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Analysis of the Relevance of Ambidexterity for the Adoption of the Industry 5.0 Management Model

JÚLIO CÉSAR RAMOS
UNIVERSIDADE FEEVALE (FEEVALE)

DUSAN SCHREIBER
UNIVERSIDADE FEEVALE (FEEVALE)

SERJE SCHMIDT
UNIVERSIDADE FEEVALE (FEEVALE)

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ANALYSIS OF THE RELEVANCE OF AMBIDEXTERITY FOR THE ADOPTION OF THE INDUSTRY 5.0 MANAGEMENT MODEL

1. INTRODUCTION

Industry 5.0 represents an advancement in industrial paradigms, going beyond the premises of Industry 4.0 by emphasizing human centrality, mass personalization, and sustainability. This model emerges in response to growing demands for more responsible and adaptable industrial practices, integrating advanced technologies with human intelligence to achieve innovative solutions. The balance between the use of emerging technologies and the demands for sustainability, ethics, and personalization characterizes the transition to Industry 5.0, which proposes a model more aligned with contemporary social and economic needs (XU; LU; VOGEL-HEUSER; WANG, 2021).

In this new context, industrial management faces significant challenges. The need to reconcile technological innovation, operational efficiency, and social values requires more integrated and adaptive approaches. Among the approaches discussed in the literature, organizational ambidexterity stands out as a strategic model capable of addressing these demands. Ambidexterity allows organizations to balance the exploration of new opportunities with the efficient exploitation of their existing resources, simultaneously promoting innovation and stability. This characteristic makes it particularly relevant for the implementation of Industry 5.0 practices (HASHEM, 2024).

In practice, organizational ambidexterity requires changes in managerial, cultural, and structural processes. For instance, managers need to foster a mindset that integrates innovation and efficiency while promoting collaboration between different sectors and the adoption of advanced technologies. However, the application of ambidexterity in the context of Industry 5.0 is still in its early stages, with theoretical and practical gaps that demand further investigation, as noted by Gastaldi et al. (2022).

This study aims to fill this gap by exploring the relevance of ambidexterity for the adoption of the Industry 5.0 management model. Based on a systematic literature review, the article examines the main factors that connect organizational ambidexterity to industrial transformation, considering the challenges and opportunities of the new paradigm. The analysis also seeks to identify the essential elements for aligning organizational practices with the principles of Industry 5.0, such as mass personalization, sustainability, and the central role of humans in production processes.

The contribution of this work lies in articulating, in an integrated manner, the concepts of Industry 5.0 and organizational ambidexterity, proposing pathways for their convergence. In addition to expanding theoretical knowledge on the interface between these topics, the study also presents practical implications for industrial management, especially regarding the adoption of practices that promote a balance between innovation and stability.

To achieve this goal, the article is structured into three main parts. The first section presents the theoretical framework, addressing the concepts of Industry 5.0 and organizational ambidexterity and exploring their intersection in the context of industrial management. Next, the methodology employed in the systematic literature review is detailed, highlighting the inclusion and exclusion criteria, as well as the analysis procedures. Finally, the results are presented and discussed, highlighting the most relevant factors for enabling the adoption of the Industry 5.0 management model and the contributions of this study to the field.

2. THEORETICAL FRAMEWORK

The theoretical framework aims to ground the research through concepts, theories, and previously conducted studies on the topic, establishing a solid basis to support the analyses and interpretations of the data. This section is intended to present the main theoretical approaches and the perspectives of authors that enrich the understanding of the investigated subjects.

2.1 Industry 5.0

Industry 4.0, an initiative that originated in Germany, has become a widely adopted concept worldwide over the past decade. Several countries have launched similar strategic initiatives, investing considerably in research to develop and implement the technologies associated with Industry 4.0. A decade after its emergence, the European Commission introduced the concept of Industry 5.0. While Industry 4.0 is characterized by a focus on technological advancements, Industry 5.0 places emphasis on human values (XU; LU; VOGEL-HEUSER; WANG, 2021).

The advancement of Industry 4.0 technologies, such as the Internet of Things (IoT), Big Data, Artificial Intelligence, and Cloud Computing, has brought significant improvements in productivity and competitiveness for industrial organizations. However, the centralization of these technologies in the production process has relegated the human being to a secondary role, which may compromise organizational efficiency and innovation. Industry 5.0 emerges as a response to these limitations, proposing a revaluation of the human role and the integration of sustainable practices, with a focus on creativity and abductive thinking—traits that current digital technologies are still unable to replicate (CICCARELLI et al., 2024).

According to Fani et al. (2024), in a study conducted in Italy, empirical data show that Lean practices can be strengthened by Industry 4.0 technologies, especially in traditional sectors such as fashion, during the transition to Industry 5.0. Companies can apply the proposed framework and its practices to facilitate the transition towards Industry 5.0 by leveraging the foundations of Lean Manufacturing. This study innovates by proposing a conceptual framework that encompasses Lean and Industry 4.0, introducing the Lean 5.0 paradigm. The case study contributes important empirical evidence for the fashion sector.

Industry 5.0 marks a new phase in global industrial transformation, with the aim of placing human well-being at the center of production systems. Its goal is to achieve social objectives that go beyond employment and economic growth, aiming to provide prosperity in a robust and sustainable way for all of humanity. However, the development of Industry 5.0 is still in an early stage, with limited and unsystematic research. Its three main characteristics are human-centricity, sustainability, and resilience (LENG et al., 2022; AGRAWAL et al., 2023).

The literature indicates that Industry 4.0 successfully reached the expected levels of productivity, although it did not prioritize social and environmental sustainability, despite moderately promoting some values. Industry 5.0, in turn, emphasizes the human element, promoting workforce reskilling, adapting technological development to workers' needs, and improving safety, health, and ergonomics in work environments. It also addresses the management of the impacts of natural crises caused by human activity (AGOTE-GARRIDO et al., 2023).

