

# Digital Transformation and Industry 5.0: a Systematic Literature Review

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**Abstract:** In the 19<sup>th</sup> century, authors like Karl Marx criticized the injustice they saw in the work relations between employees and owner of factories, and that struggle was never completely solved. Recently, a new concept has emerged, where the business puts the interest of the workers at the center of the work, and that is Industry 5.0. Not only that, it also tackles some of the most urgent issues of society, i.e., sustainability. All of that supported by Digital Transformation, which provides technologies and information to guide the decision process of industries. With the objective of investigating the scientific state-of-the-art in terms of Digital Transformation and Industry 5.0, this is a Systematic Literature Review of 41 articles which helps understand the recent research on these themes. Since 2021, there has been a growing interest in academia by this knowledge. Industry 4.0 wasn't able to explain and implement a proper relation between technologies and workers in the workplace. Besides, Industry 4.0 didn't seem to pay attention to the environmental problems caused by industries. Although Industry 5.0 is not a decoupling from Industry 4.0, it is a step forward, with some authors calling it a Paradigm Shift; a terminology use which is criticized by this research. However, the concept Industry 5.0 is not fully understood by the literature, therefore, further research is needed.

**Keywords:** Industry 4.0; Industry 5.0; Digital Transformation; Workers' well-being; Paradigm Shift; Sustainability.

## INTRODUCTION

Karl Marx (2009), in the 19<sup>th</sup> century, was one of the first and most vigorous thinkers to plead against the exploitations of the industries, in what became known as the struggle of the owners of properties and machines versus the proletariat, which are the workers, i.e., the employees. Despite his criticism, he was rational enough to recognize the power of the revolution of the industry to produce marvels in terms of scale of productions and creation of wealth (Engels & Marx, 1997). Since then, the power struggle between the owners of property and means of productions on one side, and the workers on the other side has been one of opposing forces fighting for their own interest.

Only recently, a new concept has emerged, which puts the humans at the center of the concern of the enterprises, and that concept is called Industry 5.0 (Shahbakhsh, Emad & Cahoon, 2022). While Industry 4.0 was mainly focused on Digital Transformation of businesses, Industry 5.0 is still concerned with that aspect, but with the advancement of the importance of three more characteristics for industries, mainly: human-centric approach to administration; sustainability; and resilience (Olsson, Eriksson & Carlsson, 2024). Many authors have called this evolution a paradigm shift, due to its never-before-seen business preoccupation with societal issues (Hunková & Havierníková, 2024).

However, the understanding of these concepts and developments is not clearly understood (Ciucu-Durnoi, Delcea, Stănescu, Teodorescu & Vargás, 2024). For instance, there is literature from different areas of research to help explain the concepts of sustainability and resilience and how they relate to current environmental challenges, but the literature regarding Industry 5.0 doesn't elucidate what it means to have a human-centric approach in Industry 5.0 (Pacheco & Iwaszczenko, 2024). Besides, the term Paradigm Shift, which is constantly being used to refer to Industry 5.0, is a specific definition which, in general terms, means the rupture with an outdated scientific view in favor of a new understanding (Kuhn, 1970), therefore it doesn't seem to be applicable in the case of Industry 4.0 and Industry 5.0, in the sense that they seem to be understood as complementary approaches rather than replaceable practices (Ghobakhloo, Fathi, Iranmanesh, Vilkas, Grybauskas & Amran, 2024).

Therefore, due to the relevance of the topics Digital Transformation and Industry 5.0 (Chidozie, Ramos, Ferreira & Ferreira, 2024), it is the objective of this systematic literature review

to answer to the following questions: *what is the state-of-the-art scientific production in terms of Digital Transformation and Industry 5.0?* Through a systematic literature review of 41 articles from journal qualified as Q1 (Quartile 1) and Q2 (Quartile 2) from the Scopus and the Web of Science database, it is the aim of this research to elucidate and bring forth to future researchers and practitioners the current state of knowledge related to Digital Transformation and Industry 5.0, in order that these concepts can be better understood and more consciously direct the collaborative effort of future research. In order to achieve that goal, this research has applied the PRISMA protocol of articles gathering, and the TCCM method of analyzing and presenting the articles analyzed (Paul, Khatri & Duggal, 2023).

