CIGI QUALITA MOSIM 2023
Strategizing Industry 4.0 : a systematic review

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Résumé – La quatrième révolution industrielle est un mouvement de transformation numérique qui a été observé dans différentes industries à travers le monde. Cette révolution est liée à l'utilisation de solutions de haute technologie qui permettent d'optimiser les processus décisionnels, ce qui donne lieu à de nouvelles propositions de valeur et de nouveaux modèles d'affaires. Bien que le potentiel de transformation de l'industrie 4.0 soit identifié comme une opportunité d'améliorer les processus, les produits et les services, il doit être aligné sur la planification stratégique de l'organisation pour une mise en œuvre réussie. Cette étude présente une revue systématique de la littérature traitant des stratégies de mise en œuvre de la quatrième révolution industrielle dans une perspective de gestion stratégique. La méthodologie PRISMA d'été choisie l'étude terminée par la révision de 13 articles publiés entre 2018 et 2022 à l'intersection des domaines de la stratégie, de la feuille de route et de l'industrie 4.0. Nous avons consolidé les résultats dans un cadre conceptuel pour introduire la théorie de la Stratégie 4.0. Enfin, cet article présente de nouvelles opportunités de recherche pour la recherche dans la stratégie de mise en œuvre de l'industrie 4.0.

Mots clés **- Industrie 4.0, Stratégie 4.0, Stratégie digitale.**

Abstract – The fourth industrial revolution is a digital transformation movement that has been observed in different industries around the world. This revolution is related to the use of high-technology solutions that allow optimized decision-making processes, which yields to new value propositions and business models. Although the transformative potential of Industry 4.0 is identified as an opportunity to improve processes, products, and services, it should be aligned with the organization's strategic planning for a successful implementation. This study presents a systematic literature review addressing the of strategies to Fourth Industrial Revolution implementation in a strategic management perspective. The research adopted PRISMA methodology and ended up with the revising of 13 papers publications between 2018 and 2022 from the intersection of strategy, roadmap and Industry 4.0 fields. We consolidated the results in a conceptual framework to introduces the theory of Strategy 4.0. Finally, this paper presents new research opportunities for research in strategizing industry 4.0 implementation.

Keywords **– Industry 4.0, Strategy 4.0, Digital Strategy.**

1 INTRODUCTION

The fundamental changes arising from the advancement of emerging technologies that have occurred in recent years have imposed new ways of thinking for organizations. The accelerated evolution of Information Technology (IT) has been profoundly changing human relationships, professions, the way we communicate, consume information, and do business. The advent of technological advancement and the recognition of technology as a capital of organizations presents technology management as a great potential to obtain competitive advantage.

According to (Harris, Shaw, & Sommers, 1983) Management must have a solid understanding of technology as a competitive advantage and a tactical instrument in order to fully realize this potential. Also, it will call for a higher level of expertise in technology management, a field that includes creating a technology strategy, incorporating technological choices into long-term company strategy, and implementing a thorough technology investment plan.

The most recent industrial revolution, also known as Industry 4.0, is characterized as use of emerging technologies in a combined and collaborative way to create innovation on the existing established industry, taking into consideration the various contexts such as culture, location, size and geopolitics, to create value not only for the businesses itself, but for the whole society. (Danjou, Rivest, & Pellerin, 2016) defines Industry 4.0 as "a strategy that relies on digital and ubiquitous connectivity, through different technologies, to transform processes, products and services through real time and decentralized decision making, enabling new capabilities for

systems, in cooperation with humans, to move from surveillance to autonomy".

