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Impact of artificial intelligence on business models in industry 4.0. bibliometric analysis and systematic review of the literature

Victor Yesid Sotelo Torres[1*], Alexander Rodriguez Rodelo[2], Rosa Carolina Cittelly Julio[3], Jhony Alexander Barrera Lievano[4]
[1,2,3,4]Corporación Universitaria Minuto de Dios- UNIMINUTO, Colombia; victor.sotelo@uniminuto.edu.co (V.Y.S.T.) alexander.rrodelo@uniminuto.edu.co (A.R.R.) rosa.cittelly@uniminuto.edu.co (R.C.C.J.) jobarrera@uniminuto.edu (J.A.B.L.)

Abstract: Industry 4.0 represents a paradigm shift in the business and industrial sectors, where the integration of digital and physical technologies transforms how companies operate, conduct business, create value, and interact with their customers in an increasingly automated and digitized world. Despite its technological advancements, Industry 4.0 faces significant challenges, such as resistance to change, the need for adequate technological infrastructure, and the demand for skilled personnel. This article analyzes the impact of artificial intelligence on business models within Industry 4.0, focusing on research conducted between 2018 and 2023 obtained from the Scopus database. The primary question addressed is: What specific impact does artificial intelligence have on the business models of companies in Industry 4.0? To answer this, a systematic literature review was conducted. The study concludes that AI enhances efficiency in companies, playing a significant role in decision-making, innovation, and sustainability, which are critical elements of the business models in Industry 4.0.

Keywords: *AI, Artificial intelligence, Business models, Sustainability, Efficiency, Industry 4.0, Innovation.*

1. Introduction

Industry 4.0 represents an unprecedented shift in the business and industrial landscape, driving a convergence of digital and physical technologies that profoundly transforms the way companies operate, create value, and interact with their customers. This phenomenon is not merely a technological evolution but a structural change in business models and the way companies perceive their role in an increasingly digitalized and automated environment. Schwab [1] founder and executive chairman of the World Economic Forum, describes this revolution as a transformation that changes "the way we live, work, and relate to one another" driven by disruptive technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), advanced robotics, and big data analytics, among others.

In this context, AI stands out as one of the driving forces enabling organizations not only to adapt but also to seize opportunities emerging from this dynamic and competitive environment. The adoption of AI in Industry 4.0 is closely tied to companies' need to transform to remain competitive. AI enables the automation of complex processes, production optimization, and real-time analysis of large data volumes, facilitating informed decision-making and reducing response times to market demands [2]. However, the implementation of these technologies presents significant challenges, such as resistance to change, the need for suitable technological infrastructure, and the demand for specialized talent capable of managing and optimizing these systems [3].

AI's ability to optimize business models, enhance efficiency, and improve competitiveness is crucial, prompting the need to identify its impact on business models within Industry 4.0. This becomes the central research objective for this study. One of the most important aspects of AI in this context is its ability to significantly improve operational efficiency. AI enables companies to track their operations in

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* Correspondence: victor.sotelo@uniminuto.edu.co

detail and make decisions based on predictive analytics [4] potentially transforming operations and corporate strategies.

As Davenport and Ronanki [2] argue, AI can be applied in various areas, from supply chain optimization to service personalization, making companies more agile and capable of adapting to changes in the business environment. At the same time, AI allows organizations to anticipate issues before they arise, optimize resource usage, and reduce operational costs. This focus on efficiency not only increases company profitability but also has a direct impact on sustainability, an increasingly relevant topic in the industrial domain [3].

However, implementing AI in Industry 4.0 business models also presents several challenges. One of the main hurdles is resistance to change, both within organizations and among individuals. Integrating AI systems requires restructuring internal processes and fostering an organizational culture willing to embrace automation and data-driven decision-making [5]. To overcome this barrier, companies must implement change management strategies that include ongoing training, incentives for adopting new technologies, and effective communication highlighting AI's benefits in improving productivity and reducing human error [6]. Furthermore, strong leadership is essential to drive and support these technological initiatives, creating an environment conducive to innovation and collaboration across multidisciplinary teams [7].

Transforming business models in Industry 4.0 also involves reevaluating revenue streams and how companies create and capture value. Osterwalder and Pigneur [8] define a business model as the architecture of a company's products, services, and revenue streams. In Industry 4.0, traditional models must adapt to integrate disruptive technologies and maximize the opportunities they offer [1]. Platform-based models allow companies to connect multiple stakeholders (customers, suppliers, and partners) through a single digital infrastructure, facilitating collaborative value creation and real-time data exchange.

AI plays a key role in enabling mass personalization, adapting products and services to meet specific customer needs [9]. Another relevant model is the subscription model, where customers pay recurring fees to access products or services. This model provides greater revenue stability and fosters continuous customer relationships, which are especially valuable in an industrial setting where customer loyalty and satisfaction are crucial for long-term success [8]. AI enables the prediction of future needs by offering personalized products that enhance customer satisfaction and retention [9].

Likewise, the "products as a service" model, where physical products are offered for a recurring fee, also benefits significantly. This approach facilitates predictive maintenance, optimizing resource utilization and reducing costs associated with downtime [10]. The relationship between Industry 4.0 and AI not only transforms business models but also redefines employees' roles within organizations. As AI takes on repetitive tasks, human capital is redirected toward higher-complexity and creativity-driven activities, such as strategic analysis and product or service innovation.

This shift creates a demand for specialized skills, requiring companies to invest in continuous employee training to ensure adaptation to new roles demanded by Industry 4.0 [11]. In this sense, AI is not just a tool to enhance operational efficiency but also an opportunity to foster internal talent development and strengthen a culture of innovation [11]. Current research highlights that, despite the challenges, AI has the potential to revolutionize business models in Industry 4.0, making them more agile, efficient, and customer-oriented [3]. AI's ability to process and analyze large volumes of data in real time provides a comprehensive view of operations, enabling companies to identify opportunities for improvement and optimization [12].

