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Big data in the business environment: an analysis of its contributions to Competitiveness. A Literature Review

Big data en el entorno empresarial: Un análisis de sus contribuciones a la Competitividad. Una Revisión de la Literatura

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Abstract

In the era of Industry 4.0, characterized by transformative technological advancements reshaping manufacturing processes, big data has become a common practice in business intelligence. It encompasses the use of data with advanced analytics techniques and plays an important role in business aspects and customer choice. In this context, the primary goal of this research is to comprehend the relationship between big data and the competitiveness of businesses. The research is based on a review of 83 articles published on the Web of Science in the period 2016 and 2023. Through cluster analysis, four groups of research categories are identified in this area (big data and AI in Industry 4.0, analysis of data for decision-making, big data and business innovation, and Internet of Things as a data source). The practical implications of this research are pertinent to organizational management activities involving innovation processes and decision-making, with direct implications for small and midsize enterprises competitiveness. On a theoretical level, the identified categories provide a framework for future research in understanding the connection between big data and competitiveness in the context of industry 4.0.

Resumen

En la era de la Industria 4.0, caracterizada por avances tecnológicos transformadores que dan forma a los procesos de fabricación, el big data se ha convertido en una práctica común en la inteligencia empresarial. Este abarca el uso de datos con técnicas avanzadas de análisis y desempeña un papel importante en los aspectos comerciales y la elección del cliente. En este contexto, el objetivo principal de esta investigación es comprender la relación entre el big data y la competitividad empresarial. La investigación se basa en una revisión de 83 artículos publicados en la Web of Science en el período de 2016 a 2023. A través del análisis de clusters, se identifican cuatro grupos de categorías de investigación en esta área (big data y IA en la Industria 4.0, análisis de datos para la toma de decisiones, innovación empresarial y big data, y el Internet de las cosas como fuente de datos). Las implicaciones prácticas de esta investigación son pertinentes para las actividades de gestión organizacional relacionadas con procesos de innovación y toma de decisiones, con implicaciones directas para la competitividad de las pequeñas y medianas empresas. A nivel teórico, las categorías identificadas proporcionan un marco para futuras investigaciones en la comprensión de la conexión entre el big data y la competitividad en el contexto de la Industria 4.0.

Keywords: Big data, business competitiveness, industry 4.0, innovation.

Palabras clave: Big data, competitividad empresarial, Industria 4.0, innovación.

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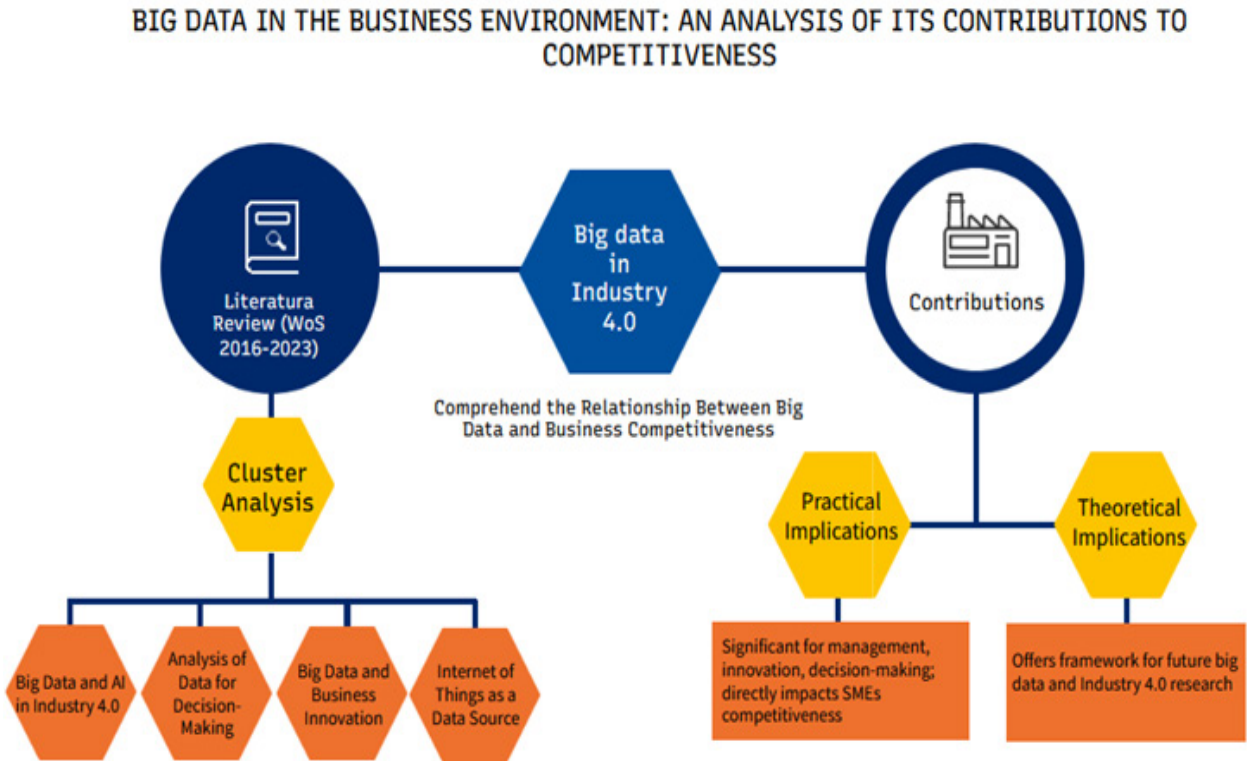
Why was it conducted?
This study is crucial as it addresses the need to comprehend the intersection between big data and business competitiveness in the era of Industry 4.0. With transformative technological advancements in manufacturing processes, big data has become a common practice in business intelligence. The study aims not only to unveil the relationship between big data and competitiveness but also to identify key categories through cluster analysis.