According to Oeij et al. (2024), European industries are about to undergo a transformative shift, prioritizing sustainability, human-centered approaches, and resilience, as outlined by the European Union. The Industry 5.0 policy of the European Commission does not merely represent a new phase of industrial development but a strategy that encourages companies to rethink their practices. This transformation requires collaboration among managers, employees, and customers to promote ecologically responsible production processes,

services, and products. In this context, companies must adopt strategies for material reuse, reducing their dependence on scarce resources and minimizing waste and pollution.

For this change to be successful, it is essential to recognize that the most valuable resource is the human worker. By leveraging the knowledge and skills of the workforce, Industry 5.0 can use the latest technologies to address not only technological challenges but also social issues such as energy transition, environmental pollution, and climate change. Industry 5.0 in Europe emerges in a context of global competition. Japan, for instance, developed "Society 5.0," which, like Industry 5.0, aims to achieve human-centered goals but focuses on creating a new ecosystem of science, technology, and innovation to solve economic and social issues. In the United States, the strategy is centered on increasing national innovation capacity through initiatives such as the National Network for Manufacturing Innovation program, which seeks to strengthen "advanced manufacturing," promoting better jobs, quality of life, and income for citizens. These global initiatives share the effort to use digital technologies for both economic and social goals, with some differences. While the EU emphasizes the human centrality in the production process, Japan prioritizes the customer, and the U.S. highlights workforce qualification (MASSARO, 2024; OEIJ et al., 2024).

According to Ghobakhloo et al. (2023), while many companies still face challenges in digitizing and establishing the necessary interconnection to increase productivity under the Industry 4.0 model, the next phase of digital transformation—known as Industry 5.0—is already gaining momentum. Major political and academic institutions, such as the European Union, argue that technological advancement is inevitable, but that social and environmental needs must be integrated into the ongoing technological revolution. Industry 4.0 was largely driven by technological advancements and the pursuit of greater industrial productivity—a goal that has largely been achieved. However, Industry 4.0 did not systematically prioritize social and environmental sustainability, although it did promote some social values unintentionally, such as resource efficiency and workplace safety.

The literature points out that Industry 4.0 brought negative effects for various social and human-centered values, mainly because social actors were unable to actively manage the pace of technological integration. Among the adverse effects are the reduction of workers' autonomy and dignity, increased income inequality at business and regional levels, the widening of the skills gap, and significant job displacement. This socially disruptive digital transformation was strongly felt, especially in Europe and other Western economies, which explains the current strong push to promote the Industry 5.0 model with a stronger emphasis on human values and sustainability (ERIKSSON et al., 2024; GHOBAKHLOO et al., 2023).

2.2 Ambidexterity

Organizational ambidexterity is a widely discussed concept in the management and innovation literature, especially in the context of increasing dynamism and complexity in global markets. The ability to balance exploration and exploitation is essential for organizations that aim to innovate while maintaining operational efficiency. Hashem (2024) emphasizes that ambidexterity is a strategic resource that enables organizations to quickly adapt to changes in the external environment while leveraging their existing capabilities.

Belhadi et al. (2022) highlight the importance of integrating ambidextrous practices within the supply chain domain, suggesting that adopting this approach enhances both resilience and organizational agility. They argue that ambidexterity in supply chain management enables greater synergy between innovation and operational efficiency, promoting competitive advantage. Paiola et al. (2024) support this perspective by analyzing the application of the concept in manufacturing and technology industries, showing that ambidexterity is crucial for maintaining competitiveness in highly dynamic sectors.

Dixit et al. (2022) broaden the discussion by exploring how digitalization can facilitate the implementation of ambidextrous practices. According to the authors, digital technologies create opportunities for organizations to simultaneously manage exploratory and exploitative activities, promoting innovation and efficiency. Sahoo et al. (2024b), in turn, identify cultural and structural barriers that may limit the adoption of ambidexterity, emphasizing the need for strong leadership and a flexible organizational culture.

Cheah and Tan (2024) explore the role of small and medium-sized enterprises (SMEs) in implementing ambidextrous practices, highlighting how these organizations can overcome resource constraints through collaborative innovation. They suggest that support from external partners is essential to facilitate the balance between exploration and exploitation in SMEs. Benzidia et al. (2021) add an international perspective, pointing out that organizations in emerging markets face additional challenges due to less developed institutional structures, which makes ambidexterity even more crucial for survival and growth.

Gastaldi et al. (2022) emphasize that the adoption of ambidextrous practices is also related to the ability of organizations to integrate innovative technologies. They argue that companies that combine technological exploration with incremental improvements are more likely to achieve sustainable success. Gouda and Tiwari (2024) complement this by stressing the relevance of strategic decision-making in balancing short- and long-term demands, promoting both radical innovation and operational efficiency.

In the field of operations management, Roldán Bravo et al. (2023) investigated how ambidexterity can be applied in production and inventory management, suggesting that integration between departments is essential to align exploratory and exploitative strategies. Al-Khatib (2023) discusses the importance of developing dynamic capabilities as a facilitator of ambidexterity, highlighting that organizational agility is a determining factor in dealing with tensions between efficiency and innovation.

Hossain et al. (2024c) and Mamun (2024) explore the human dimension of ambidexterity, analyzing how employee skills and engagement impact an organization's ability to balance exploratory and exploitative activities. They highlight that training programs and organizational learning initiatives are fundamental to developing ambidextrous capabilities in individuals and teams. Nakandala et al. (2024) add to this discussion by emphasizing the importance of alignment between leadership and organizational culture to sustain ambidextrous practices.

Bin Makhashen et al. (2020) discuss how organizations in developing markets can use ambidexterity to overcome structural and institutional barriers. They point out that strengthening collaborative networks can help mitigate resource limitations and drive innovation. Mulyana et al. (2023) contribute to the discussion with a perspective on social innovations, arguing that ambidexterity also plays an important role in creating value for local communities.

Sahi et al. (2020) address the role of strategic alliances in promoting ambidexterity, arguing that partnerships can facilitate access to new knowledge and technologies, enabling organizations to explore and exploit more effectively. This view is supported by Cheah and Tan (2024), who suggest that collaboration with external stakeholders is essential to overcome internal limitations and leverage disruptive innovations.