The connection of the terms Digital Transformation and Industry 5.0 brings up a set of very recent studies, which, despite dating back to the recent year of 2021, already raise many questions and claims for a proper understanding of the needed future research directions (Hunková & Havierníková, 2024); contributions which this research will help bring forth. Two of the main problems in terms of the current studies analyzed are the unclear interpretation of the meaning of Industry 5.0 and how it can be applied to industries, especially in terms of the pillar human-centric approach (Hansen, Christiansen & Lassen, 2024); and also the misuse and misinterpretation of the term Paradigm Shift, which seems to have been loosely used throughout most of the studies (Sverko, Grbac & Mikuc, 2022; Babkin, Shkarupeta, Kabasheva, Rudaleva & Vicentiy, 2022). In terms of findings that will contribute to future studies, two of the main ones are the observation that governmental policies should play a more critical role in aligning expectancies and directions in terms of the Industry 5.0 approach (Camarinha-Matos, Rocha & Graça, 2024), and also how corporate education should play a relevant role in future research and corporate practices (Piardi, Leitão, Queiroz & Pontes, 2024). All in all, this research stands out as a critical analysis that challenges some of the concepts proposed by researches, and its main contribution is a set of future research suggestions.

This article structure of presentation of findings is as follows: introduction; method; results of the analysis; discussion of results; suggestions of future research; and final considerations.