What were the most relevant outcomes?
The study highlights the significant intersection between big data and business competitiveness. In Industry 4.0, the strategic use of big data, along with artificial intelligence and the Internet of Things (IoT), emerges as essential for efficiency, innovation, and decision-making. While big data offers key competitive advantages, critical challenges are noted, from security to cultural adaptation. The study underscores the crucial role of big data in digital transformation and the need to overcome obstacles to maximize its potential in current business environments.

What do these results contribute?
The study significantly contributes to the understanding of big data and competitiveness. It emphasizes the growing interest in sustainability and the evolution in big data implementation, especially in the era of Industry 4.0. The identified categories and technical challenges provide a foundation for future research. Practically, it underscores the relevance of big data in organizational management and decision-making, enhancing internal efficiency and competitiveness. Theoretically, it strengthens research in the Fourth Industrial Revolution, offering a structured framework for understanding the connection between big data and competitiveness, advocating for innovation and ethical use.

Graphical Abstract



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Introduction

The rapid development of the Internet, Internet of Things (IoT), and cloud computing has led to an explosion of data in nearly every industry and business sector in recent years (1). Big data has emerged to provide and analyze rich data, creating new opportunities to improve and support decision making with unprecedented value in the digital age. The use of big data offers a potential solution to reduce the challenges that organizations face in terms of increased complexity and uncertainty in the environment (2). Simultaneously, big data poses challenges in data storage, transfer, processing, and value extraction (3).

According to Jin, Wah (1), the data provided and used by big data can mostly be divided into two types: data in the physical world, typically obtained through sensors, experiments, and observations (biological data, neural data, astronomical data, and others), and human social data that typically comes from sources or domains such as social media, the Internet, health, finance, economics, and transportation (1). While the proliferation of mobile devices and social platforms generate massive amounts of data, developing an information platform to manage these volumes poses a challenge for companies wishing to use these large amounts of data (4).

According to Sheng, Amankwah-Amoah (5), there is no set threshold to determine what size and type of data can be considered big data, as its volume is constantly growing. In fact, there are different ways of quantifying data, and different forms of analysis can generate different sets of data. Although there is no single definition of big data, there seems to be a growing consensus on the uniqueness that separates big data from what we consider big databases according to conventional wisdom.

On the other hand, organizations that can overcome these challenges and derive business value from big data will be able to gain a significant competitive advantage by better analyzing and understanding their products, customers, and transactions. Several researchers have shown interest in big data, since the rapid development of information and communication technologies (IoT, cloud computing, blockchain, Artificial intelligent, etc.) will continue to generate a significant amount of data (6-11). This has given rise to different points of view about the importance of the collection, storage and application of such data that organizations can do (1). In this sense, Manyika et al. (2011), say that big data is interpreted as the next boundary for the innovation, competition, and productivity of organizations.

The development of the Internet and technology has created a continuous network of people, equipment and companies that can now produce competitive and fully customized products for the customer through the continuous exchange of value-creating data and processes (12). This has led to the development of Industry 4.0, known as the Fourth Industrial Revolution. Machines are connected as collaborative communities in this industrial revolution. Such development requires the use of sophisticated predictive tools that systematically transform data into information to reduce uncertainty and facilitate decision-making. Businesses should be aware of these technology trends and strategies that can add business value.

Big data as a research topic is therefore of great importance to ensure that we have strong evidence that new technologies can help companies grow and thrive in a data-driven business environment. In this sense, big data continues to be a hot topic that attracts a great deal of attention from academia, industry and governments around the world (1).

doi: 10.25100/iyc.v26i1.13288

According to (13), despite the vast amount of available data and its increasing complexity, the main challenge that companies face is how to generate value from big data. In a constantly changing business environment, organizations must enhance their adaptability and flexibility by adopting a data-driven management approach that enables them to capitalize on opportunities for creating value from big data. However, there remains a lack of understanding on how to achieve greater competitiveness through the effective use of big data.

On the other hand,(14), points out that, even though the importance of big data is increasingly recognized across different sectors and industries, there is a scarcity of literature synthesis in the field of business management. The absence of a comprehensive review encompassing diverse research disciplines may have hindered the comprehension of previous advancements and, consequently, impeded the identification of clear directions for future investigations (13). Additionally, it is not evident what academic discussions have taken place in the last decade to address the challenges of big data and what knowledge has been uncovered to enhance the understanding of big data analysis. In this context (15) argues that the lack of clarity on big data is attributed to the absence of a thorough review of prior studies that clarifies the boundaries of the subject and the progress achieved by scholars. Therefore, the main objective of this study is to examine the literature related to the relationship between big data and competitiveness in the field of business management, aiming to identify key themes in research and outline future directions for study.
This study analyzes the research that has been carried out since 2016 on big data and business competitiveness. The main objective is to carry out a systematic review of the literature to better understand the relationship between these two concepts, with a specialized focus on Industry 4.0, through an analysis of the knowledge developed in recent years. The evolution of the volume of publications during the period, the order of citations by journal category, main journal and Web of Science categories are shown. Keywords and research areas were explored in more detail. They help to classify the research carried out and provide a framework for future research and classify its main challenges.

The evolution of the big data concept has transcended the mere management of large volumes of data, encompassing various dimensions including variety and speed, as well as variability, veracity, and ultimately, the value generated through action and innovation. This shift reflects a greater maturity and sophistication in the understanding and application of big data in different contexts. Thanking its growth, largely driven by Industry 4.0, the use of the broad term “Big data” in the article provides a solid and recognizable platform to explore various facets of data analysis while also placing the topic in historical context. This allows for a more comprehensive and flexible investigation into the relationship between big data and business competitiveness.