Moreover, it facilitates the creation of innovative products and services that respond to changing market demands, a critical factor for differentiation in an increasingly competitive environment [10]. In conclusion, AI has become a central pillar of Industry 4.0, with its impact on business models being both broad and profound. Its ability to transform production processes, optimize resources, and personalize customer experiences makes it an indispensable tool for companies aiming to remain relevant in the

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digital age. The adoption of AI not only represents a competitive advantage but also poses a series of challenges that organizations must address to ensure effective and sustainable implementation.

2. Methodology

This article aims to make a significant contribution to academic literature through a systematic literature review, which applies systematic approaches to individual studies to collect and synthesize data that provides a clear and precise answer to the research question [13]. To structure this approach, the methodology described by Peralta, et al. [14] is adopted, oriented toward the field of social sciences, consisting of six fundamental steps. Additionally, this procedure is complemented by the development of the components of the PRISMA [15] statement protocol ensuring transparency and rigor in the review process. The essential steps are outlined below:

Step 1: Formulating research questions: A primary research question is posed, accompanied by two complementary questions that delve into different aspects of the investigative process: What impact does artificial intelligence have on the business models of Industry 4.0 companies? What research methodologies have been implemented for these studies? What data collection instruments have been used in the development of these investigations?

Step 2: Selecting databases and formulating search equations: For the review, the Scopus bibliographic database is chosen, recognized for its extensive scope and quality of scientific content. The main terms used in the search equations are detailed in Table 1. From these terms, synonyms and equivalent key concepts are identified, which are integrated to optimize search precision and broaden the scope of results obtained. The following equation is used for the search: (artificial AND intelligence) AND (business AND model) AND (companies OR enterprises OR business) AND (industry 4.0).

Table 1.
Terms to be used in the search equation in the Scopus database.

Artificial intelligence	Business model	Companies	Industry 4.0
		Enterprises	
		Business	

Step 3: Definition of inclusion and exclusion criteria: The following criteria are established for selecting documents: the review period covers 2018 to 2023; the types of documents considered include scientific articles, book chapters, and books; and the accepted languages are English and/or Spanish. Additionally, as an essential inclusion criterion, access to the full version of the document is required to ensure a thorough analysis.

Step 4: Bibliometric analysis: Recognizing the importance of bibliometric analysis in evaluating scientific output [16] a descriptive statistical approach is employed. This analysis considers various categories, such as the identification of journals, authors, affiliated institutions, and countries of publication, among others. These factors help identify patterns and trends in knowledge production related to the research topic, offering a quantitative perspective on academic contributions in the field.

Step 5: Evaluation of the scientific quality of publications: The scientific quality of the documents included in the systematic review is assessed using eleven criteria adapted from Peralta, et al. [14] as modified by Gast, et al. [17]. These criteria enable a rigorous and consistent evaluation of the relevance and scientific robustness of the selected publications. To evaluate each quality criterion, a three-level scoring system is applied: 0.0 when the criterion is not clearly defined, 0.5 when the criterion is present but not entirely clear, and 1.0 when the criterion is fully and clearly presented [18]. Based on these parameters, the scoring scale ranges from 0 to 11 points. A document must achieve a minimum score of 7 to be considered for inclusion in the systematic review.

After applying the established criteria, the results are presented following the PRISMA [15] statement which outlines the necessary elements for the correct preparation and presentation of systematic reviews and meta-analyses, as shown in Figure 1.

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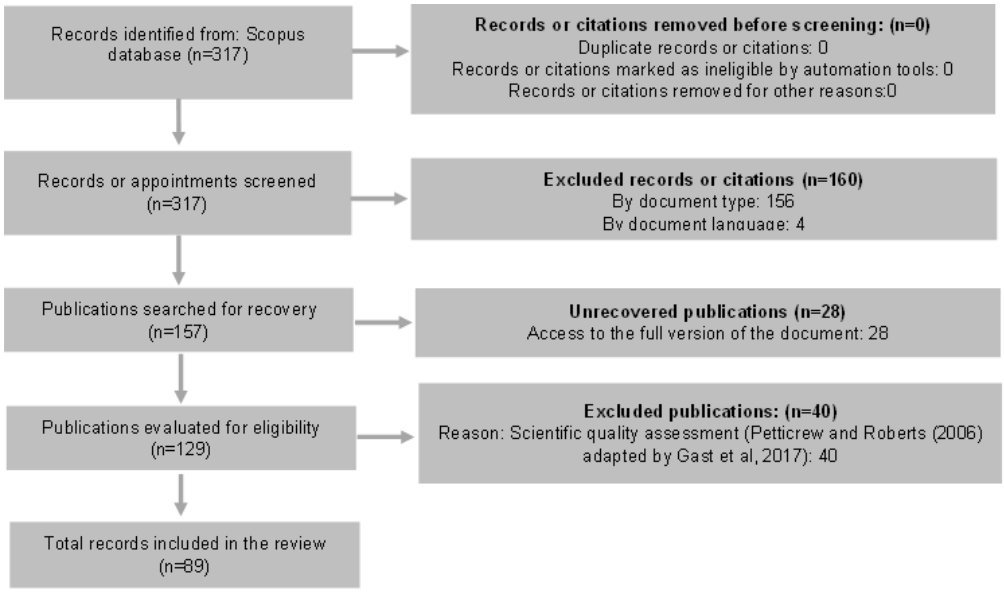

Figure 1.
Schematic of the application of the method established in the PRISMA declaration.
Source: Gonzalez, et al. [19].