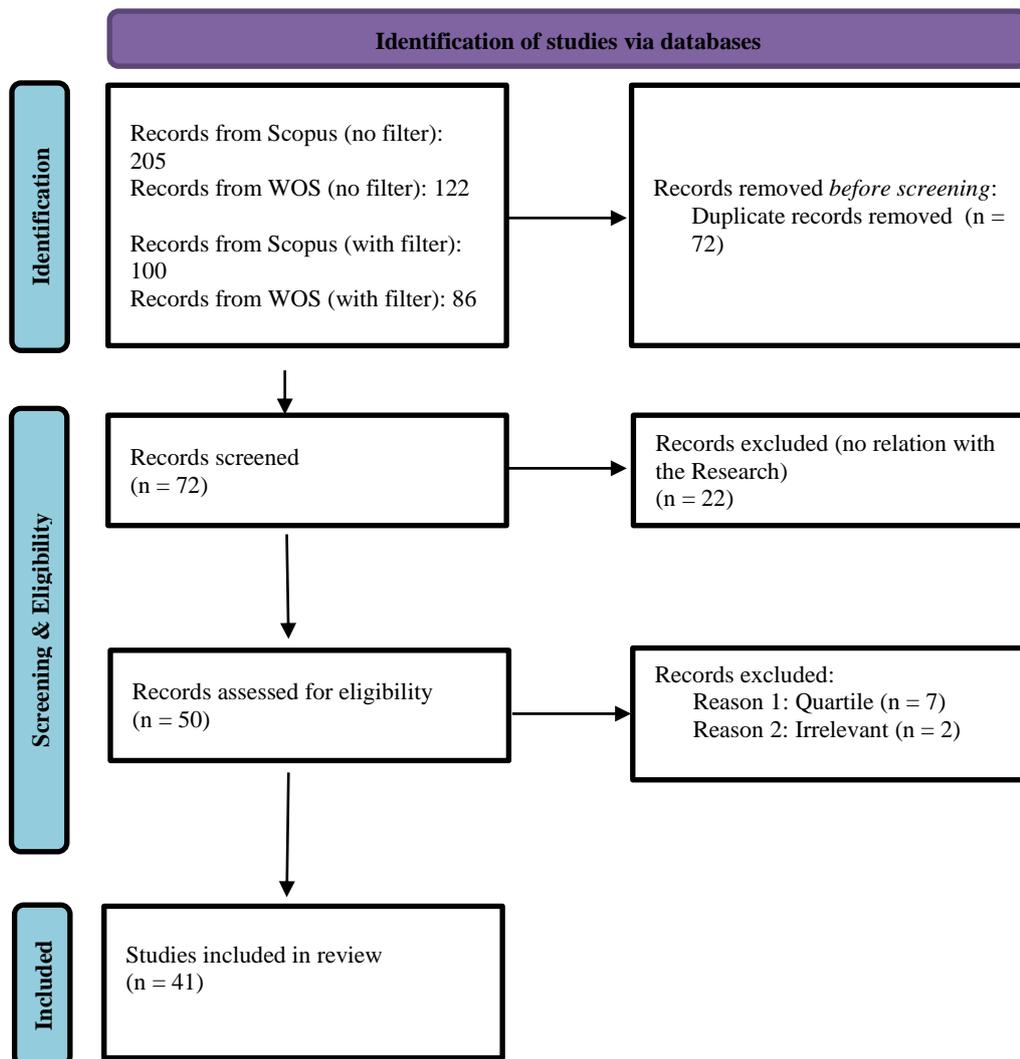
## **METHOD**

This article is a qualitative systematic literature review which follows the PRISMA approach of articles gathering (Moher, Liberati, Tetzlaff & Altman, 2009) and the TCCM (Theory, Context, Characteristics and Methods) method of analyzing and reporting the articles selected (Hassan, Rahman & Paul, 2022; Paul, Khatri & Duggal, 2023).

The PRISMA approach states 4 steps for the articles inclusion/exclusion, which are: (1) Identification; (2) Screening; (3) Eligibility; and (4) Inclusion (Liberati, Altman, Tetzlaff, Mulrow, Gøtzsche, Ioannidis, Clarke, Devereaux, Kleijnen & Moher, 2009). The process of looking for the articles of research is described in the following paragraph.

The question that this research is aiming at answering is: *what is the state-of-the-art scientific production in terms of Digital Transformation and Industry 5.0?* In order to accomplish that, it has researched both the Scopus and Web of Science databases, starting in December, 2024. The query of research was: ["digital transformation" and "industry 5.0"]. Without any filter, the Scopus search returned 205 articles, and the Web of Science search returned 122 results. The next step applied a filter to reduce the number of articles in order to focus on studies in line with this researched, which was limited to: article; article review; English language; and 6 areas of research (Business; Engineering; Economics; Social Sciences; Environmental Science; and Computer Science). This filtering brought up 100 articles in Scopus and 86 articles in Web of Science. After unifying both findings to eliminate duplicate articles, a total of 114 articles were selected for deeper analysis of abstracts, to select only the articles with Digital Transformation and Industry 5.0 concepts in their research. From this analysis, 50 articles remained. Following the goal of this research of focusing on the state-of-the-art studies, only articles published on Quartile 1 and Quartile 2 journals were selected, ending up with a total of 43 articles for the systematic literature review. Throughout the review, two articles were deemed irrelevant for this research for not

aligning with the question of this research (Aldoseri, Al-Khalifa & Hamouda, 2024; Narula, Tamvada, Kumar, Puppala & Gupta, 2024). Therefore, this research presents the result of 41 articles analyzed in depth. The PRISMA steps are described in the figure 1.



**Fig. 1.** PRISMA steps of article retrieval. Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. (Adapted by the authors of this Research).

The PRISMA approach also requires a protocol presenting additional information about the process of research (Mishra, Singh, Koles, 2021; Paul, Khatri & Duggal, 2023) and it can be found on table 1.

**Table 1**  
PRISMA protocol of research.

<b>Protocol</b>	
<b>1. Objective:</b>	Investigate the scientific state-of-the-art in terms of Digital Transformation and Industry 5.0.
<b>2. Question:</b>	What is the state-of-the-art scientific production in terms of Digital Transformation and Industry 5.0?
<b>3. Database:</b>	Scopus and Web of Science
<b>4. Keywords (Query):</b>	“digital transformation” and “industry 5.0”
<b>5. Article Inclusion Criterion:</b>	Q1 and Q2 Articles Quartile.