The contributions of this study lie in its synthesis of literature from the perspective of organizational management, highlighting the main areas of research in this academic field. The document describes the connections between the approaches adopted by scholars in relevant areas such as big data and Artificial Intelligence (AI), decision-making, business innovation and IoT as a data source. Through these aspects, challenges faced by organizations in making better use of big data to enhance their business competitiveness can be elucidated. It is anticipated that this review will serve as a platform for future research in this domain.

doi: 10.25100/iyc.v26i1.13288

Big data and business competitiveness

The concept of big data refers to the continuous generation of large volumes of structured, semi-structured or unstructured data from a variety of sources. For Hashem, Yaqoob (8), this concept refers to the growth in the volume of data that exceeds the capacity of traditional database technologies to store, process and analyze the data. In fact, massive amounts of big data are accelerating technological progress. In recent decades, advanced platforms and systems have been invented and adopted for big data processing, which provides advantages over traditional methods in various aspects of data management and analysis (5).

Today, big data analytics has become a modern practice in the field of business intelligence, which combines large data sets and advanced analytical techniques. These play an important role in influencing business activities and customer choice (16). Big data is critical to all manufacturing industries and no single company or industry can be excluded from potentially exploiting the strategic factor. Their introduction can lead to fundamental changes in the daily decision-making of individuals and organizations, and the impact on society is significant (1). With promising development and technology support, big data has become more and more necessary and important in modern business operations. Indeed, there is strong evidence that data is a critical element for companies seeking a competitive advantage (17).

On the other hand, big data and its five "Big V" determine the great advances that the development of data analysis has had. This includes volume (magnitude of data. increasing amount of data), velocity (data is collected and analyzed much faster), and variety (data is collected for multiple purposes regardless of shape or size). The coverage of this mass of data includes customers, markets, trades and interactions, population, resources, weather, facilities, infrastructure, and industries. The last v is about veracity (data quality: to make decisions, it is necessary to know that the data is true) and value (ability to transform data into business) (14, 18-20).

Finally, modern industry developed rapidly. The network economy has contributed to the great development of the industrial economy, and the traditional statistical methods of the industrial economy are no longer suitable for the development needs of modern enterprises. Today is the era of big data. The application of computer technology in industrial economic statistics is an inevitable requirement for industrial modernization and development, and it is also a new social development requirement for industrial economic statistics. Along with the widespread use of the IoT, cloud computing, mobile Internet, remote sensing, and geographic information technologies in the economic field, a more precise economic policy has gradually developed and matured (21).

Method

For this investigation, the three-stage procedure of Tranfield, Denyer (22) has been followed. The first stage is planning the review, the second stage is conducting the review, and the third stage is reporting and dissemination. Each of these steps is described below.

Planning review

Big data is a common term used to frame the analysis of a high volume of data. This analysis can lead an organization to create or improve the products and services it offers, as well

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as respond quickly to business changes that are occurring today. In recent years, big data has received more attention as it is seen as the fundamental foundation for increasing business productivity, enhancing innovation, and enhancing customer relationships. Organizations must be aware of technological trends and strategies that can improve their competitiveness. Therefore, big data bring innumerable challenges for organizations, which makes it necessary to understand the current state of research in this field. In this sense, the following research question has been identified for exploration through a literature review: What are the elements of big data analysis that help elucidate its impact on the competitiveness of organizations? The objective is to define what is known about big data in terms of organizational competitiveness. The main elements of this analysis are described as a framework for future research.

Conducting a review

The conducting phase consists of five steps: (1) defining the initial selection criteria through keywords and search terms; (2) group publications; (3) compilation of a set of considerations; (4) classification of results and (5) synthesis. The first three steps are related to data collection and organization, while the last two steps are related to data processing and analysis. See figure 1.

Big data is related to collecting, storing and extracting data to obtain information that can create significant value by improving the productivity and competitiveness of companies and creating a substantial economic benefit for consumers (23). Likewise, big data applications have been seen in various fields, including medicine, retail, finance, manufacturing, logistics, and telecommunications (24). In this sense, due to their close relationship, in this second phase for the search for publications, the terms “Big data” and “competitiveness” were selected in the title, keywords or abstract between 2016 and 2023 (May) and were compiled using the Web of Science Collections database. This database has been chosen as it is one of the most comprehensive databases of validated knowledge and is likely to have the greatest impact in the field.

Report and dissemination

The review encompassed various academic disciplines, including social sciences, industrial engineering, decision sciences, business management, accounting, economics, econometrics, finance, and interdisciplinary studies. In total, 201 documents were initially gathered. To align with the scope of relevant literature, the decision was made to include only English-language publications, resulting in a reduction to 146 documents. Subsequently, documents that did not align with the study’s objectives were eliminated, leaving a final set of 101 documents. Some articles were excluded due to lack of clarity, while others identified during the review process were added. Ultimately, the final evaluation included 83 articles. The selection and exclusion process, following the PRISMA guidelines employed in this research, is illustrated in Figure 1.

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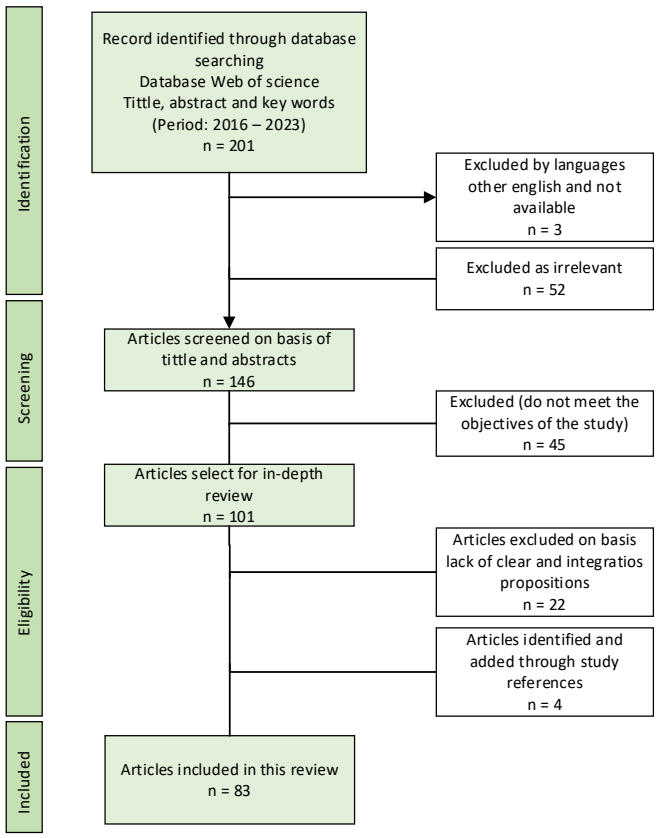