Another relevant point is the management of tensions inherent in ambidexterity. Benzidia et al. (2021) discuss how resource allocation can create conflicts between organizational units with different objectives. Roldán Bravo et al. (2023) suggest that integration mechanisms, such as cross-functional teams and governance systems, can mitigate these challenges by promoting greater alignment between exploration and exploitation.

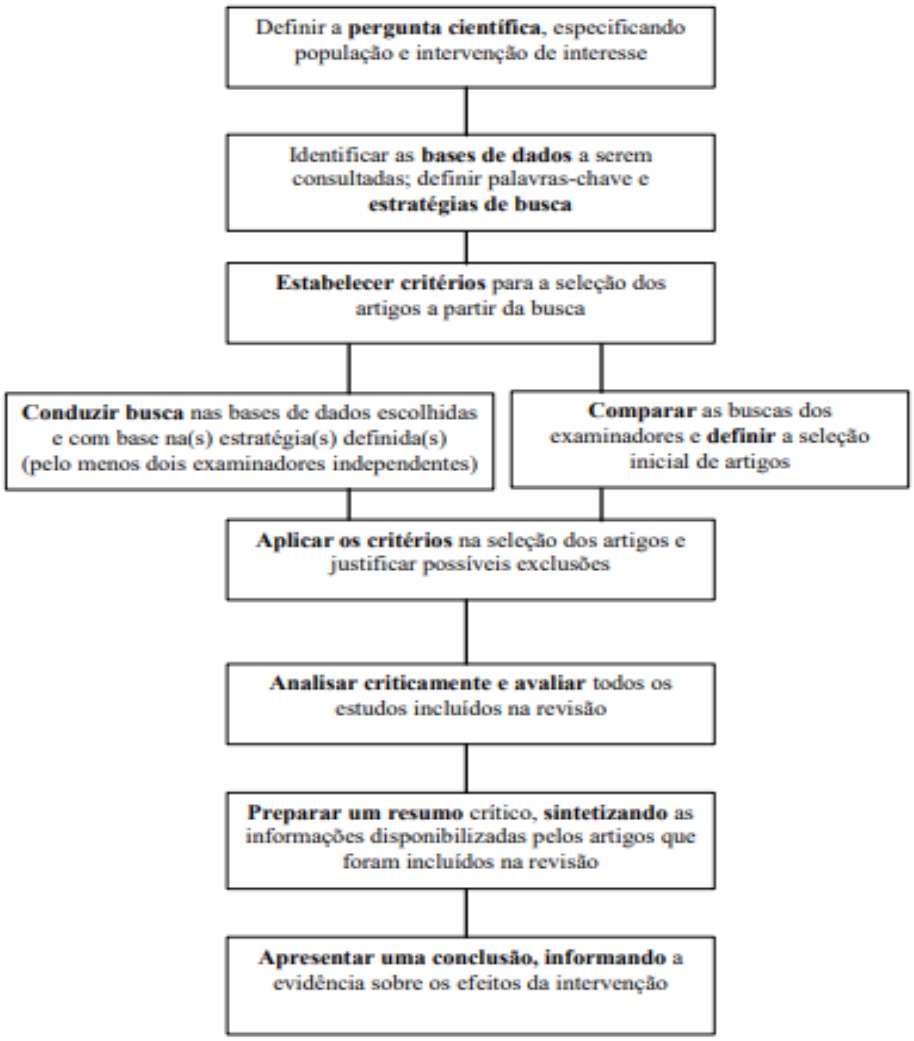
In the context of sustainability, Sahoo et al. (2024b) explore how ambidexterity can contribute to more sustainable business practices. They argue that the combination of operational efficiency with sustainability-oriented innovation is essential to meet the growing demands for social and environmental responsibility. Mamun (2024) adds that companies that adopt ambidexterity as part of their sustainability strategies are more likely to achieve long-term competitive advantages.

Finally, Hashem (2024) emphasizes that organizational ambidexterity is not merely a matter of structure or culture, but also of leadership. Ambidextrous leaders—capable of navigating between different priorities and promoting a unified vision—play a crucial role in creating resilient and innovative organizations. Thus, the study of ambidexterity continues to evolve, offering new pathways for managers and researchers interested in balancing conflicting demands in an increasingly challenging business environment.

3. METHODOLOGICAL PROCEDURES

According to Sampaio and Mancini (2007), gathering scientific evidence to guide professional practice is one of the main motivations for conducting studies that synthesize existing knowledge. Systematic reviews are designed to be precise, objective, and easily replicable. This research format helps guide new projects by suggesting novel directions for future investigations and identifying which scientific approaches have been applied in a given field. The methodology used in this article was a Systematic Literature Review (SLR). For the procedures adopted in the research, the PRISMA checklist (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), as described by McKenzie and Page (2020), was used as a reference, along with the methodological procedures proposed by Sampaio and Mancini (2007), as shown in Figure 1. These steps were divided into: scope definition; evidence search; study selection; and analysis structure. The SLR was adopted to provide an auditable and reliable search method, based on already published evidence, to meet the proposed objectives and answer the research questions.

Figure 1: General Description of the Systematic Literature Review Process



Source: Sampaio and Mancini (2007)

The first step was to define the general objective of the research: to analyze the relevance of ambidexterity for the adoption of the Industry 5.0 management model. After defining the research objective, keywords and the databases in which the search would be conducted were established. The following combinations were defined: ("industry 5.0" OR "industry 4.0" OR fashion OR shoe OR footwear AND ambidexterity).

The keywords were written in English to cover a larger volume of publications, but searches were limited to title, abstract, and keywords only, and structured to allow the identification of articles related to the research topics. The Scopus and Web of Science databases were chosen as sources due to their relevance in publications in the fields of management and business and the international scope of the studies. These databases returned 70 and 69 results, respectively. After the initial search, filters were applied to limit the document type to articles in English, within the fields of business and management, and restricted to works published between 2020 and 2024. At this stage, 36 articles were retrieved from Scopus and 39 from Web of Science, on November 11, 2024. A quantitative analysis download was generated from both databases regarding the number of articles published by country.

