big data, management, and system" respectively have the most frequency and links in scientific productions. In fact, the above research topics have been the main topics that researchers have studied or researched. On the other hand, topics such as "design science, 0.4 industry, and discovery" have received the most citations among other topics of scientific productions in this field. Also, in these productions, the term "business intelligence" has the highest co-occurrence with terms such as "knowledge management," "data mining," "data warehouse," "big data," and "knowledge discovery."

Answer to the Third Research Question. What were the clusters and topics formed based on co-word analysis and social network analysis of scientific productions related to "business intelligence and management of knowledge assets"?

To co-word analyze scientific productions related to business intelligence and the management of knowledge assets, the scientific records extracted from the Web of Science were entered into VOS Viewer software. Following the co-word

Table 2: The most important topics based on the indices of co-occurrence, impact, links and co-word pairs

Indicator	**first rank (abundance)**	**second rank (abundance)**	**third place (abundance)**	**fourth place (abundance)**	**fifth rank (abundance)**
Coincidence	Big data (115)	Data mining (91)	data warehouse (75)	system (67)	management (64)
Links	Big data (107)	management (101)	system (98)	frame (91)	Technology (85)
Citation	Design science (74)	Industry 0.4 (56)	Discovery & (identification) (55)	objects (53)	User acceptance (49)
Co-word Pair	Business Intelligence Knowledge Management (97)	Business Intelligence Data Mining (63)	Business intelligence data warehouse (62)	Big Data Business Intelligence (55)	Business intelligence knowledge discovery (31)

analysis of 2,848 keywords extracted from the scientific productions in this field, and applying a co-occurrence threshold of 5, eight clusters comprising 138 topics and keywords were formed and identified. Figure 2 displays the co-occurrence map of keywords from the scientific productions in this field. It should be noted that in this map, the thickness of the edges indicates the degree of relationships between concepts, the size of the nodes reflects the amount of knowledge available about each concept, and their color represents the cluster of concepts. Additionally, in this map, the distance and proximity of the nodes (keywords) indicate how closely related the concepts are to each other.

According to Figure 3, various topics and keywords in scientific productions related to business intelligence and management of knowledge assets in the world have been studied in a relatively uniform and intertwined manner, so that eight topic clusters have been formed. Next, in Table 3, keywords and concepts of clusters are mentioned (Table 3).

According to Table 3, each of the clusters consists of various keywords. In the

Table 3: Vocabulary and concepts of subject clusters of scientific productions related to business intelligence and management of knowledge assets

Cluster	**Keywords**	**Concept (Thematic Area)**
Cluster 1	Big Data, Management, Framework, Analytics, Decision Making, Information Systems, Challenges, social media, Future, Value Creation, Business, Industry 4.0, Artificial Intelligence, Key Success Factors, Internet, Adoption, Industry, Machine Learning, Databases, Cloud Computing	Business intelligence infrastructure and essentials
Cluster 2	Knowledge management, impact, information, efficiency, innovation, strategy, capability, business analysis, knowledge, company, integration, organizational performance, prerequisite, absorptive capacity, implementation, small and medium enterprises, knowledge sharing, intellectual capital, executive management, publishing, perspective, determinants, organizational knowledge, tacit knowledge, data	Organizational innovation management and strategy using knowledge asset management and sharing
Cluster 3	Business intelligence, system, data mining, knowledge discovery, data analysis, information management, visualization, e-commerce, ontology, text mining, online analytical processing, web, selection, knowledge acquisition, web mining, clustering, customer relationship management, searching, knowledge representation, cooperation, case study, logistics and support	Business intelligence processes and tools
Cluster 4	Design science, user acceptance, decision support, enterprise system, success, business intelligence systems, model, information technology, support, opportunities, healthcare, knowledge transfer, interoperability, forecasting, dashboard, architecture	Application and benefits of business intelligence
Cluster 5	Issues, Enterprise Resource Planning, Decision Support Systems, Design, Quality, Literature Review, Analytical Database, Maturity Model, Organizations, Organization Architecture, Data Integration, Data Quality, Data Extraction, Refinement and Loading, Metadata, Key Data Management	Organizational issues and topics affecting business intelligence
Cluster 6	Discovery, science, network, strategic intelligence, evolution, bibliography, information management, competitive intelligence, tools	Intelligence of information systems
Cluster 7	Resource-based perspective, supply chain, competitive advantage, intelligence, data science, company performance, dynamic capabilities, predictive analytics, agility	Common basics of business intelligence and knowledge management
Cluster 8	technology, production (product)	The role of technology in organizational efficiency

