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RESEARCH

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RELATIONSHIP OF INDUSTRY 4.0 TECHNOLOGIES IN BUSINESS DEVELOPMENT. A LITERATURE REVIEW

Relación de las Tecnologías de la Industria 4.0 en el desarrollo Empresarial. Una revisión de Literatura

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ABSTRACT

The incursion of information and communication technologies is generating the transformation of organizations towards intelligent industry management, involving changes in manufacturing and management of processes for development and business. In this context, the objective of this study focuses on conceptually understanding the relationship of industry 4.0 technologies in business development through a deep literary review. Within the methodology used, the use of a qualitative analysis stands out since the study tried to discover patterns and categories supported by the use of different documents, the information was processed through the ATLAS.ti9 software in order to structure, categorize and contrast the information obtained through semantic networks, co-occurrence table and the calculation of the Emergency Index. Among the main results, the obtaining of 30 codes stands out, the same ones that were generated through the processing of information from the different documents taken into consideration for the study. The codes obtained were grouped into the guiding categories (industry 4.0 technologies and business development), in addition to this, the obtaining of 13 emerging codes also stands out. That is to say: those that are most related to the study variables (industry 4.0, technology, competitive advantage, innovation capacity, decision-making, digitization, technological development, continuous improvement, productivity, business adaptation, economic benefits, business competitiveness and levels quality).

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Keywords: industry 4.0, business development, competitive advantage, economic benefits, decision making.

RESUMEN

La incursión de las tecnologías de la información y comunicación está generando la transformación de las organizaciones hacia una gestión de industria inteligente implicando cambios en la manufactura y gestión de procesos para el desarrollo y crecimiento empresarial. Bajo este contexto, el objetivo del presente estudio se centra en comprender de forma conceptual la relación de las tecnologías de la industria 4.0 en el desarrollo empresarial a través de una profunda revisión literaria. Dentro de la metodología empleada se destaca la utilización de un análisis cualitativo pues el estudio pretendió descubrir patrones y categorías apoyado en el uso de diferentes documentos, la información fue procesada a través del software ATLAS.ti9 con la finalidad de estructurar, categorizar y contrastar la información obtenida mediante redes semánticas, tabla de co-ocurrencia y el cálculo del Índice de Emergencia. Entre los principales resultados se destaca la obtención de 30 códigos, los mismos que fueron generados a través del procesamiento de información de los diferentes documentos tomados en consideración para el estudio. Los códigos obtenidos fueron agrupados en las categorías orientadoras (tecnologías de la industria 4.0 y desarrollo empresarial), adicional a ello, se destaca también la obtención de 13 códigos emergentes. Es decir: aquellos que más relación guardan con las variables de estudio (industria 4.0, tecnología, ventaja competitiva, capacidad de innovación, toma de decisiones, digitalización, desarrollo tecnológico, mejora continua, productividad, adaptación empresarial, beneficios económicos, competitividad empresarial y niveles de calidad).

Palabras clave: industria 4.0, desarrollo empresarial, ventaja competitiva, beneficios económicos, toma de decisiones.

Relação das tecnologias da Indústria 4.0 com o desenvolvimento empresarial. Uma revisão da literatura

RESUMO

A incursão das tecnologias de informação e comunicação está a gerar a transformação das organizações no sentido da gestão inteligente da indústria, envolvendo mudanças na gestão do fabrico e dos processos para o desenvolvimento e crescimento do negócio. Neste contexto, o objectivo deste estudo centra-se em compreender conceptualmente a relação entre as tecnologias da Indústria 4.0 e o desenvolvimento empresarial através de uma revisão aprofundada da literatura. Dentro da metodologia empregada, destaca-se o uso de uma análise qualitativa, pois o estudo visou descobrir padrões e categorias apoiadas no uso de diferentes documentos, as informações foram processadas através do software ATLAS.ti9, a fim de estruturar, categorizar e contrastar as informações obtidas através de redes semânticas, tabela de co-ocorrência e o cálculo do Índice de Emergência. Entre os principais resultados, foram obtidos 30 códigos, gerados através do tratamento da informação dos diferentes documentos considerados para o estudo. Os códigos obtidos foram agrupados nas categorias orientadoras (tecnologias da Indústria 4.0 e desenvolvimento empresarial), para além

dos quais foram obtidos 13 códigos emergentes. Ou seja, aqueles que mais se relacionam com as variáveis de estudo (Indústria 4.0, tecnologia, vantagem competitiva, capacidade de inovação, tomada de decisão, digitalização, desenvolvimento tecnológico, melhoria contínua, produtividade, adaptação empresarial, benefícios económicos, competitividade empresarial e níveis de qualidade).