Once the selection process was completed according to the established parameters, out of the 317 documents identified in the Scopus database, 89 records were selected for inclusion in the review. Table 2 summarizes the selected documents, providing the following details: the identification number assigned in this review, the document citation, the year of publication, the number of citations, the type of document, and the research methodology employed.

Table 2.
Documents included in the systematic review.

ID	Document citation	Year	Cites	ID	Document citation	Year	Cites	ID	Document citation	Year	Cites
1	Wan, et al. [20]	2021	109	31	Kartanaitė, et al. [21]	2021	16	61	Bergami, et al. [22]	2023	4
2	Kitsios and Kamariotou [23]	2021	102	32	Rodríguez-Espíndola, et al. [24]	2022	16	62	Gupta [25]	2022	4
3	Matulis and Harvey [26]	2021	91	33	Khalifa, et al. [27]	2021	15	63	Jallow, et al. [28]	2022	3
4	Kumar, et al. [29]	2023	90	34	Lo [30]	2023	15	64	Barbazzeni, et al. [31]	2022	3
5	Akyazi, et al. [32]	2020	84	35	Trstenjak, et al. [33]	2022	13	65	Sun, et al. [34]	2021	3
6	Rodrigues Dias, et al. [35]	2022	75	36	Ahamed and Vignesh [36]	2022	13	66	Dima [37]	2021	3
7	Gupta [25]	2021	66	37	Klumpp [38]	2018	12	67	Biclesanu, et al. [39]	2023	2

8	Jung, et al. [40]	2021	64	38	Luque-Vega, et al. [41]	2019	11	68	Hajipour, et al. [42]	2023	2
9	Trakadas, et al. [43]	2020	59	39	Eugeni, et al. [44]	2022	11	69	Sousa, et al. [45]	2022	2
10	Cantú-Ortiz, et al. [46]	2020	54	40	Han, et al. [47]	2023	11	70	Zotov and Kadirkamanathan [48]	2021	2
11	Popkova, et al. [49]	2020	51	41	Urba, et al. [50]	2022	11	71	Dumanska, et al. [51]	2021	2
12	Deebak and Al-Turjman [52]	2021	49	42	Peralta, et al. [14]	2019	11	72	Ramírez-Gutiérrez, et al. [53]	2023	2
13	Marrella [54]	2019	41	43	Redchuk and Mateo [55]	2022	9	73	Krzywdzinski and Butollo [56]	2022	1
14	Gonçalves, et al. [57]	2022	36	44	Harrington and Srai [58]	2023	8	74	Sobhanmanesh, et al. [59]	2023	1
15	Chen, et al. [60]	2021	34	45	Kihel, et al. [61]	2021	8	75	Banitaan, et al. [62]	2023	1
16	Kazancoglu, et al. [63]	2023	32	46	de-Lima-Santos, et al. [64]	2022	7	76	Dvořáková, et al. [65]	2021	1
17	Colla, et al. [66]	2020	31	47	Kraus, et al. [67]	2022	7	77	Hrbić and Grebenar [68]	2022	1
18	Awan, et al. [69]	2021	28	48	Kolmykova, et al. [70]	2021	6	78	Wu, et al. [71]	2023	1
19	Silva, et al. [72]	2021	26	49	Talafidaryani, et al. [73]	2021	6	79	Wehberg [74]	2020	1
20	Ferreira, et al. [75]	2023	26	50	Buntak, et al. [76]	2020	6	80	Cavata, et al. [77]	2020	1
21	Rajbhandari, et al. [78]	2022	24	51	Ananias and Gaspar [79]	2022	5	81	Karapalidou, et al. [80]	2023	1
22	El Bazi, et al. [81]	2023	24	52	Matt, et al. [82]	2021	5	82	Ahsan, et al. [83]	2023	1
23	Azevedo and Almeida [84]	2021	24	53	Barros, et al. [85]	2023	5	83	Park, et al. [86]	2023	0
24	Schwab [1]	2020	24	54	Borodavko, et al. [87]	2021	5	84	Popkova and Sergi [88]	2023	0
25	Longo, et al. [89]	2021	24	55	Wardhiani, et al. [90]	2023	5	85	Mortada and Soulhi [91]	2023	0
26	Rojek, et al. [92]	2023	23	56	Mohapatra, et al. [93]	2023	4	86	Kraus, et al. [67]	2023	0
27	Akyazi T. et al. (2020)	2020	23	57	Glinkina, et al. [94]	2020	4	87	Karbekova, et al. [95]	2023	0
28	Sivamohan and Sridhar [96]	2023	17	58	Kolmykova, et al. [70]	2020	4	88	Banjanović-Mehmedović	2021	0

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									and Mehmedović [97]		
29	Calabrese, et al. [98]	2023	17	59	Capetillo, et al. [99]	2021	4	89	De Souza, et al. [100]	2020	0
30	Nabeeh, et al. [101]	2022	16	60	Agrawal, et al. [102]	2023	4				

Step 6: Category Analysis. The analyzed categories emerge directly from the formulated research questions. These categories are proposed based on the questions posed, as presented below:

Table 3.
Work categories.

Question	Categories
What impact does artificial intelligence have on the business models of Industry 4.0 companies?	Improve efficiency Makes decision-making easier Improve sustainability Promote Innovation Promote technological transformation Increase productivity Automate processes Strengthen the competitive advantage Boost digital transformation Greater profitability Increase performance Corporate strategy Greater precision and safety
What research methodologies have been implemented for these studies?	Quantitative Qualitative Mixed
What data collection instruments have been used in the development of these investigations?	Database Software Case study Survey Matrix Interviews Questionnaire Focus group Observation

3. Results

The following presents a detailed bibliometric analysis of publications related to Industry 4.0 and artificial intelligence from 2018 to 2023, based on information reported in the Scopus database. Similarly, the findings related to the research questions posed in the proposed systematic literature review are also presented.