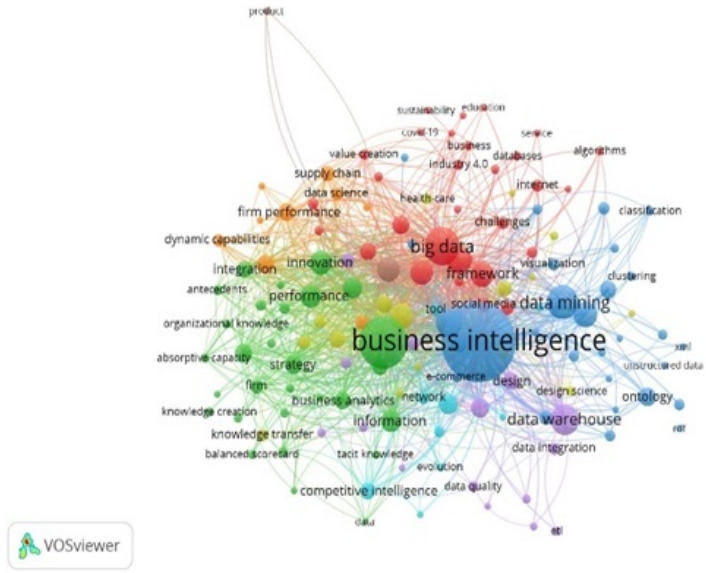

Figure 3: Co-occurrence map of keywords of scientific productions related to business intelligence and management of knowledge assets

table, aligned with the analysis of the formed clusters, the scope and thematic areas of the clusters have been determined by the keywords in each cluster. Since the important and frequent keywords are placed in clusters 1, 2, 3, and 4, these clusters reflect the significant and practical trends of researchers in this field.

Answer to the Fourth Research Question. What is the hierarchical clustering of the topics in scientific literature related to "business intelligence and management of knowledge assets" based on co-occurrence analysis?

Using SPSS software and generating co-occurrence matrices, hierarchical clustering was performed, and a dendrogram (hierarchical clustering) of the subjects was drawn. Figure 4 illustrates the hierarchical clustering of scientific productions related to business intelligence and knowledge asset management. To enhance clarity, the images of the clusters have been divided into several parts.

As can be seen in Figure 4, the keywords of the examined scientific products have formed five clusters:

1. **Business Intelligence Tools in Knowledge Management**. The results of the co-word analysis showed that keywords such as data integration, data mining, knowledge extraction, knowledge management, information management, and business intelligence systems played a significant role in the formation of Cluster 1.