As for the presentation of the information collected on the analysis of the articles selected, this research follows the TCCM (Theory, Context, Characteristics and Methods) approach (Hassan, Rahman & Paul, 2022; Paul, Khatri & Duggal, 2023), where *Theory* corresponds to presenting the main theories being discussed by the researches; *Context* refers to the countries and locations where the researches come from how it identifies with the studies; Characteristics determines specific details that might stand out in the articles analyzed; and *Methods* deals with presenting the method used by the authors in their researches and how it impacts the results found.

## **RESULTS OF ANALYSIS**

This chapter is dedicated to presenting the results of all the 41 articles reviewed, using the aforementioned TCCM method, starting with the presentation of the main theories found.

### *Theory*

The main concepts being analyzed by this research are Digital Transformation and Industry 5.0; however, there are many other concepts that come under debate when talking about these two concepts (Afzal, Li & Hernández-Lara, 2024). The term Digital Transformation seems to be quite well understood in the literature; however, that's not the case for Industry 5.0. The same can be argued for the terminology Paradigm Shift, which is recurrently mentioned by researchers. These and other theories related to the goal of this research will be shown in this chapter.

### *Digital Transformation*

Digital Transformation is the general use of technologies in the operations of companies (Shahbakhsh, Emad, Cahoon, 2022). It is more than just implementing technological processes, as it relates to a whole change in the way people work and interact with these technologies, involving the reorganization of processes of works, business models and organizational structures (Hein-Pensel, Winkler, Brückner, Wölke, Jabs, Mayan, Kirschenbaum, Friedrich & Zinke-Wehlmann, 2023). Digital Transformation is commonly associated to the use of technologies in businesses, and organizations in general, such as artificial intelligence, internet of things, cloud computing, smart factory, robotization, digitalization and digitization, blockchain, cybersecurity, metaverse, digital twins, cyber-physical systems, etc. (Chidozie, Ramos, Ferreira & Ferreira, 2024; Martínez-Gutiérrez, Díez-González, Perez, Araújo, 2024). Digital Transformation can also be understood under the interpretative lenses of the term Industry 4.0, which is the theory that analyses the implementation of all these technologies specifically in the industrial and business context (Hein-Pensel et al., 2023). Whereas there is a general understanding in regards to these concepts and terms, that's not the case with Industry 5.0 (Ciucu-Durnoi et al., 2024).

### *Industry 5.0' attempts of definition*

Industry 5.0 is a recent concept based on three pillars: human-centric; sustainable; and resilient (European Commission, 2021; Ghobakhloo, Mahdiraji & Iranmanesh, 2024) which was first used by Michael Rada in an industrial conceptualization (Akundi, Euresti, Luna, Ankobiah, Lopes & Edinbarough, 2022) and can be traced to 2018 (Fatima, Tanveer, Waseemullah, Zardari, Naz, Khadim, Ahmed & Tahir, 2022); however, it gained more popularity and applicability in 2021 with the publication of the European Commission (2021) manual of Industry 5.0 and its goal of implementation in the European industries.

In Industry 5.0, sustainability is the conventional understanding of providing the needs of the current generation, without compromising the possibility of future generations of meeting their own needs, with the difference that it is understood as an industry concern as well (Afzal, Li, & Hernández-Lara, 2024); resilience is a complement of the idea of sustainability, as natural tragedies are more recurrent due to human and industrial impact on the planet, where resilience is the ability

of surviving and going through these events (Camarinha-Matos, Rocha & Graça, 2024). The greatest conceptual contribution of Industry 5.0 is the human-centric approach, which is often stated as the collaboration of humans and machines in the production process, where machines, robots and technologies are developed more in sync with human needs and skills, in opposition to previous ways of developing industrial processes, where technologies were developed and implemented without any regard for the workers that would use or be replaced by the inventions (Piardi, Leitão, Queiroz & Pontes, 2024).