3.1. Bibliometric Analysis

The initial analysis focuses on the number of publications per year, limited to the period between 2018 and 2023, reflecting an upward trend in publication output, as identified in Figure 2.

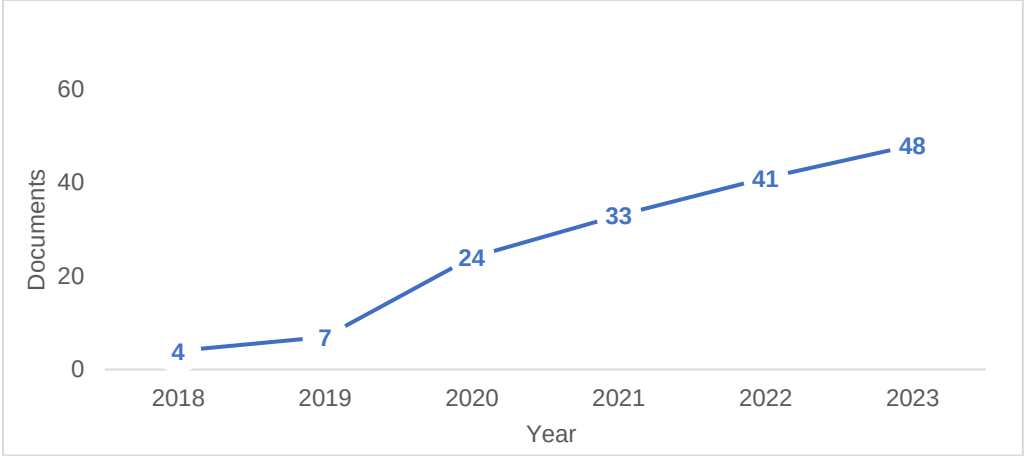

Figure 2.
Documents per year.

La figura 2 presenta el número de documentos publicados por año desde 2018 hasta 2023, se observa que existe una tendencia creciente en la producción de publicaciones. On the other hand, Figure 3 illustrates how the documents are distributed according to their publication type, based on the 89 records included in the review.

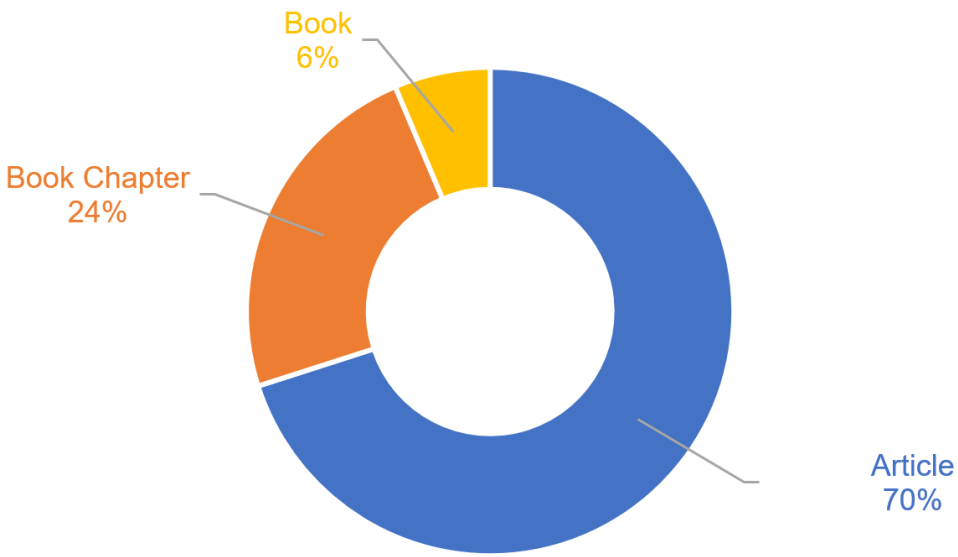

Figure 3.
Documents by type.

Figure 3 illustrates the distribution of documents by type, highlighting that articles dominate with a total of 110 (70%), underscoring their primary role in the reviewed literature. Book chapters take second place with 37 documents (24%), indicating a significant but smaller presence compared to articles. Finally, books, with only 10 documents (6%), make up the least represented category.

Regarding affiliations, Figure 4 presents the top 10 institutions with the highest number of published documents in the review, showing how academic production is distributed among leading universities and business schools.

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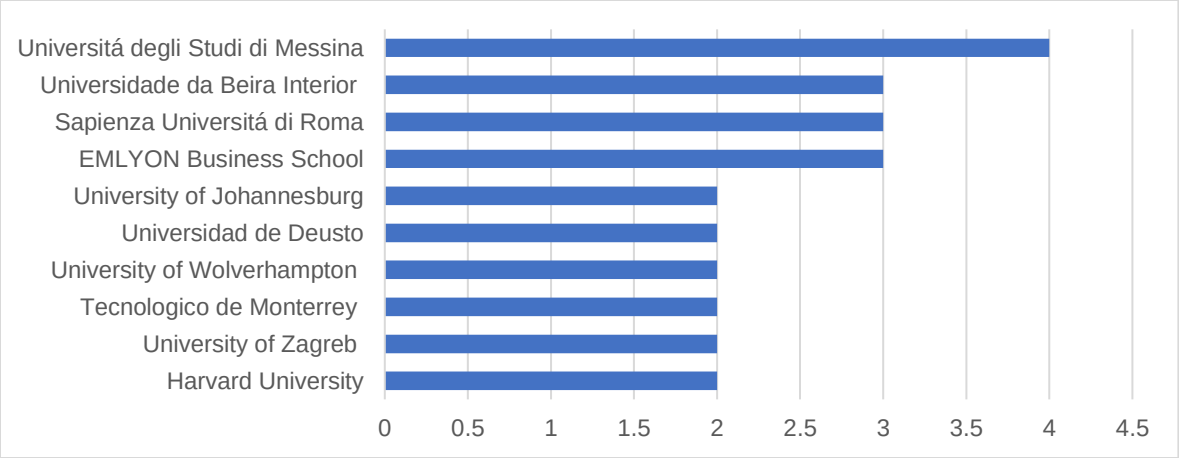

Figure 4.
Documents by affiliation.