However, several challenges still exist for the established industries to fully explore the potential benefits of the industry 4.0 (I4.0) concept. First, the I4.0 is a technological shift that requires an organized adoption and integration of new technologies, demanding companies to be flexible enough to reinvent themselves while still keeping its focus and not losing of mind the company's objectives (mission, vision, values). Moreover, the rate of technology renewal is constantly increasing, which increases the difficulty of choosing the "right" technologies to adopt (Lu, 2017). Second, Even though I4.0 has attracted the interest of academic and practitioners since the publication of the report mandated by the German government (Kagermann, Helbig, Hellinger, & Wahlster, 2013) it is still not clear how to create strategies to I 4.0 implementation. As well as the managers, that play a pivotal role in the transition do not have clear answers or tools to support their decisions within this journey. Third, digital transformation depends on the willingness of leaders to embrace Industry 4.0, manage the competences and methods, and centrally coordinate its strategy (Mittal, Khan, Romero, & Wuest, 2018), once, that top-down commitment is an essential requirement for successful change in this context (Morteza Ghobakhloo, 2019; Piccarozzi, Aquilani, & Gatti, 2018). Finally, and in summary, a successful I4.0 implementation is only possible if aligned with the organization's strategic objectives and vision.

Starting from the concept of technological strategy aims to have a technological roadmap (Garcia & Bray, 1997) defines technology roadmap (TRM) as a means to support businesses to align technological objectives to reach their strategic goals. This paper investigates the main research question (RQ) How can managers strategize I4.0 implementation? For that the authors conduct a systematic literature review to assess the current understanding of the intersection between these three fields (I4.0, Strategy and technological roadmap) and draw a research agenda from that to lead to the notion of Strategy 4.0.

2 METHODOLOGY

The research process was established with four steps: (i) initiation, (ii) data collection, (iii) data analyses and (iv) assessment and documentation, as illustrated in Figure 1 - Research Process. First, in the initiation step, the research question is defined: "How can managers strategize Industry 4.0 implementation?"; alongside with the basic rationale of the methodology. Second, in the data collection step, a search protocol is chosen, and papers are searched using the Web of Science and Compendex platforms. Third, in the data analysis step, inclusion and exclusion criteria are defined and applied to the database. Moreover, papers content is assessed to get to the final selection for papers. Finally, in the assessment and documentation step, papers are classified by characteristics to answer the research question. Likewise, the findings are synthesized and consolidated to build the conclusions.

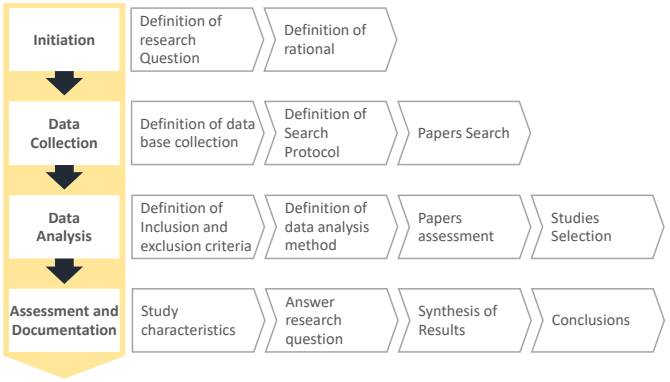

Figure 1 - Research Process

2.1 Data Collection

Data collection followed three different steps: First, the data information sources selected were the Web of Science and Compendex. Second, the search protocol was defined as demonstrated in Table 1 - Search Protocol . The search terms was defined for the Industry field based on (El Zant, 2021) from page 24 at Tableau 2 : Nombre de publications des différentes appellations de l'industrie 4.0. For strategy field the terms are strategic management, "strategic planning", "strategic thinking", "open strategy", "technology strategy", "technological strategy", Digitalization Strategy, Digital Strategy, Digitization Strategy, Data Strategy, digitalisation strategy. And finally for technological roadmap field the terms were "roamap" and "roadmapping". The document types considered it was review and articles. Also, the language accepted is English.