After this step, the 36 articles from Scopus and the 39 from Web of Science were exported into .CSV Excel files. While exporting, the complete information was selected from the databases: citation information, bibliographic information, abstract and keywords, and

funding details. A new Excel file was opened, the “File” tab was clicked, then the “Home” tab was selected, and under “Recent,” the downloaded CSV file from the database was opened. A three-step Excel Text Import Wizard screen appeared. “Delimited” was selected in step 1; in step 2, both “tab” and “comma” were selected; and in the final step, “general” was chosen before clicking finish. Thus, all database information was separated into columns.

Through the RStudio software, developed by the company Posit, which offers an open-source platform aimed at data science, scientific research, and technical communication, advanced processing of bibliographic data was performed. Using RStudio resources, the articles from both databases were integrated into a single consolidated dataset, with automatic identification and exclusion of duplicate records, resulting in a final set of 50 unique articles. RStudio, widely recognized for its versatility and ability to handle large volumes of data, employed specialized packages for organization and cleaning, optimizing the deduplication process. Titles and abstracts of the 50 articles were read, and 15 were excluded for not aligning with the study. Subsequently, the refined data was exported to Microsoft Excel, where a detailed quantitative analysis was conducted. In Excel, aspects such as the number of publications per year, the distribution of articles by journal, and the contribution of specific authors were evaluated, allowing a comprehensive understanding of the characteristics of the scientific production analyzed. This integrated approach between RStudio and Excel ensured efficiency in data processing and greater accuracy in the analyses conducted (RSTUDIO, 2024).

In the following step, the “DOI” column from the Excel file, containing the identifiers of the 35 selected articles, was transferred to the Zotero software. This program, widely used for managing bibliographic references, automatically processed the DOIs and generated the complete references of the articles, which were exported in the ABNT format, ensuring compliance with Brazilian academic standards. Additionally, Zotero enabled the export of the 35 references in a .RIS file, a widely accepted standard for bibliographic data exchange (ZOTERO, 2024).

This .RIS file was then used in the VOSviewer software, developed by Leiden University in the Netherlands. VOSviewer is a robust tool for analyzing and visualizing bibliometric and textual networks. Through it, a detailed qualitative analysis of the most frequent words in the titles and abstracts of the articles was performed. The software enabled the identification of semantic and thematic patterns by generating visual maps that illustrate term occurrences, facilitating data interpretation and the identification of relevant trends in the analyzed literature (ECK; WALTMAN, 2023).

To structure and examine the qualitative information obtained, the Nvivo software was employed. This tool enabled the organization, coding, and identification of patterns in the textual content from the abstracts, titles, and keywords. Nvivo stands out for its efficiency in handling large volumes of qualitative data, recognizing thematic connections, and conducting analytical comparisons, ensuring greater accuracy and depth in the interpretation of the articles. Moreover, the program facilitates the integration of multiple sources in a structured manner, promoting data triangulation, which strengthens the validity and reliability of the research (NVIVO, 2024).

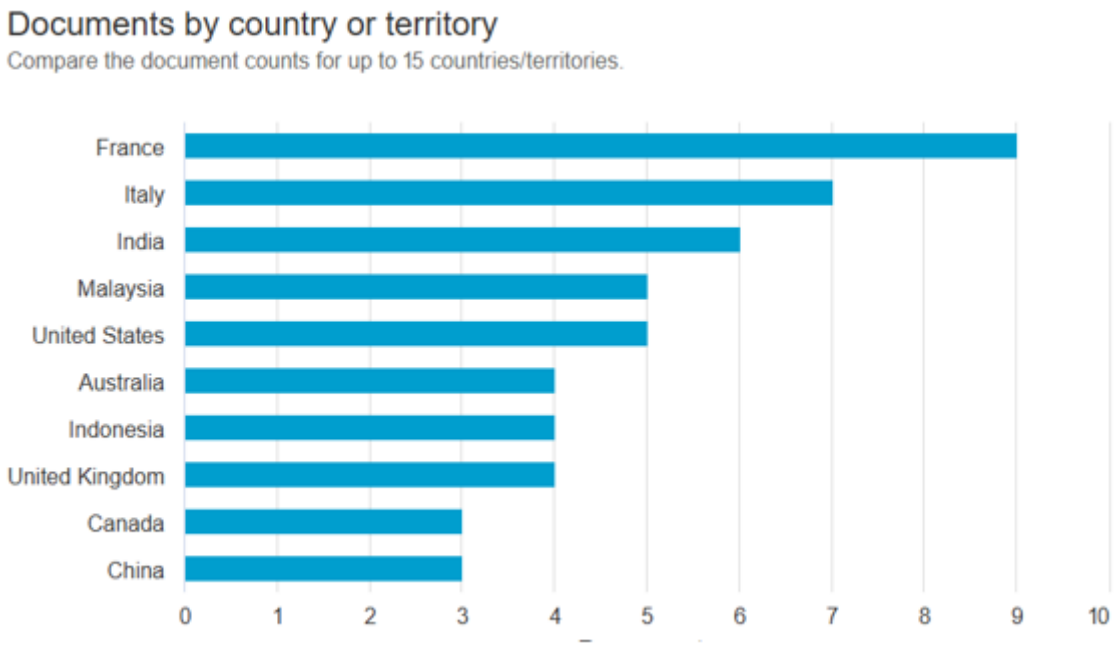
4. RESULTS

This section presents the main data obtained from the analysis conducted, based on the criteria established in the methodology of this study. The information is organized in a way that allows for a clear and systematic understanding of the identified trends, both in quantitative and qualitative terms.

4.1 Quantitative Analysis of the Articles

According to Figure 2, based on the quantitative analysis of the results obtained from the Scopus database, it was possible to identify the countries with the highest number of publications related to the researched topic. The chart shows that France leads the ranking with a total of 9 documents, followed by Italy and India. Malaysia appears in fourth place with 5 publications, while the United States registered 5 documents. Australia and Indonesia each had 4 publications, indicating significant contributions to the topic. On the other hand, the United Kingdom, Canada, and China have lower numbers, with 3 publications each.