Each of the universities or schools listed in Figure 4 has contributed more than one publication. As shown, the institution with the highest number of publications is the Universitá degli Studi di Messina, with four documents. This highlights that there is no dominance of any particular institution in terms of a significant number of publications in the field of knowledge. On the other hand, regarding authors with the highest number of publications, Figure 5 presents the top 10 in the field of knowledge.

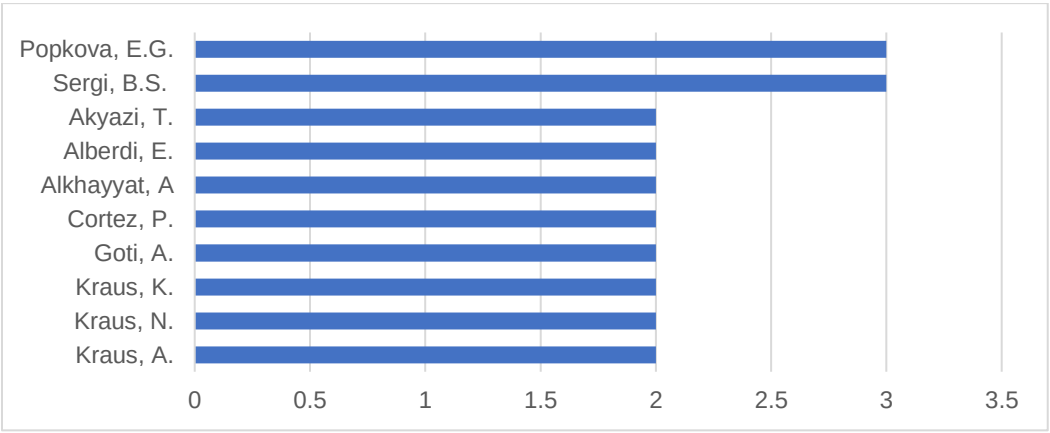

Figure 5.
Documents by author.
Source: Popkova and Sergi [88]; Akyazi, et al. [32]; Kraus, et al. [103] and Kraus, et al. [67].

As illustrated in Figure 5, the most prominent authors have made a contribution of three publications each [88]. Similar to author affiliation, it can be observed that there is no dominance of a particular author with a significant number of publications. However, a trend can be seen with the two mentioned authors, as they appear to be consolidating their presence in this specific field.

Regarding the funding sources for the publications, a similar phenomenon occurs as with author affiliation and the number of documents published by each author. Figure 6 presents the findings.

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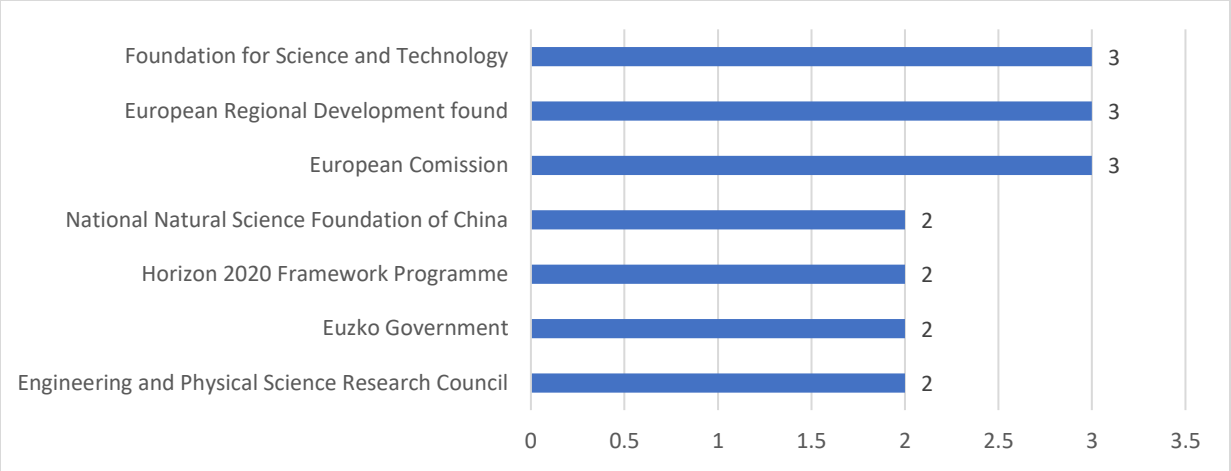

Figure 6.
Documents by funder.

As shown in Figure 6, the main funding sources for research in this field of knowledge are the European Regional Development Fund and the Fundação para a Ciência e a Tecnologia, each with three documents.

Regarding the number of documents by country, Figure 7 presents the findings from the review. Notably, Latin America does not appear in the top 9 of publications, which range between 8 and 25 documents.