Palavras chave: indústria 4.0, desenvolvimento empresarial, vantagem competitiva, benefícios económicos, tomada de decisão.

1. INTRODUCTION

The adoption of Industry 4.0 enables companies to become highly efficient and address the challenge of producing individualized products with short time-to-market and higher quality. The potential of Industry 4.0 lies in greater flexibility and scalability of manufacturing systems through information technology and industrial automation (Obermayer et al., 2022).

Industry 4.0 has brought about the introduction of cutting-edge information technology-based solutions in all aspects of production, allowing not only for the creation of specific products requested by customers but also complete related value chains. In this regard, thanks to the use of advanced information and communication technologies and open innovations, it is possible to adjust production more precisely to customer expectations while maintaining high quality, efficiency, and low costs (Grabowska and Saniuk, 2022).

New models and commercially applicable technologies such as artificial intelligence are accelerating the transformation processes of the industry by changing business methods and the current market structure itself. It is important to note that Industry 4.0 is not just about technology, but also about new ways of working. It is a concept that aligns with the fourth industrial revolution and involves all elements of the value chain, including suppliers, producers, business partners, and end customers. In this context, production within Industry 4.0 is directly associated with high-quality services (Sony and Naik, 2020).

Based on the aforementioned background, it can be mentioned that Industry 4.0 provides new paradigms that improve the performance of industrial management in companies and organizations. With the support provided by information technologies, this concept appears to be more flexible and less costly than the traditional information systems commonly employed in the business environment (Severino et al., 2019).

Currently, business models are heavily influenced by the presence of Industry 4.0, as this new paradigm leads to the emergence of new forms of communication implemented within supply chains (CEPAL, 2019). In the business field, Industry 4.0 implies the existence of a complete communication network among different actors within the organizational field (Kiel et al., 2017).

The transformation experienced in the business sphere has been directly supported by the development and use of technologies to improve performance. Consequently, their application is evident in the analysis of large amounts of data, the simulation of virtual models that enable process management, control, and quality. In addition, other technologies such as 3D printing, cloud computing, the Internet of Things, wireless payment methods, and recent advances in artificial intelligence contribute to the increasing prominence of Industry 4.0. Therefore, its integration within the organizational scope becomes necessary.

Another aspect to highlight with the experienced technological development is the integration of robotics. In this sense, these advancements have contributed to the development of various fields such as genetics, biotechnology, and nanotechnology, paving the way for the development of artificial intelligence (Morán, 2019). This situation has led to a significant leap in processes and business management. Based on this foundation, through these types of tools, companies seek to gain a competitive advantage in the market as they facilitate management and have a positive impact on business performance (Ruiz et al., 2018; Demuner et al., 2022).

Furthermore, companies have been structuring their manufacturing processes through the use of virtual computers connected to the internet and advanced analytics platforms. These platforms allow for the processing of a series of data to make decisions and generate end products that satisfy existing market needs (Lalaleo and Martínez, 2022). In addition to the aforementioned, the communication offered by these technologies is synchronized through devices that enable direct contact between production plants, offices, and departments, allowing them to share information and communicate in real time regardless of their location. This facilitates the execution of various activities (Reyes and Ordóñez, 2020).

Finally, it is important to highlight that due to the size of the company and the fact that some of these technologies are still very expensive, the implementation of these technologies cannot be considered an easy task under any circumstances. However, nowadays, the market offers a wider range of solutions with options of all kinds, which has started to democratize access to them. In this regard, companies, according to their capabilities, implement the use of technologies that provide a significant impact, especially in managing their information, in order to improve performance and organizational management (Álvarez, 2015).