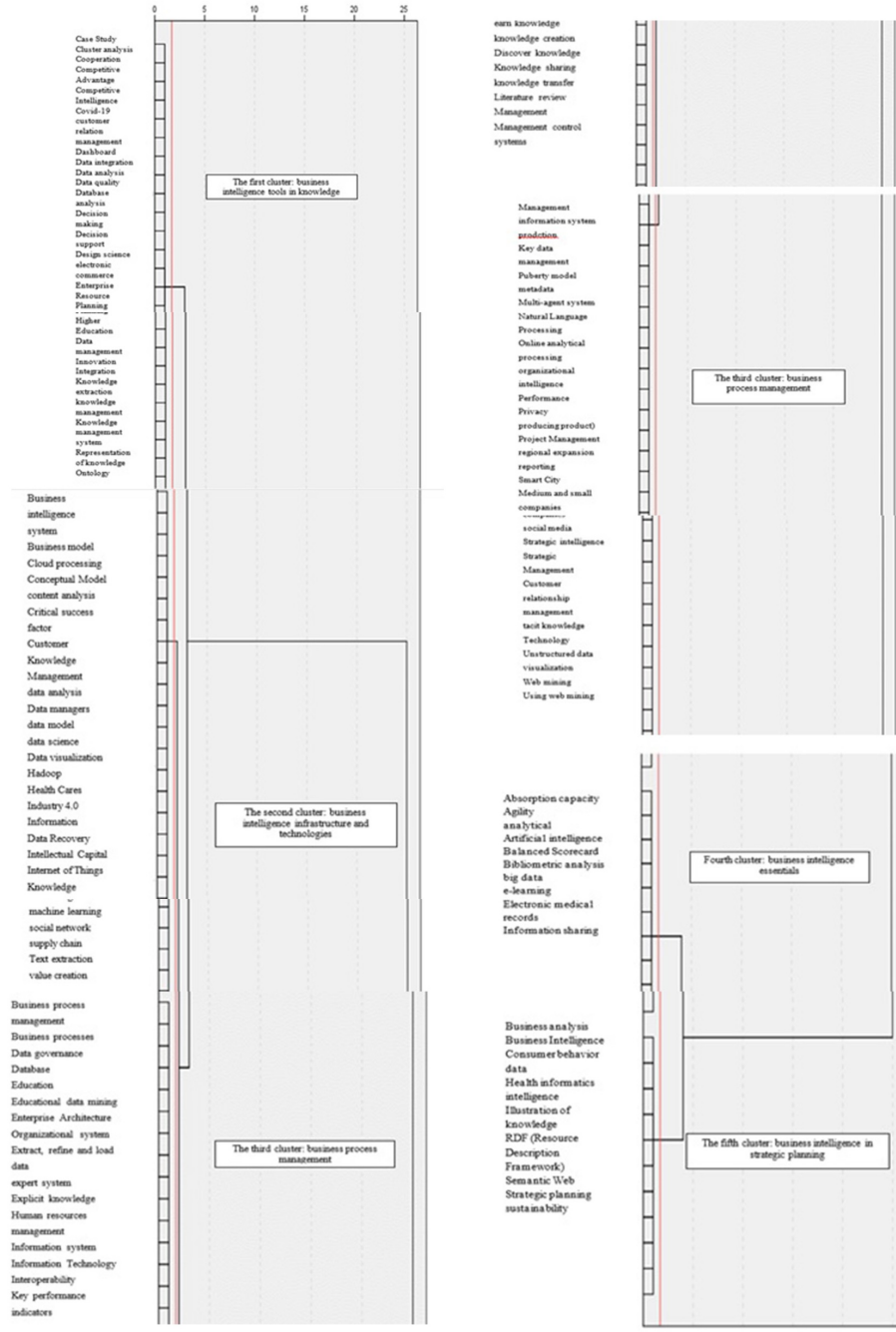

Figure 4: Hierarchical clustering of scientific productions of business intelligence and knowledge assets management

2. **Business Intelligence Infrastructure and Technologies**. The keywords in this cluster, including data science, Industry 4.0, Internet of Things, machine learning, social networks, and supply chain, indicate that this cluster can be referred to as Business Intelligence Infrastructure and Technologies.

3. **Business Process Management through the Management of Knowledge Assets**. The identification, study, and review of topics in Cluster 3, such as business processes, organizational architecture, organizational systems, data extraction, refining and loading, key performance indicators, management information systems, key data management, production (product), and medium- and small-sized companies, suggest that the name Business Process Management is appropriate.

4. **Business Intelligence Essentials**. The results from the co-word analysis indicated that keywords such as artificial intelligence, absorptive capacity, big data, and agility contributed to the formation of Cluster 4.

5. **Business Intelligence in Strategic Planning**. The keywords in this cluster, including data, semantic web, strategic planning, consumer behavior, and business intelligence, suggest that this cluster can be referred to as Business Intelligence in Strategic Planning.

Answer to the Fifth Research Question. In terms of the maturity and development level of the clusters resulting from the co-word analysis, what is the status in the strategic diagram related to the scientific literature on "business intelligence and management of knowledge assets"?

The scores related to the density and centrality of the clusters resulting from the co-word analysis of scientific productions are shown in Table 4.

The results showed that the third cluster, named "Business Process Management through the Management of Knowledge Assets," has the highest centrality at 51, while the fifth cluster, titled "Business Intelligence in Strategic Planning," has the highest density at 1.1. In the strategic diagram, the horizontal axis represents centrality (the degree of cluster correlation), and the vertical axis indicates density (the degree of internal communication within each cluster). It should be noted that the origin of the graph was set to 0.423 and 89.0, respectively, based on the average centrality and density of the clusters. The strategic diagram is presented below, based on the aforementioned scores.