Fig 1. Flowchart of the selection of publications through PRISMA

The distribution of the years of publication of these articles is shown in graphic 1. The number of articles on big data and competitiveness continues to grow due to the growing interest of businessmen and academics in various areas of knowledge (the same trend is expected by 2023). As the world becomes more data-driven, the value of big data in gaining a competitive edge becomes evident. The upward trend in the number of articles reflects the growing importance of leveraging data analytics to enhance decision-making, optimize operations, and stay ahead in competitive markets. This upward trajectory is expected to continue beyond 2023 as companies recognize the transformative potential of big data in driving innovation and sustainable growth.

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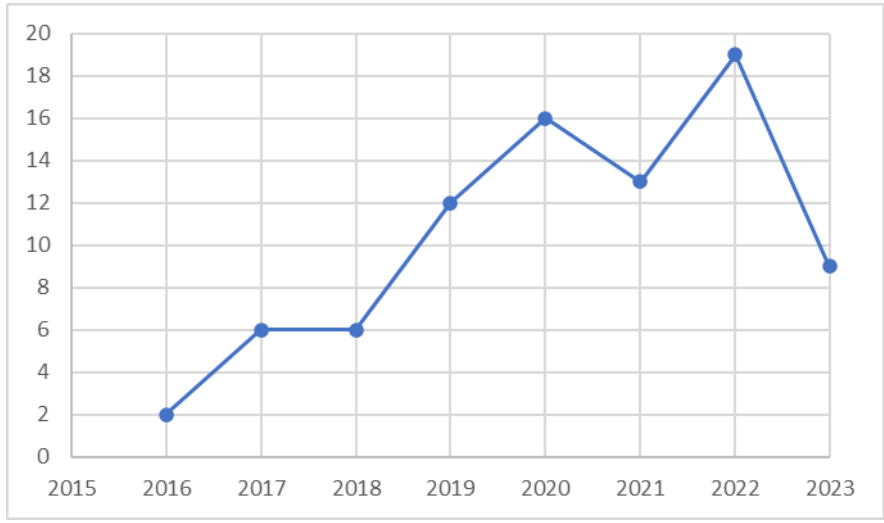

Graph 1. Distribution of publications on big data and competitiveness per year.

Patterns in research production on the intersection of big data and competitiveness across various countries are evident in Table I. In the top 10 countries, China leads prominently with a remarkable 13.0%, indicating a strong focus and leadership in this area. The United States follows in second place with 5.5%, which is significant but notably below China's contribution. Additionally, the presence of South Korea, Italy, and the United Kingdom among the top five suggests geographical diversity in knowledge production at the intersection of big data and competitiveness. Spain, Portugal, India, Brazil, and Russia are also featured, emphasizing the global breadth of research in this field. This analysis provides valuable insights into the geographical distribution of contributions to understanding the relationship between big data and business competitiveness.

Table 1. Top 10 countries shaping research on Big Data and Competitivenes

Country	**Record count**	**%**
China	11	13.3
Usa	5	6.0
South Korea	4	4.8
Italy	4	4.8
England	3	3.6
Spain	3	3.6
Portugal	3	3.6
India	3	3.6
Brazil	2	2.4
Russia	2	2.4

Table 2 summarizes the ten most influential journals in terms of Web of Science citations on topics related to big data and competitiveness, led by sustainability with 43%, International Journal of Production Economics with 12.4%, and IEEE Access with 8%. These figures demonstrate the prominent relevance of "sustainability" as the most important field of

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study in big data and competitiveness, reinforcing its pivotal role in driving environmentally conscious and socially responsible business practices. The high percentage of citations in this area highlights its critical impact on the advancement and understanding of the subject in academic and business communities.

Table 2. Top journals in terms of big data research citations and competitiveness

Journal	Total citations
Sustainability	347
International journal of production economics	100
Ieee access	65
Journal of business research	61
Journal of knowledge management	55
Technological forecasting and social change	41
Engineering	40
Applied sciences-basel	36
Industrial marketing management	31
Journal of business-to-business marketing	30

The Web of Science categories studied were mainly information systems, covering 38.2% and telecommunications with 23.6%. Other areas such as electrical and electronic engineering and science and environmental studies also have a significant number of publications, which indicates that different fields of research are using the term big data and competitiveness as an area of study. See table 3.

Table 3. Top categories of the Web of Science in research on big data and competitiveness

Web of Science Categories	Record Count	%
Computer Science Information Systems	34	38.20
Telecommunications	21	23.59
Engineering Electrical Electronic	18	20.22
Environmental Sciences	11	12.36
Environmental Studies	11	12.36
Green Sustainable Science Technology	11	12.36
Business	10	11.23
Management	10	11.23
Engineering Multidisciplinary	9	10.11
Computer Science Theory Methods	8	8.98

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Keyword analysis

Keyword analysis aims to identify relevant research topics and their relationships with other studies of big data. All keywords (author and PLUS keywords) in the co-occurrence network were used to denote research topics in different disciplines. In the keyword network diagram (figure 2), the most frequently occurring keywords are indicated by larger circles and the lines connecting the keywords indicate the degree of similarity. There were four terms spanning 29 terms related to keywords that appeared at least five times. These terms define the four categories or cluster of big data analysis and competitiveness. The yellow cluster is led by the concepts "Industry 4.0" and "management" and has been called artificial intelligence in industry 4.0 because the descriptors "AI", "challenge", "framework" which prevail and have a strong relationship with this concept according to the literature. The concept of Industry 4.0 refers to a higher level of automation in the industrial sector, where cyber-physical systems work together with the Internet to improve management, productivity, and operational efficiency by connecting elements and interfaces in real time between the virtual world and the physical [25]. Industry 4.0 has been more concerned with the design and implementation of smart factories through the application of emerging technologies in production systems where big data and artificial intelligence stand out [18].