Table 1 - Search Protocol

Search Protocol	
Data information source	Web of Science and Compendex
Search terms in Query format	**Industry 4.0** = ("Industrie 4.0" OR "Industry 4.0" OR "Industrial 4.0" OR "Industrial Internet" OR "Industrial Internet of things" OR "Smart production" OR "Manufacturing 4.0" OR "Smart factory" OR "smartfactoty" OR "Factor* of the future" OR "Advanced manufacturing" OR "Intelligent manufacturing" OR "Industri* of the future" OR "High value manufacturing" OR "Smart industry" OR "Integrated industry" OR "Digital factory" OR "Manufacturing renaissance" OR "Digital manufacturing" OR "Make in India" OR "Made-in-China 2025" OR "chinese Manufacturing 2025" OR "smart industry"
	Strategy = (strategic management or "strategic planning" or "strategic thinking" or "open strategy" or "tecnolog* + strategy" or "Business transformation")
	Roadmap = Roadmap*
Documents Type	ARTICLE OR REVIEW
Language	English

2.2 Data Analysis

In order to seek more reliability and robustness of the data analysis, this research utilizes the PRISMA Statement for

Reporting Systematic Reviews. The PRISMA concentrates on techniques to ensure the clear and complete systematic reviews, and has become a significant reference in academics studies (Liberati et al., 2009). The PRISMA flow diagram describes the stages of data analysis is demonstrated in Figure 2 - PRISMA Flow Diagram.

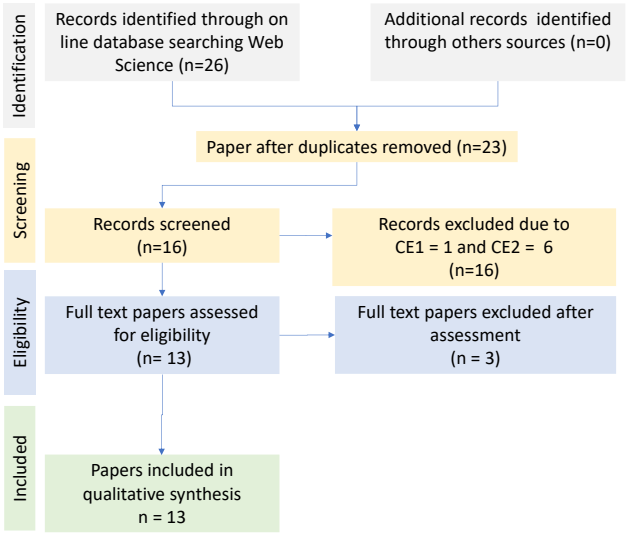

Figure 2 - PRISMA Flow Diagram

According to the PRISMA process, the first phase to analyze data is identification. In this case, 26 papers were identified. The second phase, screening, it was applied the exclusion and inclusion criteria, presented in Table 2 - Eligibility Criteria. As a result, 7 papers were excluded. Third, in the Eligibility phase, the papers without relevance for the research topics were excluded. Finally, in the Included phase, 13 papers were selected.

Table 2 - Eligibility Criteria

Criteria Type	Code	Description
Exclusion	CE1	A paper without full text available to assess.
	CE2	The paper is not matching with a research scope.
Inclusion	CI1	Industry 4.0 and strategy approaches are the main objects reviewed, surveyed, or discussed.

3 RESULTS

3.1 The papers landscape

The final list reviewed in this article is composed of thirteen papers. The papers reference is presented in the Table 3 - References versus Citations. These papers were published between 2018 and 2022 and, the most of them describe a conceptual and literature review approach.

In one hand, the backdrop articles present a relevant academic reconnaissance, as an example of the first in citation ranking is (M. Ghobakhloo, 2018), a study that uses a thorough literature evaluation to analyze the manufacturing sector's future. According to this report, Industry 4.0 is an integrated approach to value creation made up of 12 design principles and 14 technological developments and, the strategic plan is highlighted as a vital tool for transitioning in the conclusion. Another article in the same outlook is the second in this ranking (Mittal et al., 2018), publication that offers a critical analysis of the maturity models for smart manufacturing and industry 4.0 and emphasizes the shortcomings of the SME viewpoint, demonstrating the necessity for an industry 4.0 SME vision to guide SME leaders on their journey towards Industry 4.0.