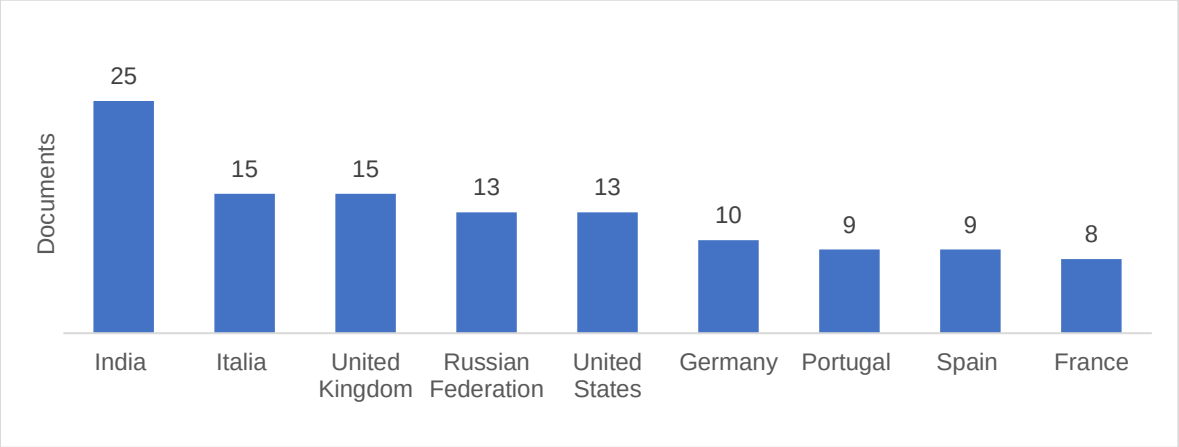

Figure 7.
Documents by country.

As can be seen, India consolidates its position in first place with 25 published documents. Italy and the United Kingdom follow with 15 documents each, reflecting significant research activity in Europe regarding this field of knowledge, with countries such as Russia, Portugal, Spain, and France contributing with fewer publications. This solidifies Europe as the region with the highest number of publications in this area.

On the other hand, Figure 8 presents an analysis of the co-authorship network in the studies reviewed, highlighting the interactions between researchers in the field. Below, an interpretation of the observed connections and collaborative patterns is provided.

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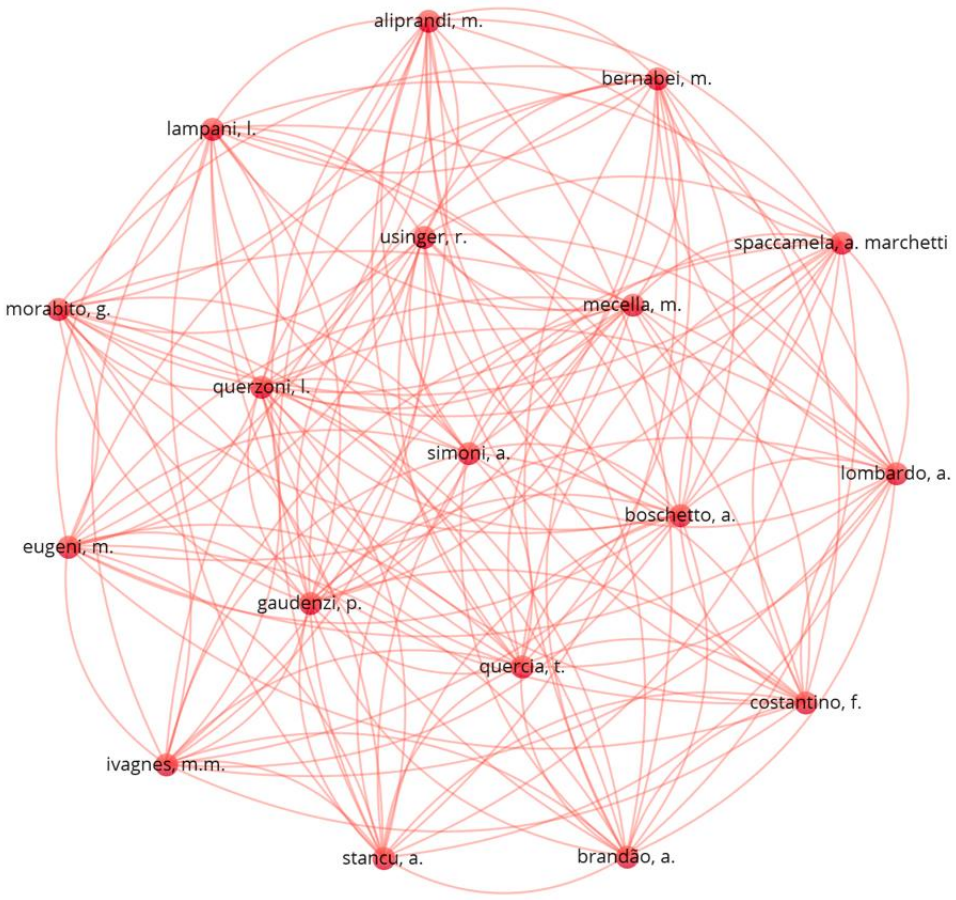

Figure 8.
Analysis by author.

Figure 8 shows a co-authorship network where researchers such as Simoni and Lombardo occupy central positions, indicating a high frequency of collaborations. The closer working groups between nodes, such as those of Spaccamela and Marchetti, reflect intense collaboration. In contrast, authors like Morabito and Ivagnes are positioned on the periphery of the network, suggesting lower integration within the core of collaboration. This pattern reveals a structure in which a few authors concentrate the connections, while others maintain more isolated links.

Figure 9 presents an analysis of the most frequent keywords in the studies related to the field of knowledge, highlighting the main technologies and concepts emerging in the literature.