The red cluster focuses on innovation and its impact on business performance, highlighting concepts such as "information", "supply chain management", and "competitive advantage". The relationship between these concepts is that innovation, supported by effective supply chain management and strategic use of information, can boost business performance, and give companies a competitive advantage in a dynamic and challenging business environment.

The blue cluster has been called IoT as a data source and includes the descriptors "analytics", "logistics", "digital transformation", and "supply chain". In this sense, big data provides the necessary database to carry out analysis and obtain valuable information. Analytics allows insights to be extracted from this data, while logistics benefit from using those insights to improve efficiency and quality of service. In addition, IoT facilitates real-time data collection and communication between devices, which empowers analysis and data-driven decision-making. Together, these concepts drive digital transformation and promote innovation in various fields of business.

The green cluster is called data analytics for decision making. In this cluster, the terms "business intelligent", "strategy" and "adoption" stand out and how they can impact "business performance". These concepts are interrelated, in the sense that the use of data analytics and business intelligence allows companies to obtain strategic information. The correct strategy and successful adoption of these tools help improve business performance by identifying opportunities and optimizing operations based on solid, data-driven analysis.

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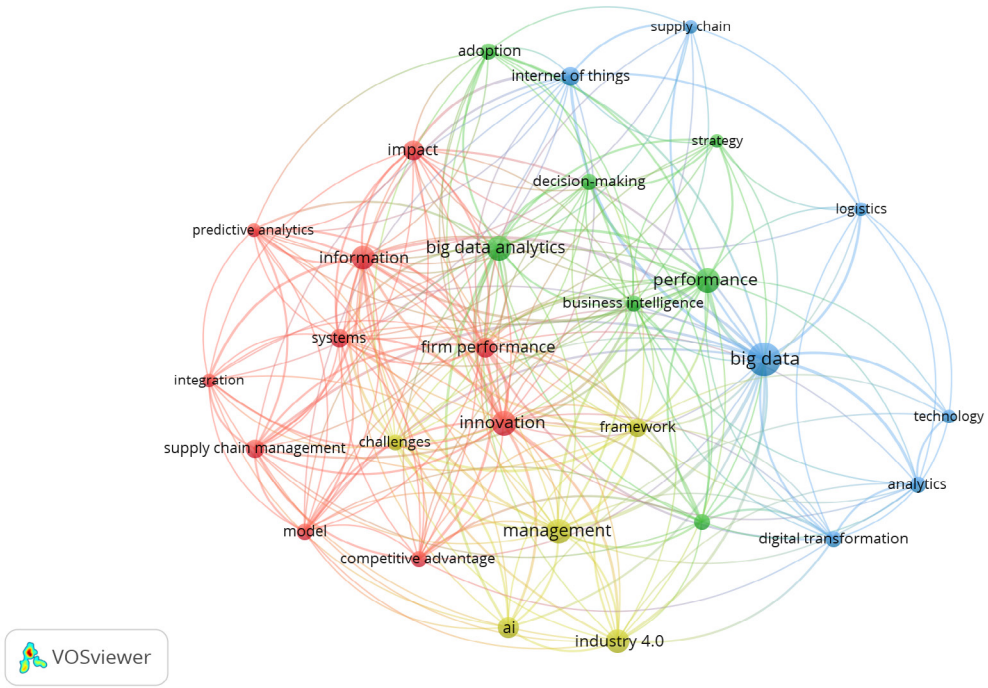

Fig 2. Links between keywords of the reviewed articles

The cluster analysis has allowed classifying the literature on big data and competitiveness into 4 categories. Each one represents a group of keywords identified in the studies. Table 4 summarizes the four categories, the key contents, and the main authors supporting them. This approach provides a clear and structured view of the different topics addressed in the literature, facilitating a deeper understanding of relevant research in this field. Furthermore, it identifies key researchers who have significantly contributed to the advancement of knowledge around big data and competitiveness.

Table 4. Main categories of research on big data and competitiveness from the cluster analysis

doi: 10.25100/iyc.v26i1.13288

Category	Key Contents	Authors
Big data and AI in Industry 4.0	The technological tools of Industry 4.0 allow the improvement of industrial processes. Industry 4.0 facilitates the integration of processes into the supply chain and creates benefits for customers. The use of big data has led to sustainable development and improved business competitiveness. Big data facilitates the use of valuable data throughout a product's life cycle. The application of artificial intelligence and big data in automation and innovative design methods has become an unavoidable trend in the field of product design. The generation and processing of data are undergoing revolutionary transformation owing to the combined effects of big data, data analysis, and artificial intelligence. AI takes analysis to the next level in the development and testing of models, enabling greater automation and sophistication. Data are becoming increasingly meaningful and open new paths for machine learning and artificial intelligence. The problem has gone from collecting massive amounts of data to understanding them, that is, turning data into knowledge.	(12, 18, 25-35) (36)
Data analytic for decision-making	The use of data analysis tools facilitates decision-making (the value of data in decision-making). Effective decision-making based on data analysis ensures competitiveness and sustainable growth. There is a growing demand for data structures that screen and examine information to allow timely and primarily evidence-based decision-making. Data analytics must be able to anticipate and influence consumer behavior. The integration of collaborative data in business intelligence (BI) systems facilitates decision-making processes. The implementation of a decision plan, including data analysis, has a direct impact on company performance.	(3, 9, 11, 37-44)