One the other hand, there are articles emerging in the academic appreciation, as (Gallego-Garcia, Groten, & Halstrick, 2022; Joshi, Sharma, Bartwal, Joshi, & Prasad, 2022; Sony, Antony, & Mc Dermott, 2022; Valerio, da Silva, & Neves, 2020; Zekhnini, Cherrafi, Bouhaddou, Benabdellah, & Raut, 2021).

Table 3 - References versus Citations

Reference	Citations
(M. Ghobakhloo, 2018)	1091
(Mittal et al., 2018)	810
(Ghadge, Kara, Moradlou, & Goswami, 2020)	283
(M. Ghobakhloo & Fathi, 2020)	274
(Facchini, Oleskow-Szlapka, Ranieri, & Urbinati, 2020)	128
(Ching, Ghobakhloo, Iranmanesh, Maroufkhani, & Asadi, 2022)	37
(Machado et al., 2021)	28
(Kumar, Vrat, & Shankar, 2021)	20
(Gallego-Garcia et al., 2022)	7
(Sony et al., 2022)	5
(Zekhnini et al., 2021)	4
(Joshi et al., 2022)	1
(Dorneanu et al., 2022)	0

According to the impact factor, the journal that presented the most relevant impact is Journal of Cleaner Production. On the other side, the journal that presented more publications is the Journal of Manufacturing Technology Management, selected for this review, with four references. We noted that most of the journals publishing in this interception is from the engineering category.

3.2 The papers Overview

In this section, we present a summary of the selected papers.

(Ching et al., 2022) studied regarding the potential benefits of Industry 4.0 and the digital industrial revolution for environmentally friendly manufacturing. The results demonstrated that Industry 4.0 supports sustainable manufacturing through 15 closely related functions, including business model innovation, customer-oriented manufacturing, employee productivity, harmful emission reduction, improved manufacturing profit margin, intelligent production planning and control, manufacturing agility, manufacturing productivity and efficiency, new employment opportunities, resource and energy efficiency, and reduced manufacturing. Within the roadmap for sustainable manufacturing created for the study, each sustainability function's role was thoroughly outlined. Overall findings indicated that Industry 4.0 can be a key enabler for sustainable production.

(Dorneanu et al., 2022) discusses the usage of state-of-the-art machine learning and artificial intelligence technologies for utilizing massive data produced by real-time smart sensors. It also outlines a strategy plan to incorporate such technologies in order to create an autonomous smart plant, with self-adaptation and self-regulation for both short- and long-term production management.

(Facchini et al., 2020) proposes a roadmap for Logistics 4.0, beginning from the I4.0 capabilities. The study presents the

two study cases application and discusses the x maturity dimensions to develop maturity toward the fourth industrial revolution in the logistics perspective, they are: Knowledge, Integrated Strategy and Leadership, Adopting Employees, Adopting IT Systems, Integrated Smart Products, Adopting Smart Warehouses and Adopting Technologies.

(Gallego-Garcia et al., 2022) The "GUVEI"-Model, a five-step process (Get, Use, Virtual, Expand and Improve), was developed as a framework model for sustainable and continuous development and to describe the general actions to be taken to attain a completely digitalized organization in the fourth industrial revolution considering the technological perspective.

(Ghadge et al., 2020)performs a critical literature review to identify key drivers and barriers for Industry 4.0 implementation under four business dimensions: strategic, organisational, technological, and legal and ethical. It also presents a system dynamics simulation model that aims to understand the impact of Industry 4.0 implementation on supply chain parameters, by including both the identified driving forces and barriers for this technological transformation. The results of the simulation are then utilised to develop a conceptual model for a successful implementation and acceleration of Industry 4.0 in supply chains.

(Mittal et al., 2018) presents a critical review of smart manufacturing and industry 4.0 maturity models and highlights the limitations in the SME perspective, which demonstrates a need for industry 4.0 SME vision in order to direct SME leaders at the steps their journey towards Industry 4.0.

(M. Ghobakhloo, 2018) discusses the future of the manufacturing industry through a systematic literature review. The study presents that Industry 4.0 is an integrative method of value creation that is constituted of 12 design principles and 14 technology trends. The conclusion presents the strategic roadmap as a critical resource for transitioning.