2. OBJECTIVES

The objective of this study is to conceptually understand the relationship between Industry 4.0 technologies and business development through a literature review by searching for information in high-impact scientific articles. The information processing aims to establish a convergence of perspectives that contributes to identifying labels that allow for the characterization of this relationship through semantic networks.

In the study context, the intention is to identify dimensions that help establish frequently used terms in the business field, which enable the establishment of the direct relationship between Industry 4.0 technologies and business development.

3. METHODOLOGY

The study is based on a qualitative approach. According to Hernández and Mendoza (2018), this approach involves organizing the collected data, transcribing the information when necessary, and subsequently coding it. In this sense, coding can be executed at two levels: 1) generating units of meaning (codes), and 2) establishing categories that group the identified codes. Therefore, this study aims to establish patterns and categories through the coding of a series of documents (articles retrieved from searching and exploring different databases) whose content is associated with the proposed theme.

To support the study, a considerable number of documents (articles) were considered, and inclusion criteria were applied based on exclusively considering materials that contain specific information on Industry 4.0 technology and business development. Another aspect to highlight within these criteria is that the documents used for the study had to have a substantial bibliographic foundation to support each of them. On the other hand, the exclusion criteria involved the exclusion or omission of bibliographic material that lacked a sufficient body of scientific literature to support the previously presented content.

Once the documents that meet the characteristics detailed in the previous lines have been identified, the next step in the process was focused on information processing, for which it was relevant to use the ATLAS.ti9 software. The use of this software allowed for the processing of qualitative information. To reinforce this initial idea, it is worth mentioning what Sabariego et al. (2014) state about ATLAS.ti: "It is a specialized software package for qualitative data analysis that allows for extracting, categorizing, and interlinking data segments from various documents" (p.123). In this context, the use of the mentioned software facilitated the establishment of different patterns that guided the execution of the study through stages such as structuring, categorization, contrast, and interpretation.

Based on the aforementioned background, the use of ATLAS.ti9 enabled the following actions: the generation of semantic networks, and visualization of the relationships among the processed documents. Furthermore, the program allowed for establishing levels of correlation among the identified codes through co-occurrence analysis. Additionally, the origin of the identified codes is presented through code-document analysis, and finally, those codes that are most closely related to the object of study were determined by calculating the Emergence Index (IDE).