Figure 2: Articles published by country in the Scopus database



Source: Scopus (2024)

This distribution reveals the predominance of European, Asian, and North American countries among the top contributors to the topic, highlighting global engagement in the scientific production related to the subject. France and Italy, in particular, stand out as reference hubs, possibly reflecting policies and investments focused on this specific area of research, as shown in Figure 2.

Subsequently, Figure 3 presents the quantitative analysis of the research results from the Web of Science database, filtered by the areas of management and business, which revealed the fields with the highest volume of publications on the investigated topic. The treemap visualization highlights the following categories:

Figure 3: Articles published by subject area in the Web of Science database

Source: Web of Science (2024)

1. Business: With 28 publications, this field leads the ranking, representing the highest concentration of studies related to the topic. This reflects the importance and focus of the research in the business field.

2. Management: Ranking second with 27 publications, this area reinforces the relevance of studies focused on management practices and organizational strategies.

3. Regional Urban Planning: With 6 publications, this field suggests connections between the researched topic and aspects of regional and urban development.

4. Industrial Engineering and Information Science & Library Science: Both fields have 3 publications, indicating moderate interest in exploring technical and informational aspects of the topic.

5. Environmental Studies, Economics, and Computer Science – Interdisciplinary Applications: Each of these areas has 2 publications, showing specific, although less expressive, contributions.

6. Business Finance and Engineering Manufacturing: Each registered 1 publication, representing lower-impact areas in the context of this research.

This distribution shows a significant predominance of the business and management fields, aligned with the initial focus of the study. The contributions from other areas, though smaller in number, reinforce the interdisciplinary nature of the topic and the diversity of perspectives in the scientific literature analyzed, as illustrated in Figure 3.

In Figure 4, the quantitative analysis of the results obtained from the Web of Science and Scopus databases, considering a total of 35 articles, allowed the identification of the annual distribution of publications on the researched topic. The chart reveals the following trends:

2020: 5 publications were identified, indicating a moderate initial interest in the topic during this period.

2021: A decrease to 3 publications was observed, suggesting a possible decline in scientific output that year.

2022: A significant increase occurred, with 7 publications, showing growing interest and academic production.

2023: Despite the previous year's growth, the number of publications dropped again to 4, indicating fluctuations in study volume.

2024: This year stands out with a marked peak of 16 publications, highlighting strong growth and possibly greater relevance or investment in the topic.

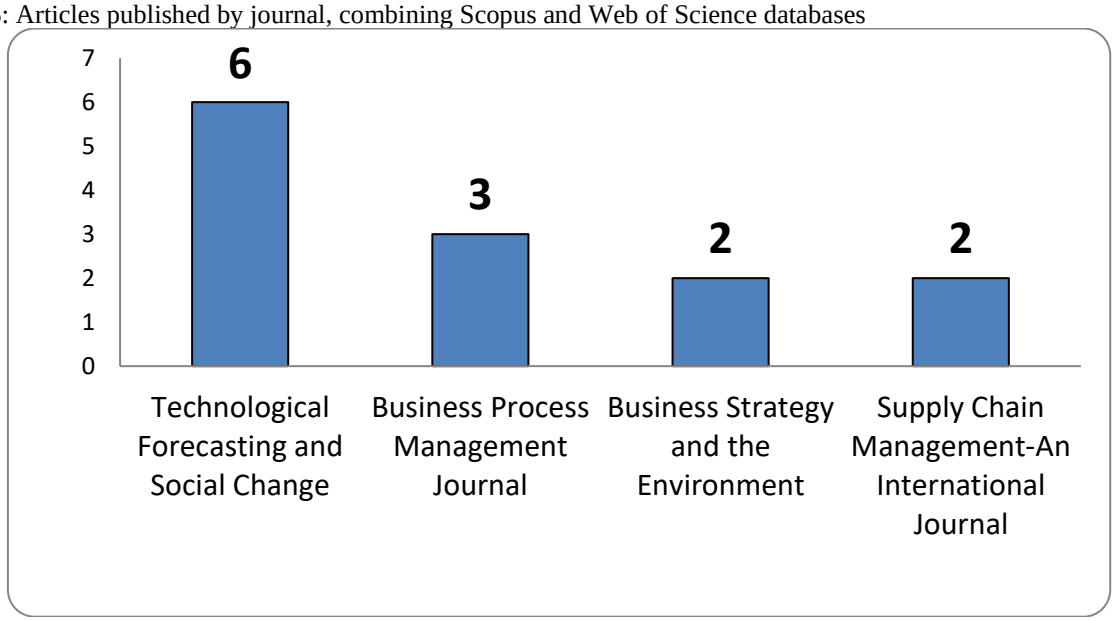
Figure 4: Articles published per year, combining Scopus and Web of Science databases

Source: Author (2024)

According to Figure 4, the evolution over the years shows an irregular growth pattern until 2023, followed by a substantial increase in 2024. This may indicate that the topic is gaining more recent attention, possibly due to advances in the area, increased awareness, or shifts in global research priorities.

Based on Figure 5, the quantitative analysis of results revealed a higher concentration of publications in specific journals. The journal Technological Forecasting and Social Change stood out as the most relevant, with 6 published articles, corresponding to approximately 17.14% of the total. Business Process Management Journal followed with 3 articles, accounting for around 8.57%.