(M. Ghobakhloo & Fathi, 2020) presents lean-digitized manufacturing as a strong allied to corporate survival in the industry 4.0 era. The findings highlight that Industry 4.0 transformation demands the organizational integration of high technologies and the digitization of whole value chains.

(Joshi et al., 2022) discuss the importance of integrating OPEX strategies and Industry 4.0 as a way to optimize cost, productivity and flexibility to improve quality and value stream mapping (VSM). The research identifies major challenges that prevent the integration of OPEX strategies, such as lean, with I4.0 technologies in manufacturing, and highlights the urgent need to comprehend the integration opportunities as well as to determine the challenges for manufacturing SMEs and further suggest a strategic roadmap for the future.

(Kumar et al., 2021) conducts a literature review and discussion with experts to identify key challenges to Industry 4.0 and rank the solutions to overcome them and ensure successful adoption. The study recognizes a total of 23 Industry 4.0 barriers and proposes 18 solutions by introducing a hybrid framework that combines the Modified Stepwise Weight Assessment Ratio Analysis and Weighted Aggregated Sum Product Assessment methodologies. The practical application of the suggested framework is illustrated using an empirical case study of an Indian auto component manufacturing company.

(Machado et al., 2021) carries out a qualitative investigation with the goal of identifying and consolidating the organizational circumstances necessary for digital transformations. The study includes visits and in-depth interviews with three Swedish manufacturing firms of different sizes and sectors; and it suggests a questionnaire to facilitate discussion and evaluations of the organizational readiness for digital transformation.

(Sony et al., 2022) explores the relationship between technological capacity and strategic adaptability on the effective deployment of Industry 4.0 by conducting a qualitative study. It uses a grounded theory methodology on 34 senior managers from North America and Europe and proposes a framework enlisting several aspects of technological competence and strategic flexibility that influence the successful adoption of Industry 4.0.

(Zekhnini et al., 2021) performs a critical analysis of the literature to pinpoint important factors influencing and limiting the adoption of Industry 4.0 in the context of four business dimensions: strategic, organizational, technological, and legal and ethical. Additionally, it proposes a system dynamics simulation model that incorporates both the stated forces driving and impeding this technological revolution in order to understand the effects of Industry 4.0 deployment on supply chain parameters. The simulation's findings are then used to create a conceptual framework model for accelerating and implementing Industry 4.0 in supply chains.

4 DISCUSSION

For the discussion, we return to the research question proposed in the introductory part of the paper.

4.1 How can managers strategize Industry 4.0?

Both (Casadesus-Masanell & Ricart, 2010) and (Teece, 2010) define the strategy as the driver to achieve the purpose of the organization, which goes very well with one of the ways of interpreting the strategy proposed by (Mintzberg, Ghoshal et al. 2003) in which the strategy is interpreted as a plan, or as "the most practical way of understanding a strategy, that is, one in which there is some type of action defined for each situation or context, which can be understood as a guideline (or a set of them) to express what the company can do to gain an advantage over its competitors".

Starting from the (Casadesus-Masanell & Ricart, 2010) and (Teece, 2010) strategy perspective and based on the findings from the reviewed papers towards answer the research question, we proposed a conceptual framework to organize the constructs that compound the theoretical fundaments of the Strategy in a Industry 4.0 context. Our conceptual framework has named Strategy 4.0 and its graphically represented in Figure 3 - Strategy 4.0 Conceptual Framework. The framework is composed of three constructs: Digital Maturity, Digital People Readiness and Data Literacy.

Figure 3 - Strategy 4.0 Conceptual Framework

The table below displays the constructs and the corresponding more relevant authors that contribute to each construct, which outlines the conceptual framework – see Table 4 - Publications versus Constructs.