4. RESULTS

4.1. Semantic networks

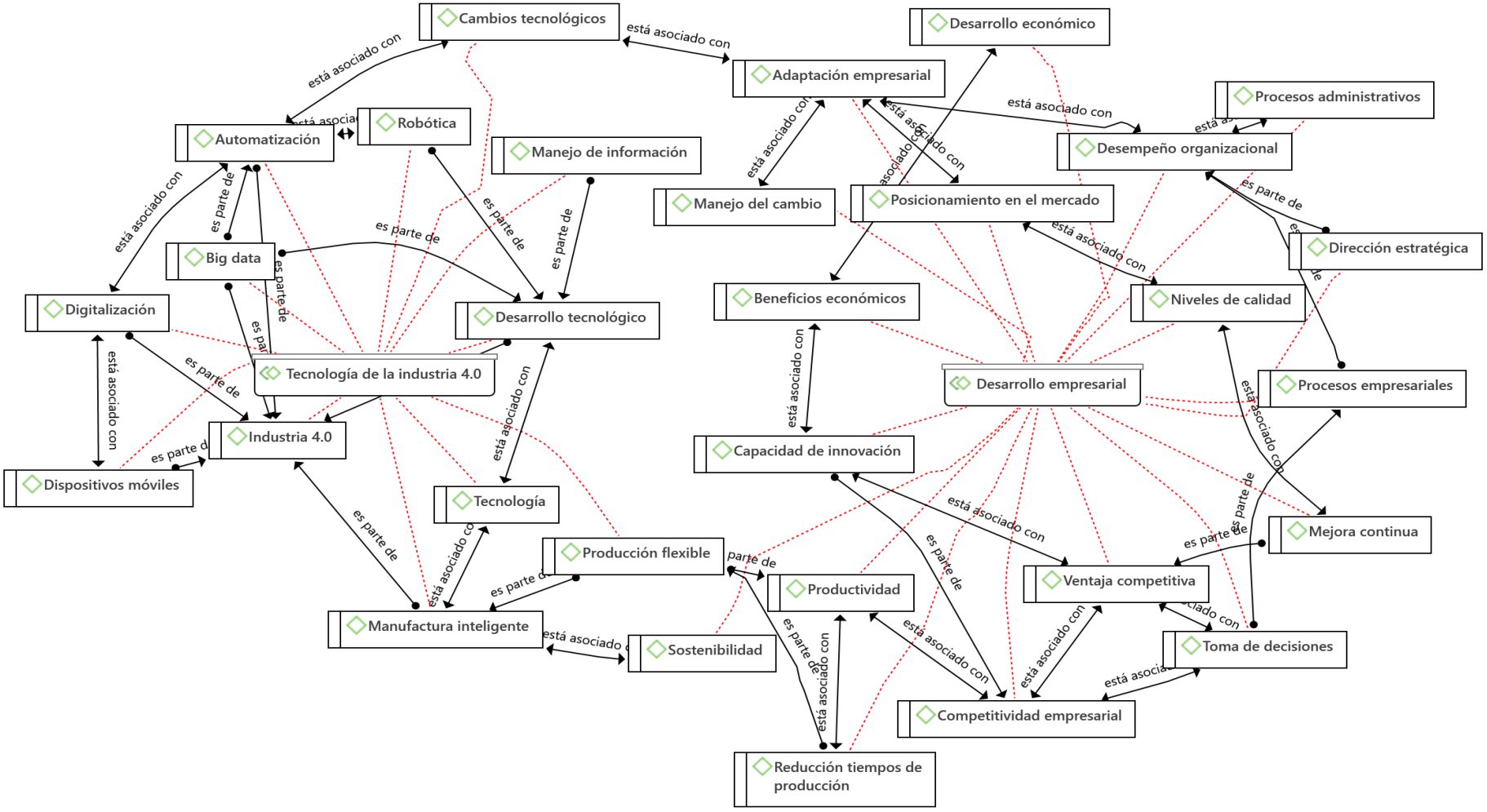
From the perspective of González et al. (2021) as cited in Lalaleo and Martínez (2022), "a semantic network constitutes an interconnected representation scheme, as a way of representing linguistic knowledge, where codes and their interrelationships are illustrated through a graph" (p. 344). Based on this, as a first step, it was necessary to establish guiding categories through the convergence of perspectives, that is, through the processing of the collected documents in this case. The information was exclusively obtained from scientific articles retrieved from important scientific databases.

On the other hand, once the guiding categories within the study were established, the next aspect of being developed was the coding process, which focused on parameterizing quotes from the analyzed documents, where a compilation of them accounted for a series of meanings (González et al., 2021). Based on this, the coding process began with the creation of code groups (industry 4.0 technology and business development) and document groups (articles). Subsequently, codes were assigned freely within the different documents used. As a result, the procedure allowed for the identification of a total of 30 codes, which were grouped into the previously defined guiding categories for further analysis.

Within the technology dimension of Industry 4.0, 12 codes were identified: automation, big data, technological changes, technological development, digitalization, mobile devices, industry 4.0, information management, intelligent manufacturing, flexible production, robotics, and technology. On the other hand, in terms of the business development dimension, a total of 18 codes were identified: business adaptation, economic benefits, innovation capacity, business competitiveness, economic development, organizational performance, strategic management, change management, continuous improvement, quality levels, market positioning, administrative processes, business processes, productivity, reduction in production times, sustainability, decision-making, and competitive advantage.

Once the coding process was completed, converging the processed information was next. This procedure involved gathering and dialectically cross-referencing all the collected information based on the variables considered in the study (see Figure 1).

Figure 1. *Semantic networks (groups of codes, groups of documents, and interconnections between codes).*



Source: Lalaleo et al. (2023).