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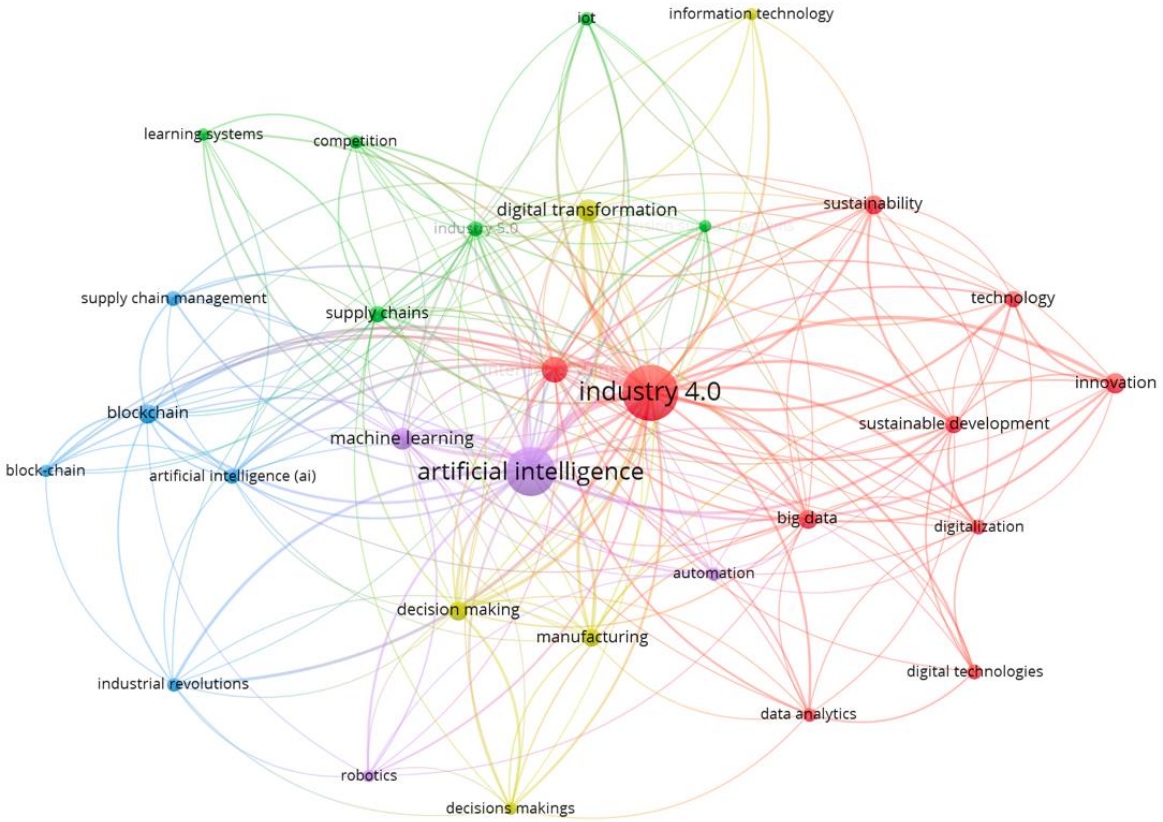

Figure 9.
Analysis of concurrency by keywords.

Figure 9 shows that "Industry 4.0" is the most frequent keyword, with 89 occurrences, accounting for the highest percentage of appearances (23%). "Artificial Intelligence" also shows a high frequency, with 69 occurrences and 18% representation. The term "Internet of Things" represents 5% (19 occurrences), and "Machine Learning" accounts for 4% (14 occurrences).

The relationship between the different keywords indicates a strong interconnection between emerging technologies such as IoT, Machine Learning, and Big Data, all of which are crucial for the automation and digitization of industry. These technologies work complementarily, driving the transformation of industrial processes towards more efficient and connected models. Additionally, the presence of terms like "sustainable development" and "sustainability" suggests that sustainability is emerging as an important consideration within the framework of Industry 4.0.

3.2. Category Analysis

The following presents the results emerging from the three research questions posed. The findings provided serve as the foundation for addressing and analyzing the study's issues.

Question 1: What type of impact does artificial intelligence have on the business model of companies in Industry 4.0? The following outlines the various impacts that artificial intelligence has on the business models of companies in Industry 4.0, based on the analysis of the reviewed documents.

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Table 4.
The type of impact of artificial intelligence on the business model of Industry 4.0 companies.

Impact	Number of documents	Document ID
Improve efficiency	32	1, 3, 5, 8, 11, 12, 15, 19, 22, 24, 25, 27, 30, 31, 36, 39, 43, 53, 54, 56, 60, 61, 63, 69, 70, 78, 80, 81, 83, 85, 87, 88
Makes decision-making easier	9	7, 9, 18, 23, 34, 35, 65, 74, 79
Improve sustainability	8	16, 17, 20, 29, 32, 40, 48, 55
Promote Innovation	8	37, 38, 44, 57, 59, 64, 84, 86
Promote technological transformation	7	21, 49, 52, 62, 72, 73, 76
Increase productivity	5	6, 33, 41, 45, 66
Automate processes	5	13, 50, 51, 58, 89
Strengthen the competitive advantage	4	46, 67, 75, 82
Boost digital transformation	4	4, 10, 14, 47
Greater profitability	3	26, 42, 71
Increase performance	2	68, 77
Corporate strategy	1	2
Greater precision and safety	1	28

As shown in Table 4, 36% of the reviewed documents highlight artificial intelligence (AI) for its contribution to operational efficiency in Industry 4.0. Additionally, 10.1% of the documents emphasize AI's role in decision-making. Sustainability and innovation, each representing 9% of the documents, also reflect the relevance of AI in promoting sustainable practices and fostering innovative environments within companies.