According to Figure 5, the detected clusters are present in the first, second, and third areas. Clusters one, two, and three are located in the first area. It is important to note that the clusters situated in the first area are mature and central to that research domain. In contrast, the fifth cluster is located in the second area.

Table 4: Density and centrality of the clusters resulting from the co-word analysis of scientific productions

Cluster number	cluster title	Density	Centerality
1	Business intelligence tools in knowledge management	1.04	26
2	Business intelligence infrastructure and technologies	1.042	25
3	Business process management through knowledge asset management	1.02	51
4	Business intelligence Essentials	0.244	2.2
5	Business intelligence in strategic planning	1.1	11

The clusters in the second area are not axial; however, they are developed and are of a lower order than the clusters in the first area of the diagram, indicating potential for further development. The fourth cluster, which is located in the third area, is the least significant compared to the other clusters in terms of importance and influence within the research domain. In other words, the clusters in the third area are emerging or peripheral because they address marginal issues that have attracted little attention due to their centrality and low density. Conversely, the clusters in the fourth area are core clusters, but they have not yet developed, meaning they have not reached maturity.

6. Discussion & Conclusion

This research was conducted to elucidate the application of business intelligence in managing knowledge assets through a co-word analysis of scientific literature related to "management of knowledge assets and business intelligence." Utilizing techniques such as co-word analysis, social network analysis, hierarchical clustering, and strategic diagrams, we analyzed 929 relevant scientific productions from 1994 to 2022 sourced from the Web of Science database.

The findings reveal an upward trend in the integration of business intelligence and knowledge management, with publication and citation growth rates averaging 28% and 8.9%, respectively. This aligns with bibliometric research by De las

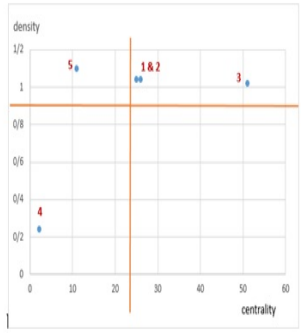

Figure 5: Strategic diagram of scientific productions of business intelligence and management of knowledge assets

Heras-Rosas and Herrera (2021), which highlighted a rising interest in competitive intelligence. Additionally, Lopez-Robles and *et al.* (2018) noted a significant increase in literature published in "Studies of Intelligence in Business." Collectively, these findings underscore that organizational approaches aimed at leveraging business intelligence for performance enhancement are increasingly prominent in the context of emerging technologies.

In terms of key themes, the research identified a predominance of keywords such as "big data," "data mining," "data warehouse," "management," "system," and "design science," particularly the growing significance of "Industry 4.0" and "discovery." Notably, "business intelligence" frequently co-occurred with "knowledge management," "data mining," "big data," and "knowledge discovery." Previous studies by Liang and Liu (2018), Lopez-Robles and *et al.* (2018), and Zou and *et al.* (2019) corroborated the findings, identifying similar high-frequency keywords and thematic focuses, such as cloud computing and competitive intelligence.

Through a co-word analysis encompassing 2,848 keywords, we identified eight clusters, each containing specific themes. These clusters ranged from business intelligence infrastructure and requirements to the role of technology in organizational efficiency. This thematic mapping reveals that while some studies have narrowly focused on business intelligence, others have explored its interplay with knowledge management from various perspectives. The formed clusters highlight the multifaceted dimensions of business intelligence implementation and its relationship with knowledge management—critical considerations for managers and decision-makers.

The analysis indicates that business intelligence is a potent tool for managing organizational assets. In today's data-driven landscape, organizations must not only recognize the importance of knowledge management but also effectively

utilize the vast amounts of data generated as knowledge assets. This imperative aligns with the ongoing Fourth Industrial Revolution and the anticipated Fifth Industrial Revolution, positioning business intelligence as a vital area for enhancing organizational performance and securing a competitive edge.