4.2. Co-occurrence analysis

Within this procedure, it was necessary to create a matrix with the number of co-occurrences between the different identified codes. This allows us to observe the correlation between the established codes through the processed information.

Table 1.

Co-occurrence table.

Codes	Correlation	
Big data / Mobile devices	1,00	100%
Decision Making / Competitive Advantage	0,79	79%
Economic benefits / Business competitiveness	0,60	60%
Competitiveness / Economic benefits	0,60	60%
Continuous improvement / Competitive advantage	0,60	60%
Flexible production / Reduction of production times	0,60	60%
Reduction of production times / Flexible production	0,60	60%
Competitive advantage / Continuous improvement	0,60	60%
Technological changes / Digitization	0,58	58%
Digitization / Technological changes	0,58	58%
Economic development / Economic benefits	0,50	50%
Market positioning / productivity	0,50	50%
Productivity / Market positioning	0,50	50%
Industry 4.0 / Competitive advantage	0,48	48%
Technology / Industry 4.0	0,46	46%
Business adaptation / Decision making	0,43	43%
Organizational performance / Business competitiveness	0,43	43%
Technological development / Economic benefits	0,42	42%
Automation / Business Processes	0,40	40%
Innovation capacity / Technological changes	0,40	40%
Information management / Sustainability	0,40	40%
Change Management / Competitive Advantage	0,40	40%
Administrative processes / Automation	0,40	40%

Business Processes / Automation	0,40	40%
Sustainability / Information management	0,40	40%
Quality Level / Competitive Advantage	0,38	38%
Strategic Direction / Organizational Performance	0,33	33%
Smart manufacturing / Continuous improvement	0,33	33%
Robotics / Reduction of production times	0,25	25%

Source: Lalaleo et al. (2023) using ATLAS.ti9.

4.3. Code-document analysis

Within the code-document analysis, each document is assessed for its interaction with the assigned codes. This analysis quantifies the frequency of codes in the different analyzed documents, in this case, exclusively using information from scientific articles.

Table 2.

Code-document analysis

	Articles				**Totals**		
	Absolute	Relative to the row	Relative to the column	Relative to the table	Absolute	Relative to row	Relative to the table
Business development	27	100,00%	49,09%	49,09%	27	100,00%	49,09%
Industry 4.0 technology	28	100,00%	50,91%	50,91%	28	100,00%	50,91%
Totals	55	100,00%	100,00%	100,00%	55	100,00%	100,00%

Source: Lalaleo et al. (2023) using ATLAS.ti9.

Within Table 2, the presented information allows for detecting the frequency of codes in the analyzed documents (articles) and their percentage distribution. Specifically, in the development of this study, the following can be mentioned: out of 100% of the identified codes in the processed documents, 50.91% contain information related to Industry 4.0 technology, while the remaining 49.09% demonstrate a direct relation to business development.

4.4. Analysis of the Emergency Index (EI)

In this section, the different codes that emerged, meaning those that have a stronger relationship with the study area, are presented. To do this, it was necessary to calculate the Emergency Index (EI) for each code. This calculation involved identifying the sum of rooting (E) and density (D). Once these values were determined, the next step was

to calculate the arithmetic mean of the EI. Any code with a value higher than the arithmetic mean was considered an emergent category. As mentioned earlier, the resulting codes are those that have a stronger relationship with the identified guiding categories. In the specific case of this study, the following codes stood out: Industry 4.0, technology, competitive advantage, innovation capacity, decision-making, digitalization, technological development, continuous improvement, productivity, business adaptation, economic benefits, business competitiveness, and quality levels (see Table 3).

Table 3.