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Big data and business	The application of big data improves organizations' ability to innovate and respond to market opportunities. Big data leverage open innovation processes. Big data analysis capabilities have a positive impact on business model innovation. The application of a social big data model can open innovation processes within a company. Competitiveness and innovation have benefited considerably from new platforms and methodologies leveraged through data analytics. Big data have made significant contributions to innovation, productivity, and competitiveness. Big data technology is applied to all aspects of human life and brings about technological innovations in various industries. The main drawbacks of the application of big data are the privacy and trust of the data. Businesses must explore innovation opportunities derived from big data and develop appropriate data-driven strategies to enhance competitiveness.	(19, 28, 45-50)
IoT as a data source	Big data obtain valuable information from the data generated by IoT devices, which makes it an effective data analysis tool. Smart supply chain information collaboration is based on the application of the IoT and big data. The arrival of the big data era has led to the development of other technologies, such as IoT, cloud computing, and wireless communication. Big data and IoT technologies have become important competitive tools because of their ability to collect and process data. As IoT devices become miniaturized, their applications grow, as does the amount of data. Proper analysis of big data offers possibilities for sustainable supply chains to increase their competitiveness and improve their performance and efficiency. With a high volume of product flows and complex supply chain processes, more data are generated and collected in supply chains using various sensory and tracking technologies.	(10, 27, 28, 51-56)

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Synthesis of big data and business competitiveness an agenda for future research

Based on the categories of Big Data and Competitiveness identified in the literature review, the following section presents the concepts for each category and the implications they have in an agenda for future research.

Artificial Intelligent e Industry 4.0

Industry 4.0 is a term defined in Germany in early 2010 to about the digital transformation of industry, shaping it with the Fourth Industrial Revolution (57). It refers to the interconnection of intelligent industrial products and processes (12). The development of the Internet and technology has created a continuous network of people, machines and companies, a process of value creation through the constant exchange, which is now possible thanks to the Industry 4.0 buyer (12).

Industry 4.0 is thus established as an easy alternative to adapt to the changes brought about by market demand, based on interconnection elements, and generating greater customer satisfaction and improved business performance. The Industry 4.0 concept is attractive to both modern academic and economic contexts for two main reasons: the first is that innovation is linked to the socio-technological progress that reconditions the new industrial revolution and that is expected throughout the global economy; the second reason is based on the expected efficiency of Industry 4.0 and its ability to solve today's global problems (58). According to Wang, Wan (59), the implementation of Industry 4.0 requires three elements: the horizontal integration of the value chain, vertical integration of networked production systems and engineering, and digitization throughout the value chain. These requirements are supported by new technologies, including automated robots, simulation, horizontal and vertical system integration, industrial IoT, cyber security, cloud-based services, additive manufacturing (3D printing), augmented reality, and big data analytics (60). In Industry 4.0 factories, machines are connected in a collaborative community that exchanges information. This connection requires the systematic processing of data into information using advanced predictive tools to remove uncertainties for better-informed decision decisions.

To illustrate the changes Industry 4.0 will bring to factories, society, and daily life, the 5G era will be characterized by the explosive growth of mobile data traffic, the rapid rise of connected devices, everything in the cloud, and convergence services. This will bring trends such as hyper-realistic media in Knowledge as a Service. All of these are enabled and leveraged by big data analysis (61). Big data is then presented as a technological development related to Industry 4.0 to obtain useful information that helps organizations understand market behavior to predict future needs through the production of innovative business models, projects, products, and services. Leveraging big volumes of data brings enormous benefits as it can be used to reduce production costs and working capital, and to further increase productivity, improve quality and generate higher business revenue in both sectors (62). Recent developments in the big data phenomenon have led companies to increasingly focus on internal and external data management to take advantage of new opportunities suitable for maintaining competitiveness (63).

Therefore, the application of big data from the point of view of Industry 4.0 is very important because it can change the entire business process. A company's competitive advantage may depend on its ability to capture and analyze data to gain business insights (64). Big

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data applications have been used in various fields including medicine, retail, finance, manufacturing, logistics and telecommunications (24). In the future, with the emergence of Industry 5.0, the use of data will also be essential for promoting the training of robots that meet the needs of society (65).

Finally, according to (33), three aspects must be considered to ensure that the implementation of AI brings value to organizations. First, an adequate governance framework is essential to ensure that AI and business analytics are implemented and used responsibly and ethically. Without an appropriate governance framework, there is the risk of AI being used in a discriminatory or harmful manner. In addition, data quality is crucial for the success of AI and business analytics. If the data are not of high quality, AI models will not be able to learn or make accurate predictions. Finally, key employees must be trained to use AI and business analytics effectively. Without proper training, employees may not be able to use these technologies responsibly or efficiently.
These are just some factors that can lead to a lack of transparency in the implementation of AI and business analytics. It is essential to address these factors to ensure that the technologies are implemented and used responsibly and ethically.

Data analysis and decision-making

Big data analytics refers to the overall process of applying advanced analytics skills, such as data mining, statistical analysis, and predictive analytics, to identify patterns, correlations, and trends. Its main contribution is to improve operational efficiency and business profit, and with the proliferation and rapid growth of data, it is becoming essential for enterprises (9, 16). This amount of data floods business operations in time time real-time and impacts decision-making through information mining (5). However, the size of data is often a problem for organizations when choosing how much data to collect and how to analyze and use it. Knowing how to extract valuable information and get the most out of it can be more important than the quality and quantity of data (9).

By collecting and interpreting large amounts of data, companies can identify competitors and respond to customer preferences (5). Furthermore, big data management requires advanced and primarily technology-based analytical approaches, as well as state-of-the-art statistical algorithms consisting of gadget learning, enterprise analytics, clustering, and social community analysis to advantage insights and help decision-making processes (6).
In this sense, big data is a decision support system that includes the overall process of collecting large amounts of data (1). In general, for effective data analysis in decision-making, data warehouses that integrate online transaction processing systems; databases for special storage purposes; online analytical processing for multidimensional analytical data; and data mining, which involves mining data using various technical techniques to extract useful knowledge from the collected data, are required (66). In addition, Balachandran and Prasad (67) define cloud computing and big data as the two most important technologies in recent years. By integrating these two key technologies for data storage and distribution, they explore the improvement of organizational decision-making processes through business intelligence.