Figure 5: Articles published by journal, combining Scopus and Web of Science databases



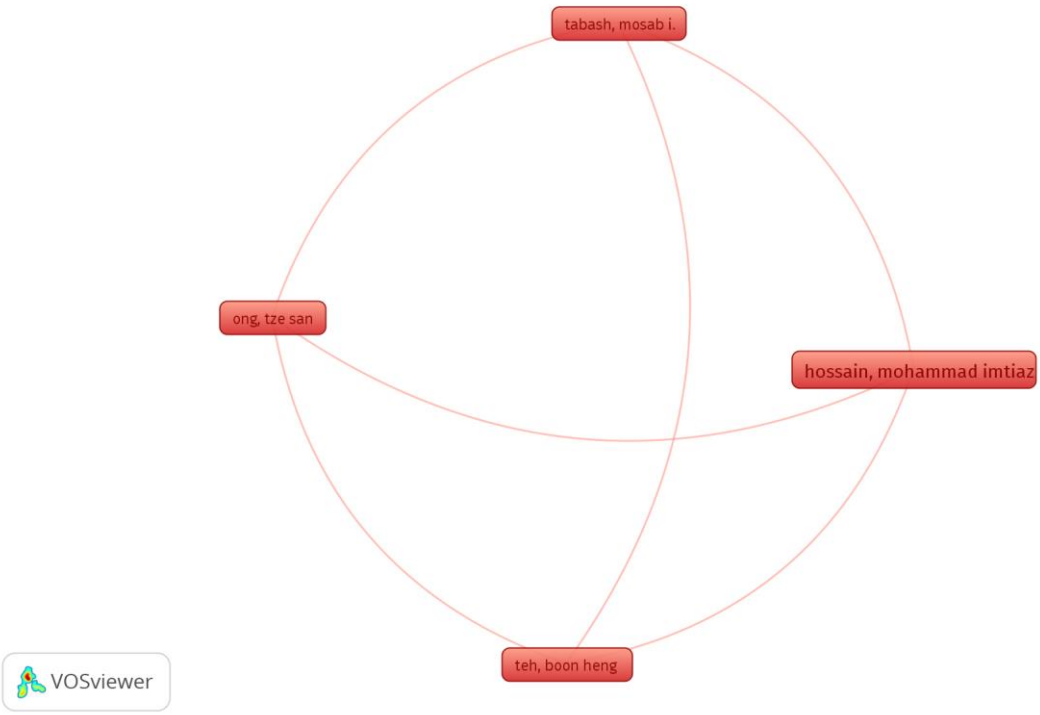
Source: Author (2024)

Additionally, the journals Business Strategy and the Environment and Supply Chain Management – An International Journal contributed 2 articles each, representing approximately 5.71% of the total publications. These data indicate that knowledge dissemination related to the research is concentrated in specific journals, with Technological Forecasting and Social Change playing a significant role in the analyzed landscape, as demonstrated in Figure 5.

4.2 Qualitative Analysis of the Articles

VOSviewer is widely used software for creating and visualizing bibliometric maps, especially in analyses of collaboration networks among authors, institutions, or keywords in scientific publications. The main purpose of the software is to enable visual analysis of data extracted from databases such as Web of Science and Scopus, identifying patterns, clusters, and relationships that help in understanding relevant themes and collaborations in a specific research field, as represented in Figure 6 (ECK; WALTMAN, 2023).

Figure 6: Most relevant authors, generated by VOSviewer Software

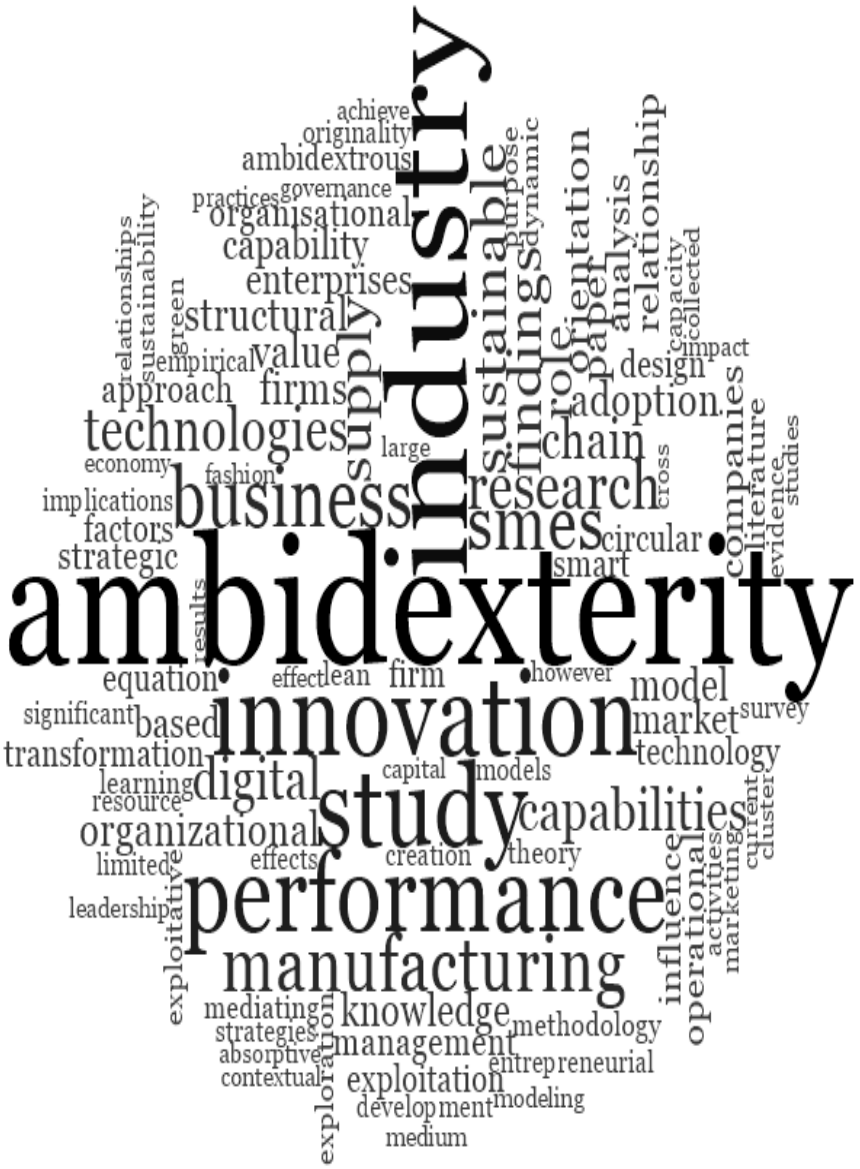


Source: Eck and Waltman (2023)

In this research context, VOSviewer was used to identify the most relevant authors with the highest number of publications. In the map presented, the authors Tabash, Mosab I., Hossain, Mohammad Imtiaz, Teh, Boon Heng, and Ong, Tze San appear connected, indicating a collaboration network or related areas of study. The visualization shows that Tabash, Mosab I. and Hossain, Mohammad Imtiaz have a stronger connection, which may suggest frequent co-authorship or complementary research topics. The relevance of this type of analysis lies in the ability to identify key academic actors in a specific field and understand their collaboration dynamics. This helps researchers recognize influences, establish potential partnerships, and deepen their understanding of trends in the area.