Moreover, the study identified a positive correlation between the implementation of knowledge management processes and the extent of business intelligence usage. Prior research by Najafi Yazdi (2012), Ranjbar and *et al.* (2013), and **?** supports this notion, emphasizing the beneficial impact of these processes on organizational performance. Similarly, the works of **?**, Shokry and Ghazizadeh (2020), and Abusweilem and Abualoush (2019) demonstrated the significant influence of business intelligence and knowledge management on key organizational performance indicators. Conversely, Rastegar and Hakaki (2020) found that knowledge management's infrastructural capabilities directly and indirectly affect business intelligence through open innovation, while Jedali and jedali (2021) showed its positive impact on employees' innovative behavior. The findings highlight that business intelligence serves as a valuable tool in knowledge management, fostering organizational competitiveness.

The hierarchical clustering analysis yielded five clusters:

- Business Intelligence Tools in Knowledge Management
- Business Intelligence Infrastructure and Technologies
- Business Process Management through Knowledge Asset Management
- Business Intelligence Essentials
- Business Intelligence in Strategic Planning

The identified clusters reflect the most frequently occurring keywords within the scientific literature. While there are overlaps between the clusters from different analyses, the identification of maturity and development levels offers valuable insights. In the strategic diagram, clusters 1, 2, and 3 are situated in the first area, indicating their maturity and centrality within the research domain. In contrast, cluster 5 resides in the second area, suggesting potential for development, while cluster 4, located in the third area, is less significant and represents emerging or peripheral themes.

This scientometric study illustrates the intellectual structure of knowledge in the realms of business intelligence and knowledge management, revealing important and emerging topics alongside existing thematic gaps. The comprehensive identification of key topics and clusters offers valuable insights for researchers, educators, and organizational managers. Based on our findings, we propose several

suggestions for future research and executive actions to further advance the understanding and application of business intelligence in managing knowledge assets.

7. Executive Suggestion

Based on the findings of this research, the following suggestions are proposed:

- **Attention to Key Components:** Organizations should focus on the components, processes, mediating variables, tools, and other critical considerations related to the application of business intelligence in managing knowledge assets. This involves analyzing the identified keywords and concepts to forecast and implement necessary measures in relevant executive and research projects.
- **Infrastructure Development:** It is imperative for managers in organizations and businesses to establish the necessary infrastructure to harness business intelligence and knowledge management effectively. This includes devising strategies for organizational innovation and leveraging technologies such as the Internet of Things, data science, and social networks, as highlighted by the key concepts identified in this study.
- **Encouraging Scientific Collaboration:** Expanding collaborative efforts among researchers across fields such as data science, information science, knowledge science, smart technologies, and knowledge management is crucial. Such interdisciplinary collaboration can enhance the effectiveness of scientific outputs based on the specialized terms identified in this research.

8. Suggestion for future research

The following suggestions are presented based on the findings of this research:

- **Content and Structure Analysis:** Future studies should analyze the content and structure of the concepts and keywords within the scientific documents of the identified subfields and clusters. This analysis should aim to address the limitations of the tools and technologies required by research centers, particularly in Iran.
- **Comparative Co-occurrence Analysis:** Conduct a comparative analysis of the co-occurrence of scientific productions based on important keywords and concepts identified in this study, such as "data warehouse," "knowledge discovery," "data mining," "big data," and "Industry 4.0." This analysis should focus on their frequency, connections, and overall impact.

- **Interdisciplinary Co-occurrence Analysis:** Perform a comparative analysis of the co-occurrence of keywords in scientific productions related to knowledge management and business intelligence across various fields, including computer science, management, business economics, and information science, based on the specialized keywords identified in this research.

- **Broader Database Co-word Analysis:** Conduct co-word analysis of related scientific productions in other databases, such as Scopus and Google Scholar, to extend the scope of the research.

- **Advanced Content Analysis Techniques:** Implement content analysis of related scientific productions using additional techniques such as co-citation analysis and text mining to gain deeper insights into the subject matter.

9. Research limitations

The limitations of the present study include:

- **Scope of Research:** The study's limited scope and the inability to integrate scientific productions from other databases, such as Scopus and Google Scholar, restrict the co-word analysis to the database utilized in this research.

- **Methodological Constraints:** The timing and scope of the research prevent the application of alternative methods and techniques, such as co-citation analysis and text mining, for content analysis of related scientific productions, which would allow for comparative findings across different methodologies.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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