In the context of big data, decision science focuses on identifying the values, uncertainties, and optimal decisions. Normative decision theory seeks to find the best methodologies and tools for decision-making based on bounded rationality. Decision-making is present at all

doi: 10.25100/iyc.v26i1.13288

stages of big data, and various techniques such as optimization, statistics, machine learning, visualization, and social network analysis are applied to improve the decision-making process in each stage. Although perfect solutions may not be achieved owing to various challenges, these techniques are valuable for handling the complexity of big data. Additionally, regardless of the challenges, technologies and tools have been developed to support decision making at each stage of big data processing and application. So far, big data have played a central role in numerous decision-making and forecasting domains, such as business analysis, product development, loyalty, healthcare, medical practice, tourism marketing, and transportation (68).

Big data and business innovation

Various studies have highlighted the opportunities and benefits that big data collection, processing, and analysis can bring to companies in terms of innovation, efficiency, productivity, quality, and customer satisfaction, thereby creating a major competitive advantage (69). It is important to understand the role of big data in business innovation, especially in B2B organizations, and where this innovation impacts the customer experience further down the value chain (19).

Del Vecchio, Mele (46), in their study of the tourism sector, show that the introduction of big data offers various opportunities for open innovation and sustainable growth. Acknowledging the importance of big data as a source of open innovation and showing how social networks can be used to encourage closer interaction and user engagement. Social networks are invaluable sources of information that enable open and collaborative innovation in service delivery. Considering that open innovation uses external knowledge in the innovation process and market expansion, big data can be identified as a source of open innovation, including the use of knowledge input and output, which helps to accelerate innovation in the organization (70). Therefore, it can be said that big data and open innovation have a natural relationship. Both deal with highly relevant external knowledge sources for achieving business excellence (46).

Internet of Things as a data source

The new industrial revolution is changing the rules of competition as the digitization of factories and the adoption of IoT concepts completely transform business models and become efficient tools for data analysis (71). Several studies show that ease of data acquisition has become one of the most important competitive tools for organizations, thanks to the connectivity of the IoT and the ability of big data to collect and analyze information from this data (10, 27, 51-54). The progress of IoT technology has enhanced data analysis as it enables real-time data collection from industrial processes for example in the supply chain. IoT encompasses various devices like smart helmets, drones, robots, smart glasses, and smart pipes, which offer real-time assistance and safety by detecting potential damage. These devices transmit the collected data in real-time for monitoring and control purposes (72). Big data provides the opportunity to extract valuable information from large amounts of heterogeneous data collected through various sources (for example, IoT), allowing the integration of sensors in different processes, including manufacturing (73). In this sense, with the increasing miniaturization of IoT devices, a large amount of data has been generated during the last decade. However, this data is meaningless without analytical capabilities. The development of big data solutions and data analysis will provide valuable information on the data generated by IoT devices (55).

doi: 10.25100/iyc.v26i1.13288

The application of big data and IoT in supply chains has improved logistics management using sensors and smart devices. It provides real-time information, visibility, and traceability of products, facilitating planning, problem detection, and data-driven decision making. The combination of big data and IoT enables process automation, reduces delivery times and operational costs, optimizes efficiency, and enhances customer satisfaction for a competitive advantage. However, the implementation of big data in supply chains presents technological risks, followed by human and organizational risks as the main challenges (56).

Finally, the application of big data along with other technologies, such as AI or IoT, offers significant opportunities for business competitiveness, decision-making, and innovation. Nonetheless, they also pose important challenges related to security, privacy, interoperability, scalability, latency, data quality, costs, ethical considerations, and energy consumption. Effectively addressing these challenges is essential for fully leveraging the potential of big data in the context of digital transformation.

The application of big data in organizations poses several challenges, as identified in the state-of-the-art research. First, the collection and management of large volumes of data require appropriate infrastructure and technologies, which can lead to high implementation and maintenance costs. Additionally, the processing and analysis of these data requires professionals with specialized skills in data science and analysis, which represents another challenge in terms of talent and training. Data privacy and security are also critical concerns because handling sensitive information can be vulnerable to breaches and cybersecurity risks. Similarly, the effective integration of insights derived from big data analysis into organizational decision-making may require cultural changes and adaptation processes. In summary, the successful application of big data involves overcoming various barriers. Table 5 categorizes the technical implementation challenges based on the identified categories in the state of the art, along with the transversal implementation challenges discussed by various authors.

Table 5. Technical and transversal challenges of big data implementation

Categories	**Technical challenges**	**Author**
Big data and AI in Industry 4.0	Technological complexity	(36)
	Data collection and management	
	Valid and meaningful insights from AI and big data frameworks used require data of sufficient quality.	
	Changes in the workforce	(74)
	Poor AI scaling due to algorithms that have been designed based on computational models that are no longer realistic for big data	(35)

doi: 10.25100/iyc.v26i1.13288

Data analysis and decision-making	Availability of data for decision making	(5, 14, 18-20)
	Data complexity	
	Analytical capacity for decision making	
	Integration with the organization's current decision-making process	(75)
Big data as a source of innovation	Management and processing of large volumes of data	(3, 46)
	Integration of heterogeneous data sources	
	Analysis and extraction of knowledge	
	Data analysis barriers within the systematic innovation process	(76)
IoT as a data source	Scalability	(77)
	Latency and connectivity	
	Energy consumption	
Transversal challenges	Interoperability	(36, 75, 77)
	Ethical and legal aspects	(15)
	Costs	(75)
	Cultural change and resistance to change	(78)
	Privacy and data security	(36, 49)
	Reliability and veracity of the data	(36, 75)
	Learning and leadership	(7, 78)

Agenda for future research

The fields of AI, big data analytics, big data and business innovation, and big data and IoT are all still in their early stages of development. However, the potential benefits of these technologies are vast, and they are likely to play a major role in shaping the future of business, industry, and society. There are many challenges that need to be addressed before these technologies can be fully realized, such as data privacy and security, Data complexity, interoperability, and accessibility, etc (Fan et al., 2014; Jagatheesaperumal et al., 2021; Younan et al., 2020, Sivarajah et al., 2017, Fan et al., 2014, Grover et al., 2018, Jagatheesaperumal et al., 2021; Al Zahrani and Al Hebbi, 2022, Fan et al., 2014; Jagatheesaperumal et al., 2021, Grover et al., 2018; Gupta and George, 2016). However, it is important to invest in research in these areas to ensure that we can reap the benefits of these technologies while minimizing the risks. Based on the research results and challenges, the following is a future research agenda:

Artificial Intelligent and Industry 4.0

- AI and predictive maintenance: How can AI be used to develop predictive maintenance models that can help businesses to identify and address potential problems before they occur?