NVivo is a software designed to assist in the analysis of qualitative and mixed data. It is widely used in academic research to organize, analyze, and interpret large volumes of unstructured data, such as interviews, documents, and scientific literature. In the context of bibliometrics, NVivo can be used to identify patterns and recurring themes in article titles, keywords, and abstracts, as in the case of the research on Industry 5.0 and ambidexterity, as shown in Figure 7 (NVIVO, 2024).

Figure 7: Word Cloud generated by Nvivo Software



Source: Nvivo (2024)

The qualitative analysis of the word tree generated by NVivo reveals the most frequent words in the titles, keywords, and abstracts of the 35 analyzed articles. The term ambidexterity stands out the most, indicating its centrality in the discussions and within the context of the researched topic. Other important terms such as innovation, industry, performance, and manufacturing reinforce the connection between ambidexterity and the challenges of innovation and performance in industrial contexts. Words like digital, sustainability, capabilities, and business suggest that the articles address current aspects such as digital transformation, sustainability, and organizational capability management.

The predominance of these terms reflects a strong interconnection between the themes of Industry 5.0 and ambidexterity, especially concerning the balance between resource exploitation and organizational capabilities. The visualization also points to an innovation-oriented approach and the pursuit of high performance in complex and constantly evolving industrial environments. This qualitative analysis provides a better understanding of the trends and key research focuses related to the topic, as shown in Figure 7.

5. DISCUSSION

The adoption of Industry 4.0 (I4.0) has been a strategic priority for manufacturing companies seeking solutions to address ongoing challenges. As highlighted by Hashem (2024), the transition from I4.0 to Industry 5.0 represents a significant advancement by integrating advanced digital technologies with values centered on sustainability, human-machine collaboration, and greater personalization in production processes. However, despite its importance, the adoption of I4.0 still presents substantial empirical gaps, especially in developing countries.

This study emphasizes the influence of factors such as Absorptive Capacity (AC), innovation ambidexterity, and Learning Capability (LC) in the I4.0 adoption process. According to Hashem (2024), these elements play a crucial role in organizational development and are essential for understanding the mechanisms that lead to the successful implementation of I4.0. AC and LC are viewed as critical enablers, allowing companies to effectively acquire, share, disseminate, and apply knowledge, which is vital for adoption and technological advancement.

Innovation ambidexterity, defined as the ability to balance the exploration of new opportunities with the efficient exploitation of existing capabilities, emerges as a vital contextual dynamic. Hashem (2024) reinforces that innovation ambidexterity not only complements the adoption of I4.0 but also aligns with the principles of Industry 5.0, promoting a balance between innovation and sustainability. In this regard, the present study contributes by identifying innovation ambidexterity as a significant predictor of I4.0 adoption and by highlighting that LC amplifies the connection between innovation exploration and technological implementation.

The relationship between Industry 4.0 (I4.0), sustainable performance, and organizational ambidexterity has gained prominence in academic and practical discussions, especially in the context of digital transformation in the supply chain. According to Belhadi et al. (2022), I4.0 capabilities are crucial for accelerating this transformation and promoting sustainable performance. The study highlights that organizational ambidexterity (OA), defined as the ability to balance the exploration of new opportunities with operational efficiency, plays a key role in addressing the sustainability paradigm, integrating economic and socio-environmental prosperity throughout the supply chain.

This perspective aligns with the concept of innovation ambidexterity, which is also essential for adopting emerging technologies such as I4.0. Innovation ambidexterity facilitates the balance between exploratory innovation—necessary to develop new business models based on circular principles—and incremental innovation, which improves existing processes. In the context of sustainability, Belhadi et al. (2022) emphasize that supply chains embracing digital transformation and using circularity as a strategic guide are better positioned to achieve superior sustainable performance.

The relationship between Industry 4.0 (I4.0) and contextual ambidexterity, as discussed by Paiola et al. (2024), presents important insights on how companies can manage disruptive innovations in their business models. In the context of I4.0, the exploratory process is intensified due to the lack of prior experience and the need for significant investments in knowledge. Contextual ambidexterity—defined as the ability to balance the exploration of new opportunities with existing operational efficiency—emerges as an essential strategy to address the disruptions caused by the introduction of advanced technologies.

Paiola et al. (2024) highlight that the contextual ambidexterity adopted by the companies studied differs from the classic proposal, which suggested that ambidexterity should be a quality present in all individuals within the organization. Instead, companies delegate specific exploration tasks to selected groups or individuals, in cooperation with key customers.

This approach enables the new business model to be co-developed with clients and suppliers, creating a business model that mitigates risks and ensures effectiveness.

As discussed by Paiola et al. (2024), disruptive business model innovation in an I4.0 setting is intrinsically linked to contextual ambidexterity. The ability to balance the exploration of new opportunities with existing operational efficiency—while leveraging cooperation with key clients—represents a strategic path to organizational success. This approach not only enables digital transformation but also establishes a solid foundation to sustainably and innovatively address I4.0 challenges.

The integration of lean manufacturing, sustainability, and the adoption of Industry 4.0 (I4.0) technologies represents a convergence of goals focused on resource efficiency, waste minimization, and continuous improvement. According to Dixit et al. (2022), both lean and sustainable manufacturing promote optimal resource use and waste reduction, while I4.0 digital technologies provide advanced tools to achieve these goals. I4.0 enables greater operational visibility, facilitating value stream mapping and contributing to emission reduction and sustainability goals.