Question 2: What research methodologies have been implemented in the development of the studies? Regarding the methodological approach, Table 5 presents the distribution of documents based on the research methodology used, categorized into three types: quantitative, qualitative, and mixed.

Table 5.
Documents by research methodology.

Research Methodology	Number of documents	Document ID
Quantitative	47	2, 4, 5, 6, 8, 9, 12, 15, 18, 19, 20, 21, 24, 26, 28, 29, 30, 31, 34, 36, 38, 39, 41, 42, 45, 49, 50, 51, 53, 55, 56, 58, 64, 65, 66, 67, 69, 70, 74, 77, 80, 81, 82, 84, 85, 87, 89
Qualitative	18	1, 3, 7, 13, 14, 16, 22, 23, 32, 33, 37, 40, 46, 47, 54, 62, 63, 73
Mixed	24	10, 11, 17, 25, 27, 35, 43, 44, 48, 52, 57, 59, 60, 61, 68, 71, 72, 75, 76, 78, 79, 83, 86, 88

Of the 89 documents processed, 53% correspond to quantitative research, making this methodology the most predominant in the majority of the studies, which favor numerical analysis and statistics for addressing their research. The qualitative methodology, with 18 documents, represents 20% of the total, and finally, the mixed methodology, which combines both quantitative and qualitative elements, represents 27% of the total. A trend toward the use of numerical data and statistical analysis is evident in the reviewed research corpus.

Question 3: What Instruments Have Been Used in the Development of the Studies?: The table provides a detailed overview of the data collection instruments employed in the reviewed studies.

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Table 6.
Documents by data collection instruments.

Data collection instrument	Number of documents	Document ID
Database	39	2, 4, 5, 9, 10, 12, 15, 18, 19, 24, 25, 26, 27, 28, 29, 34, 40, 42, 43, 48, 49, 50, 53, 60, 61, 65, 69, 72, 74, 75, 76, 77, 82, 84, 86, 87, 88, 89
Software	26	8, 11, 17, 18, 26, 29, 30, 31, 35, 36, 37, 39, 41, 42, 47, 51, 56, 70, 71, 77, 78, 79, 80, 81, 83, 85,
Case study	21	1, 3, 10, 11, 13, 14, 16, 22, 33, 35, 37, 43, 44, 54, 61, 63, 68, 71, 73, 75, 83
Survey	11	6, 20, 21, 38, 50, 52, 57, 60, 64, 67, 76
Matrix	11	16, 17, 25, 44, 47, 55, 59, 62, 79, 86, 88
Interviews	10	7, 14, 23, 32, 46, 52, 57, 72, 73, 76
Questionnaire	5	35, 45, 55, 59, 66
Focus group	3	22, 23, 55
Observation	1	32

As shown, databases stand out as the most common resource, being used in 31% of the analyzed documents. Software comes in second place with 20%, reflecting the importance of computational tools for data analysis and modeling. Other instruments, such as case studies, are used in 17% of the documents.

Together, the distribution in the table reflects a variety of instruments used, with a clear predominance of quantitative techniques, in line with the research methodology that predominates in the body of knowledge addressed.

4. Discussion

As evidenced by the results, 36% of the reviewed studies highlight the contribution of artificial intelligence (AI) to operational efficiency in Industry 4.0. This supports the assertions made by Brynjolfsson and McAfee [4] and Davenport and Ronanki [2] who emphasize that AI allows companies to optimize production and automate complex processes, as AI can profoundly transform business operations and strategies.

Additionally, 10.1% of the documents address the significant role of AI in decision-making, due to its ability, among other things, to process large volumes of data [5].

Sustainability and innovation are two key aspects in the current business context, each representing 9% of the analyzed documents. This underscores the importance of AI in promoting sustainable practices and creating innovative environments within companies. According to Brock and Von Wangenheim [3] AI not only helps improve operational efficiency but also has a positive impact on the environment, which reinforces these findings.

This comparison helps us better understand how AI is influencing business models within Industry 4.0. It highlights its transformative role in areas such as efficiency, innovation, and sustainability. In a world where companies seek to adapt and thrive, integrating these dimensions becomes essential for long-term success.

5. Conclusions

The growing use of artificial intelligence (AI) in Industry 4.0 is a rapidly expanding phenomenon, as demonstrated by the bibliometric analyses conducted. This is understandable, given the significant impact AI has had on the business realm in general. The purpose of this research was to examine how AI influences business models within Industry 4.0. The results indicate that its effect is primarily manifested in improving operational efficiency, facilitating informed decision-making, promoting sustainable practices, and stimulating innovation. These findings suggest that AI should not only be viewed as a technological tool but also as a strategic driver that fuels both innovation and sustainability.

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In terms of the methodologies used, there is a clear preference for quantitative approaches (53%), which focus on measuring the tangible benefits of AI through numerical and statistical data. However, mixed methodologies (27%) also play an important role by offering a more comprehensive view that combines both quantitative and qualitative data.

Regarding research instruments, the predominant use of databases (31%) and software tools (20%) reflects a trend toward the exhaustive analysis of structured information. Despite this, case studies (17%) remain valuable, as they provide in-depth and specific analyses that complement quantitative approaches.

In summary, artificial intelligence has established itself as a crucial element in the transition to more efficient, sustainable, and innovative business models within the context of Industry 4.0. However, the dominance of structured, quantitative methodologies suggests an opportunity to expand research toward qualitative approaches that address the challenges and perceptions of AI from a more human perspective. As a future research direction, it is essential to explore the impact of AI on the emerging Industry 5.0, a model that not only aims to optimize efficiency but also integrates social and environmental sustainability objectives, promoting a balance between economic development and ecological responsibility.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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