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- AI and new product development: How can AI be used to accelerate new product development and bring innovative products to market faster?
- AI and personalized customer experiences: How can AI be used to create more personalized and engaging customer experiences?

Data analysis and decision-making

- Real-time data analysis and decision-making: How can big data analytics be used to develop real-time monitoring and analytics systems that can help businesses to make better decisions faster?
- Data-driven decision-making in complex environments: How can big data analytics be used to support decision-making in complex and uncertain environments, such as financial markets and disaster response?
- Explainable Artificial Intelligent: How can big data analytics be used to develop explainable AI models that can help decision-makers to understand how and why the models make their predictions?
- The ethical and social implications of big data analytics: How can big data analytics be used in a responsible and ethical manner, and how can we mitigate the potential negative impacts of big data analytics on society?

Big data and business innovation

- Develop new products and services: How can big data be used to develop new and innovative products and services?
- Customer experience: How can big data be used to improve the customer experience?
- Business models: How can big data be used to create new business models and revenue streams?
- Efficiency and productivity: How can big data be used to improve operational efficiency and productivity?
- Business decision: How can big data be used to make better business decisions?

Internet of Things as a data source

- Real-time data analysis and decision-making: How can big data and IoT be used to develop real-time monitoring and analytics systems that can help businesses make better decisions faster?
- New products and services: How can big data and IoT be used to develop new products and services that are more responsive to customer needs and deliver more value?
- Personalized customer experiences: How can big data and IoT be used to create more personalized and engaging customer experiences?
- Supply chain optimization: How can big data and IoT be used to optimize supply chains and reduce costs?
- Sustainability and environmental performance: How can big data and IoT be used to improve sustainability and environmental performance?

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Conclusions

The systematic review is a useful tool to inquire about intellectual and academic development in a particular area. The growing interest in big data and competitiveness is evident in the increasing number of publications, aligning with the global shift towards data-driven decision-making. Sustainability emerges as a dominant theme, reflecting its pivotal role in shaping environmentally conscious business practices.

The interest in big data new implementations is evident thanks to the development of other technologies promoted by Industry 4.0. The concept of big data is coined for the analysis of a high volume of data; however, it is evident that it is a more advanced analysis to create or improve products, processes, and services, in addition to responding quickly to business changes promoted by the digitization of the industry.

The study has made it possible to identify that a change is taking place in the way data is collected, stored, processed, and analyzed due to the development and greater penetration of mobile technologies in which users enter information from anywhere in the world. Organizations should be aware of these trends and use them as a competitive strategy to generate new products and services for their customers. In this sense, it continues to be shown that big data is a topic of great relevance in academic research; it demonstrates how emerging technologies can help organizations progress in business environments based on data.

Through the identification of technical and cross-cutting challenges, this study highlights the importance of proper strategic planning, investments in infrastructure and personnel training, and the adoption of data-driven organizational culture. With the successful implementation of these strategies, companies can enhance their competitiveness and stay at the forefront of an increasingly dynamic and challenging business environment with a high level of data utilization.

The practical implications of this work are relevant to the organizational management activities involved in innovation processes. To the extent that organizations, regardless of their size, introduce techniques to take advantage of massive data, these will be used more efficiently in different areas of the organization. On the one hand, the use of massive data brings real value to companies, since it helps decision-making, maintaining competitiveness and internal efficiency. On the other hand, the application of big data can improve an organization's ability to innovate and respond to market opportunities and positively impact business model innovation.

The study has also allowed the categorization of the literature into the most relevant aspects of big data application, such as its significant relevance in future applications of other technologies, such as AI and IoT. It is also possible to identify organizational aspects in decision making and how they can impact the innovation process. In this regard, the convergence of competitiveness, big data, and AI in the context of Industry 4.0 represents a strategic imperative for companies seeking to thrive in a data-driven landscape. As Industry 4.0 continues to unfold and pave the way for Industry 5.0, the effective harnessing of big data and AI will remain instrumental in shaping a competitive advantage, fostering innovation, and ensuring sustained success in the evolving business landscape.

The theoretical implications of this study are related to the strengthening of research on innovation in the context of the Fourth Industrial Revolution, leveraged using information and communication technologies. Moreover, the identification of key categories and their

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essential contents provides a structured insight that can enrich and guide existing theory. This approach contributes to the construction of a more robust theoretical framework for understanding the dynamic connection between big data and competitiveness in the business domain.

The set of categories identified in the relationship between big data and competitiveness frames research in this area and can generate new theoretical research or be validated with future research through case studies or empirical analysis. Moreover, technical, and cross-cutting challenges have been identified, which may be relevant for other researchers seeking to propose solutions for companies facing them. Effectively addressing these challenges requires a long-term perspective and continuous commitment to the adoption and responsible use of big data in the organizational context.

Finally, the research agenda on big data and business innovation has the potential to revolutionize the way businesses operate. By investing in research in this area, we can help businesses to develop new and innovative products and services, improve the customer experience, create new business models and revenue streams, and improve operational efficiency and productivity. We can also help businesses to use big data in a responsible and ethical manner, and to ensure that the benefits of big data are shared equitably across society. It is important to focus on research that can have a real-world impact. Businesses are looking for practical solutions to their problems, so it is important to develop research that can be applied in the real world.

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