Calculation of the Emergency Index (EI)

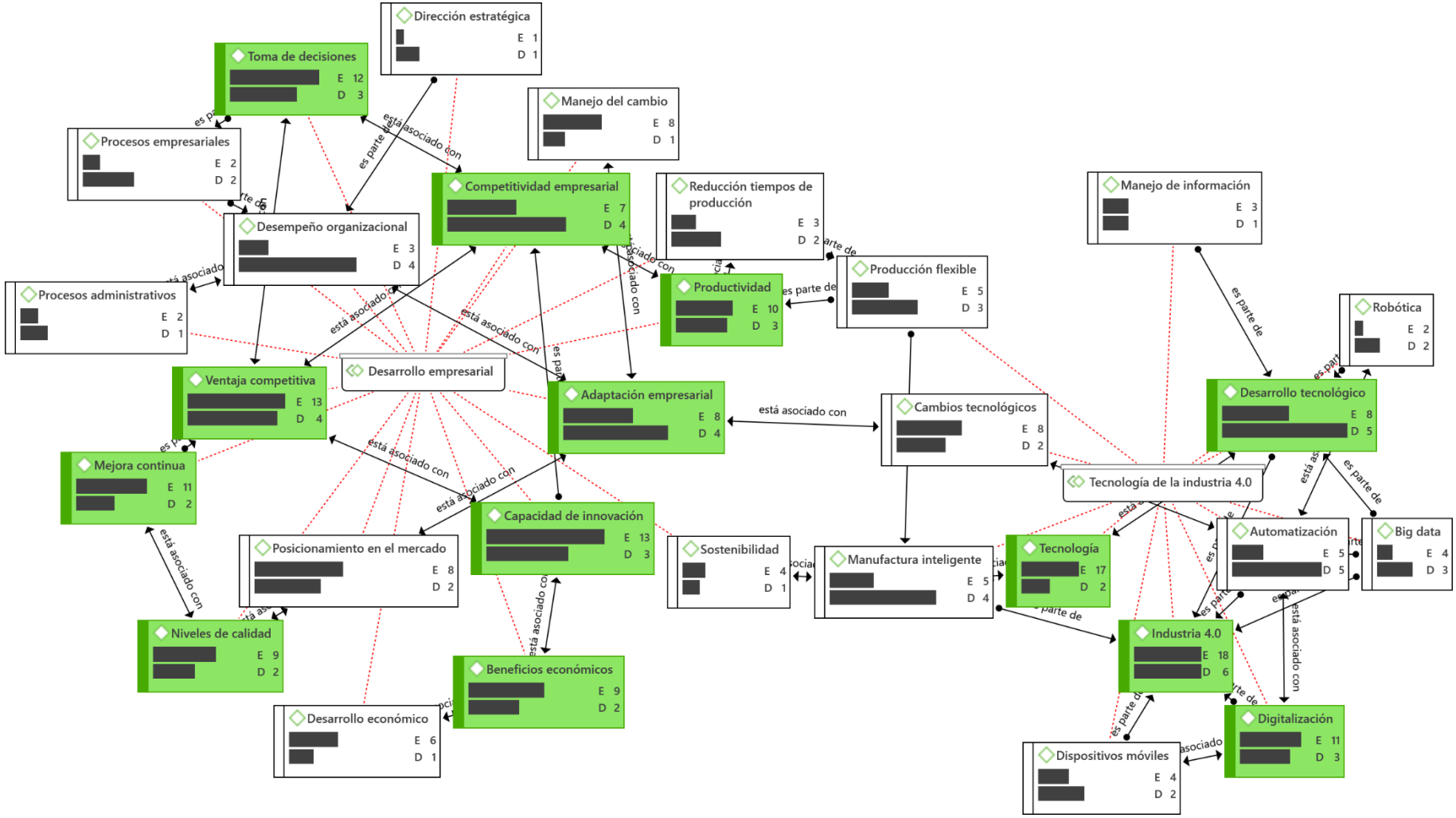
	Códe	**Rooting**	**Density**	**EI**
○	Industry 4.0	18	6	24
○	Technology	17	2	19
○	Competitive advantage	13	4	17
○	Innovation capacity	13	3	16
○	Decision Taking	12	3	15
○	Digitalization	11	3	14
○	Technologycal development	8	5	13
○	Continuous Improvement	11	2	13
○	Productivity	10	3	13
○	Business adaptation	8	4	12
○	Economical Benefits	9	2	11
○	Business competitiveness	7	4	11
○	Quality Levels	9	2	11
○	Automation	5	5	10
○	Technologycal changes	8	2	10
○	Market positioning	8	2	10
○	Change management	8	1	9
○	Smart manufacturing	5	4	9
○	Flexible Production	5	3	8
○	Big data	4	3	7
○	Economic development	6	1	7