Table 4 - Publications versus Constructs

Publications	*Digital Maturity*	*Digital People Capabilities*	*Data Readiness*
(Ching et al., 2022)	X		
(Dorneanu et al., 2022)			X
(Facchini et al., 2020)	X		
(Gallego-Garcia et al., 2022)		X	
(Ghadge et al., 2020)	X		
(M. Ghobakhloo, 2018)	X	X	X
(M. Ghobakhloo & Fathi, 2020)		X	
(Joshi et al., 2022)	X	X	
(Kumar et al., 2021)		X	
(Machado et al., 2021)		X	
(Mittal et al., 2018)	X		
(Sony et al., 2022)		X	X
(Zekhnini et al., 2021)	X	X	

4.1.1 Strategy 4.0: Digital Maturity

In different areas of knowledge, maturity models are essential elements for organizations to obtain a clear view of the current state of maturity of their processes, as well as the identification of the gap related to the intended future state, as well as having a comparison for their positioning in relation to competitors. (De Bruin, Rosemann, Freeze, & Kaulkarni, 2005) defines maturity models as "one of the widespread areas in the field of improving organizational performance. They identify organizational strengths and weaknesses as well as providing benchmarking information." Also, the author highlights that "organizations continually face pressures to gain and retain competitive advantage, identifying ways of cutting costs, improving quality, reducing time to market and so on, become increasingly important. Maturity models have been developed to assist organizations in this endeavour" (De Bruin et al., 2005).

In the Industry 4.0 context, our study shows it is not different. Strategizing and moving towards digitalization requires a complete understanding of a company's current stage of transition (Facchini et al., 2020). (M. Ghobakhloo, 2018) states that "the promise of Industry 4.0 is real, but for companies that are mature enough to embrace it and have devised a comprehensive transition strategy", and also (Mittal et al., 2018) affirms "The availability of industrial-backed white papers emphasizes the practical application and relevance of maturity models to drive Smart Manufacturing".

In fact, the digital maturity refers to the level of development of an organization's digital capabilities and the efficiency with which it employs digital technologies to achieve its goals. The extent to which an organization incorporates digital technologies into its operations, strategy, culture and customer experience is reflected in this metric. The organization's overall readiness to adopt and employ digital technology to spur growth and innovation is the key emphasis of digital maturity (M. Ghobakhloo, 2018; Mittal et al., 2018).

In addition, in the context of the strategy 4.0 formed from the articles in the studied corpus, the industry 4.0 advancement maturity reveals the enablement of new capabilities for additional domains as Lean 4.0 (M. Ghobakhloo & Fathi, 2020; Joshi et al., 2022) Supply Chain 4.0 (Ghadge et al., 2020; Zekhnini et al., 2021), Logistics 4.0 (Facchini et al., 2020) and Sustainability 4.0 (Ching et al., 2022).

4.1.2 Strategy 4.0: Digital People Capabilities

According to (Kane, 2019), digital literacy goes beyond the simple technical expertise to a more broad view of purpose and suitability, it is the "knowledge of the business value and application" of the new technologies. While digital literacy was a strategic advantage in the third industrial revolution, it has become an essential competency for leaders and collaborators in the Industry 4.0, particularly for those who need to acquire new skills (da Silva et al., 2022; Sakurada, Geraldes, Fernandes, Pontes, & Leitão, 2021). In this way, we could say digital literacy encompass technical knowledge combined with the business value view and applicability.

Putting this concept under perspective, even with all the advances and new technologies, humans are still at the center of the digital transformation, as they need to understand how to combine the available tools and data in a new way (Drath & Horch, 2014) and plan on how to use them in a strategic manner to extract the maximum benefits and value in this process. As (Kane, 2019) noted, "it is your people who will fuel—or thwart—your digital transformation".

In this research review we observed a direct correlation between the the digital people capabilities to the emerging field of digital literacy literature (da Silva et al., 2022; Kane, 2019; Ostmeier & Strobel, 2022; Sakurada et al., 2021). According to (Kane 2019), digital literacy goes beyond the simple technical expertise to a more broad view of purpose and suitability, it is the "knowledge of the business value and application" of the new technologies. While digital literacy was a strategic advantage in the third industrial revolution, it has become an essential competency for leaders and collaborators in the Industry 4.0, particularly for those who need to acquire new skills (Sakurada, Geraldes et al. 2021, da Silva, Soltovski et al. 2022).