Additionally, I4.0 technologies, such as the Internet of Things (IoT), promote the efficient integration of operations, a continuous flow of goods and services, and reduced energy consumption. This alignment between the lean approach, sustainability, and I4.0 converges toward enhanced productivity and quality, with a focus on waste elimination and customer centrality. As noted by Dixit et al. (2022), a high degree of collaboration among people, processes, and products is essential to achieving lean and sustainable objectives.

The ability to integrate lean tools into digitized manufacturing allows for the development of new production technologies. This integration is enabled by innovation ambidexterity, which acts as a positive mediator between lean, sustainability, and I4.0 adoption. Organizations with ambidextrous capabilities are able to balance continuous improvements in existing processes with the adoption of disruptive technologies. As an example, Dixit et al. (2022) highlight Toyota's fuel cell system, which combines fuel cell technology (resulting from lean tools) with hybrid technology (focused on sustainability), incorporating I4.0 sensors as part of the system.

The research conducted by Sahoo et al. (2024b) offers an in-depth analysis of the factors influencing Circular Economy (CE) performance in manufacturing contexts, contributing both to theoretical advancement and practical implementation. Based on robust statistical analysis using Structural Equation Modeling (SEM), the authors address critical questions related to the adoption of Industry 4.0 (I4.0) technologies and their connection with organizational ambidexterity and innovation performance.

One of the main findings of the study highlights that the adoption of I4.0 technologies significantly enhances manufacturers' information acquisition capabilities. This enhancement occurs through the integration of real and virtual domains, as well as the promotion of autonomous learning systems. According to Sahoo et al. (2024b), this capability is essential to fostering organizational ambidexterity, enabling companies to balance exploratory behaviors. This ambidexterity is, in turn, a critical factor in driving innovation performance, leading to substantial improvements in CE outcomes.

On a practical level, Sahoo et al. (2024b) offer important recommendations for manufacturing managers interested in leveraging I4.0 technologies. These include the gradual implementation of such technologies, always aligned with broader business strategies; the promotion of a flexible organizational culture open to innovation; and strategic planning that considers not only technological advancements but also the development of social systems. These elements are crucial for creating an organizational environment that supports both innovation and CE objectives.

The research by Roldán Bravo et al. (2023) contributes to the understanding of the concept of ambidexterity in Supply Chain 4.0 (SC4.0) by proposing and validating a pioneering measurement instrument. This study advances the literature by exploring the antecedents of Lean Supply Chain Management (LSCM) implementation and demonstrating its mediating role in the relationship between SC4.0 ambidexterity and companies' operational performance.

A central point in Roldán Bravo et al.'s (2023) discussion is the introduction of the SC4.0 ambidexterity concept, which is based on the ability to balance the exploration of emerging and mature technologies in the context of the transition to Industry 4.0. The authors propose that structuring these complementary activities can benefit not only internal operational levels but also the integration among supply chain members. Applying this ambidextrous approach promotes more effective use of technological resources and facilitates the implementation of lean practices in a digitized environment.

Sahi et al. (2020) suggest that companies seeking to align market and entrepreneurial strategies may achieve superior revenues by dedicating balanced efforts between exploiting existing resources and exploring new opportunities. These findings have significant practical implications for managers, who must continuously assess the internal and external determinants that influence the relative emphasis on exploration in their operational strategies.

The study by Sahi et al. (2020) reinforces the importance of operational ambidexterity for business performance, especially in SMEs from emerging markets. By balancing exploration, companies can optimize resources, seize new opportunities, and achieve operational excellence. These insights provide a robust foundation for formulating strategies that align operational practices with long-term organizational goals.

6. FINAL CONSIDERATIONS

The study conducted highlights the relevance of organizational ambidexterity as a key strategic concept for the adoption of the management model proposed by Industry 5.0. While Industry 4.0 emphasized automation and the integration of advanced technologies to maximize productivity and efficiency, Industry 5.0 introduces a new perspective centered on human value, mass personalization, and sustainability.

In this context, ambidexterity emerges as an approach capable of balancing innovation and operational efficiency, allowing organizations to respond swiftly and holistically to contemporary demands. Based on the systematic literature review conducted—analyzing 35 articles published between 2020 and 2024—there is a growing academic interest in the relationship between Industry 5.0 and organizational ambidexterity. The use of tools such as NVivo for qualitative analysis and VOSviewer for quantitative analysis revealed that the terms "ambidexterity," "industry," and "sustainability" are central to this discussion.

The predominance of publications from European and North American countries suggests that these regions are leading research and practice toward this new industrial paradigm. The quantitative analysis showed a significant increase in publications in 2024, indicating that the interface between Industry 5.0 and ambidexterity is gaining greater relevance.

This growth can be attributed to the increasing recognition of the need for more balanced and adaptable industrial practices—those that consider both the exploration of new opportunities and the efficient use of existing resources. France, Italy, and India stood out as leaders in scientific output, while other countries also contributed significantly, evidencing a global effort to understand and implement the principles of Industry 5.0.

From a practical perspective, the study indicates that organizational ambidexterity is not merely a theoretical tool but a viable approach to facilitate the transition to more human-centered and sustainable management models. Organizations that can integrate innovation and

efficiency—promoting cross-sector collaboration and adopting advanced technologies—are better positioned to face the challenges posed by Industry 5.0.

Moreover, the application of ambidexterity requires cultural and structural changes, including the adoption of more flexible managerial practices and the promotion of an organizational mindset oriented toward balancing exploration and stability. Finally, this research contributes to the field by expanding the understanding of the convergence between Industry 5.0 and organizational ambidexterity.

This study not only offers theoretical insights but also presents practical implications for industrial management. The findings reinforce the importance of aligning organizational practices with the principles of Industry 5.0, promoting sustainability, human protagonism, and competitive performance in a dynamic and constantly evolving industrial environment.

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