○	Organizational performance	3	4	7
○	Mobile devices	4	2	6
○	Reduction of production times	3	2	5
○	Sustainability	4	1	5
○	Information Management	3	1	4
○	Business procedures	2	2	4
○	Robotics	2	2	4
○	Administrative processes	2	1	3
○	Strategic direction	1	1	2
Average				10

Source: Lalaleo et al. (2023) using ATLAS.ti9.

Figure 2.

Semantic networks with the identification of the identified emergent codes.



Source: Lalaleo *et al*. (2023).

5. DISCUSSION

A study conducted by Maresova et al. (2018) suggests that managers should explore other forms of business model innovation and create customer-driven innovations rather than product-oriented ones. On the other hand, another study conducted by Kiel et al. (2017) addresses the fact that the Industrial Internet of Things poses several implications for manufacturers in terms of economic, ecological, and social aspects related to sustainable value creation.

Another interesting aspect to highlight is the results presented by León (2020), where it is evident that the Internet of Things represents the technology that has had the most impact on companies. This is followed by cloud/client architecture, while 3D printing and augmented reality are the technologies that are less commonly used in business management. Based on this important data, it can be mentioned that the use of these technologies marks a turning point for organizations in general (Lalaleo et al., 2021), as they allow them, in the first instance, to collect data that helps them analyze the current market conditions and design and implement actions to stay relevant in such a competitive market as the one currently being observed (Berrones, 2022; Salazar et al., 2020).

In addition to the aforementioned, the use of Industry 4.0 technologies has contributed to the development of business innovation strategies, as it enables a better understanding of the potential use that these technologies project in the future of organizations. Studies conducted by Bonilla et al. (2017), Cano (2017), Ynzunza et al. (2017), Guerrero et al. (2018), Mora and Guerrero (2020), Vargas (2021), and Lalaleo et al. (2023) demonstrate that resources related to Industry 4.0 technologies provide companies with tools to drive innovation processes.

Furthermore, it is important to highlight that the use of current technologies such as the Internet of Things, Big Data, 3D printing, or the Cloud are decisive resources in harnessing the potential associated with Industry 4.0. This is related to the mass customization of products and services, as well as increased utilization of inactive data present in the organization's processes and improvement in production time (Pacheco and Rodríguez, 2019).

The development of new information and communication technologies has brought companies much closer to their customers and suppliers, allowing them to respond more quickly to their needs and adapt to the dynamic environment of the current global economy, which demands innovative processes (Bonilla et al., 2020; Coello et al., 2021). These technologies are generating the transformation of companies towards intelligent industry management, implying changes in manufacturing and process management for business development and growth.

6. CONCLUSIONS

The study allowed, in the first stage, the identification of two guiding categories (Industry 4.0 technology and business development) through the convergence of perspectives. This required processing information from a series of documents

(scientific articles), where, after the performed coding, codes were identified that helped characterize the variables under study. On the other hand, in the second stage, through co-occurrence analysis, it was possible to identify those codes that have the highest correlation with the guiding categories. This particular aspect allowed for establishing the relationship generated between the different identified codes.

Among the most significant correlations generated after processing the information, the following stand out: Big Data and mobile devices with a perfect correlation, that is, 100%; decision-making and competitive advantage with a correlation of 79%; economic benefits and business competitiveness with a correlation of 60%.

Finally, it is important to highlight that the study allowed for the identification of emerging codes, i.e., those codes that have a greater relationship with both Industry 4.0 technology and business development. In the case of Industry 4.0, the emerging categories include digitalization, technological development, technology, and Industry 4.0. On the other hand, for business development, the identified emerging categories are related to business competitiveness, innovation capacity, productivity, business adaptation, competitive advantage, continuous improvement, and quality levels.

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