In this way, we could say digital literacy encompass technical knowledge combined with the business value view and applicability, therefore, digital people capabilities has a relevant central approach in the authors discussions and, it is a fact that a successful strategy 4.0 should take into consideration not only the requirements for the technological digital transformation, but mainly address the competences development on the existing workforce to advance the future generation of Industry 4.0 professionals in strategic, tactical and operational levels (Gallego-Garcia et al., 2022; M. Ghobakhloo, 2018; Kumar et al., 2021).

(Kumar et al., 2021) presents as the first in the list of barriers/challenges of implementing industry 4.0 the item "Training of workforce/employee for acquiring adequate knowledge and core digital skills". Also, the authors highlight that one major issue firms encounter while implementing I4.0, particularly in underdeveloped countries, is a lack of proper training to improve the digital competencies and soft skills of current employees, this high-tech approach would require proper digitalization strategy. In the same conclusion (Joshi et al., 2022) presents lack of trained support as key driving challenge for I4.0 implementation.

However, the digital people capabilities affects more then training. The (Kumar et al., 2021) sequence demonstrates that the top-ranked solution for removing the majority of Industry 4.0's obstacles is "commitment from senior management towards implementation". The organization's top management is crucial in fostering digitalization-related operations and is in charge of carrying out a successful I4.0 organizational reorganization, permitting sufficient process standardization. The same assumption come up from the (Joshi et al., 2022) and (M. Ghobakhloo & Fathi, 2020) analysis that the management support is pointed as a crucial challenge.

(Sony et al., 2022) indicates that organizations need to understand the nature of the relationship in the implementation of I4.0, he noted that moderating factors such the kind of organization, industry, organizational culture, and leadership may be some of the variables whose impact should be explored. (Machado et al., 2021) suggests “a dialogue tool to promote alignment and leadership engagement leadership, to help to build-up and evaluate teams responsible for encouraging the changes on a local level”.

In summary, this conceptual construct emphasizes that Strategy 4.0 call for new competencies, and digital teams’ features relate to these competencies, thus it is crucial to be mindful to develop and inspire this advancement.

4.1.3 Strategy 4.0: Data Readiness

In the I.4.0, large and complex volumes of data must be smartly and precisely analyzed in a timely manner, leveraged by the use of technology, but still requiring very specific people knowledge to handle that data, and also make data-based decisions across a wide range of work areas (da Silva et al., 2022).

The digitization of manufacturing processes permeates the key idea behind IoT is having objects (things) capable of sensing the environment by means of sensors (e.g., temperature, pressure, position, speed, heart beats, etc.) and/or interacting with the environment (e.g., by sending an alert, playing a sound, closing a valve, moving a lever, etc.), and also able to connect with each other to share information, as part of a unified framework (be it an autonomous simple network or a broader network ecosystem) (Gubbi, Buyya, Marusic, & Palaniswami, 2013; Vermesan & Friess, 2014). These interconnected devices (things) would then be able to take action or make decisions based on data from its own framework and ecosystem.

Hence, the strategy 4.0 stated in this study also underscored the data as a core asset for the organizations and data readiness is key construct in this conceptual framework. Also, this concept is close to the emergent branch of the literature about data literacy, that it refers to the ability to “collect, understand, analyse, use, explain, identify, interpret, implement, communicate, evaluate and manage data” (Pratama, Lestari, Sari, Putri, & Adiatmah, 2020).

(Dorneanu et al., 2022) presents the knowledge of the combination of integration of data collected from different IoT sources and in different formats, processed through computational resources energy and connectivity allows the development of advanced analysis and generation of insights from artificial intelligence algorithms, and finally, the convergence between the real and virtual worlds for improved decision making.

(M. Ghobakhloo, 2018) display that data from operations and business systems, as well as from supply partners and customers, may all be integrated thanks to the development of smart manufacturing systems and smart supply chain management. In turn, this degree of integration provides a comprehensive perspective of the upstream and downstream supply chain activities, adding value across the whole supply network.

Moreover, (Dorneanu et al., 2022) proposes a roadmap toward the smart plants based on data technologies: big data and machine learning. The proposal features that a new generation of production systems with smart sensing and intelligent services, connected by ubiquitous sensors, intelligent hardware, control systems, computing facilities, and information terminals, can be created through model-based agent intelligent networks. Also, the authors point out that data advancement provide capabilities like general location awareness, forecasting and early warning, cooperative optimization, and decision making.

(Sony et al., 2022) introduces a framework for competitive advantage and successful I4.0 implementation. Their framework defines that organizations must utilize Cloud, IoT, Big Data and Analytics core technologies, as well as technological capability and strategic flexibility optimally to meet dynamic market needs. Furthermore, organizations should also consider the interactive effect of these technologies when implementing I 4.0 in their organizations. As a principle for obtaining competitive advantage, I 4.0 implementation is not only due to the implementation of isolated technologies, but also to the continuous development of data readiness as a dynamic capability.

In summary, companies must be able to manage the entire data lifecycle, from selecting the appropriate data to collect, handling its flow and storage requirements, to finally extracting insights from it. This requires an understanding of data sources, quality, and the tools and techniques available for collecting and managing data. Companies must also be able to store data securely and efficiently, and use data to identify patterns, trends, and insights that can help them make informed decisions and stay ahead of the competition. Therefore, data readiness has become an imperative requirement for companies to secure their competitiveness.

5 CONCLUSION

The term Industry 4.0 has transcended its status as a mere buzzword and is now acknowledged by both academics and managers as a continuous process that will revolutionize the way businesses operate. Despite this recognition, authors agree that the transformation from traditional industry to Industry 4.0 will not be a simple undertaking, with various obstacles and hurdles to overcome. Thus, to effectively make the shift to Industry 4.0, there is a need for comprehensive strategic management strategies that can provide adequate support for the transition.

This paper provides a systematic literature review of most relevant papers where there is an intersection between the research of Industry 4.0 and Strategic Management. We have used the PRISMA method for data selection, starting with 26 records and reaching 13 most relevant records. To organize the findings, we propose a Strategy 4.0 conceptual framework composed of three constructs: Digital Maturity, Digital People Capabilities and Data Readiness. The concepts suggest businesses that want to prosper in the digital age must develop their human capital by putting an emphasis on data readiness and employing it to reach digital maturity (Gallego-Garcia et

al., 2022; Ghadge et al., 2020; M. Ghobakhloo, 2018; M. Ghobakhloo & Fathi, 2020; Kumar et al., 2021; Sony et al., 2022; Zekhnini et al., 2021).

The results indicate that there a lack of the studies to address the strategic perspective of I4.0 implementation. Most of the studies are literature review methodology approach and, they are still limited in scope and depth. Even assuming that there is no one-size-fits-all strategy, and in-depth research covering all possible scenarios would be impracticable, studies in the area are still incipient, and there is much room for contribution.

Also, the way of digitalization journey, as well as the implementation process of I4.0 efforts, require more investigation and scholars need to understand the steps of a detailed strategic roadmap for a successful transition from traditional manufacturing into Industry 4.0 (Dorneanu et al., 2022; Facchini et al., 2020; M. Ghobakhloo, 2018; Kumar et al., 2021; Machado et al., 2021; Mittal et al., 2018).

Regardless of the limitations, this paper contributes to theoretical research in the fields of I4.0 and Strategic Management by giving directions on what domains need to be addressed to support the practitioners looking forward to being prepared for the digital transformation.

For the future research we recommend scholars explore empirical approach to address strategic management tools to support organizations in I4.0 4.0 implementation. Another interesting avenue for future research is investigates how to measure the digital people capabilities to perform I4.0 implementation.

Even though the limitations, this paper will contribute to the work of researchers attempting to identify the advanced of research in the intersection between the emergent field of Industry 4.0 and the Strategy.

6 REFERENCES

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