The European Commission (2021) in its Industry 5.0 manifesto advocating for the implementation of it in the European Factories states that the companies should not ask what we can do with the technologies that are invented, but rather ask what the technologies can do for humans. One of the interpretations that can be drawn from Industry 5.0 is that it tries to fix the problems caused by Industry 4.0 in terms of not concerning with the massive replacement of humans by the new technologies in the industries and by the fact that many workers' knowledge is completely out of step with the fast pace of technological advancement (Pacheco & Iwaszczenko, 2024). Therefore, for some authors, Industry 5.0 is an evolution from Industry 4.0, while for others it is merely a complement in terms of concepts that weren't tackled by Industry 4.0 (Nazarejova, Soltysova & Rudeichuk, 2024; Ciucu-Durnoi et al., 2024).

Some authors go even further, in stating that Industry 4.0 was a way of pushing the workers out of the industries, in the understanding that they were merely a cost for the companies, and that as the intent didn't work out, as business realized that completely robotizing and automating industries was not feasible, the concept of Industry 5.0 was an attempt to fix that goal's mishap (Sverko, Grbac & Mikuc, 2022; Ghobakhloo et al., 2024). Whereas sustainability and resilience are terms that come from other disciplines, which also relate to the industries, and that have measurable and observable results, the term human-centric still lacks a clear definition, steps of applicability and measurements of successful implementation (Babkin, Shkarupeta, Kabasheva, Rudaleva & Vicentiy, 2022), although efforts have already been made in that direction (Piardi et al., 2024).

As a supposed evolution from Industry 4.0, many authors refer to Industry 5.0 as a *Paradigm Shift*; however, the use of that term and interpretation has also received criticism and is further explored next.

### *Industry 5.0 as a Paradigm Shift*

For many authors, Industry 5.0 is a Paradigm Shift, in the sense that it is a next step in the evolution that brought industrial evolution from Industry 1.0 to Industry 4.0 (Hunková & Havierníková, 2024), whereas other authors criticize that interpretation, stating that Industry 5.0 is not a Paradigm Shift (Babkin et al., 2022; Ghobakhloo et al., 2024). In fact, Paradigm Shift is a very specific terminology, coined by Thomas Kuhn (1970), to designate the transitions and disruptions in scientific theories. For Kuhn (1970), science doesn't evolve in smooth continuums of development and increased understanding of science as a view and experience of the world, but as sudden shift and disruption, caused by new views, interpretations, theories and terminologies in science; in other words, a Paradigm Shift comes to replace old interpretations of the world in science (Kuhn, 1970).

Therefore, it is not clear whether Industry 5.0 is a Paradigm Shift or if it is a complement of Industry 4.0 (Ávila-Gutiérrez et al., 2021; Ciucu-Durnoi et al., 2024). When authors refer to Industry 5.0 as a Paradigm Shift, it is done without a reference to Thomas Kuhn and its interpretation of the term, offering a superficial interpretation both of the concepts of Industry 5.0 and of Paradigm Shift (Ghobakhloo et al., 2024). Not even the term Industry 4.0 is fully understood, for that matter (Hansen, Christiansen & Lassen, 2024), but it is a recognized fact that the human factor is a critical element whether for Industry 4.0 or Industry 5.0 (Fatima et al., 2022).

### *Corporate Education and Smart Manufacturing (Human-Centric Approach)*

On the surface, Industry 4.0 was an attempt to automatize and robotize the industries, to what became known as Smart Manufacturing (Alimam, Mazzuto, Tozzi, Ciarapica & Bevilacqua,

2023), but on a deeper interpretation, it was also about eliminating the human factor from the production and administration process as much as possible (Sverko, Grbac & Mikuc, 2022). As it didn't work out as well as anticipated, because the human element proved to be an essential piece in the administration and production process, the term Industry 5.0 was thought of as an attempt to refocus the attention of industry from the machines to the humans (Shahbakhsh, Emad & Cahoon, 2022). Hence, the goal is still the same, in terms of implementing the concept of Smart Manufacturing; however, this time, with the understanding of the inexorable need of the human element to its implementation, and it brings forth the problem of the barriers and the need for in-company educational strategies, for example (Olsson, Eriksson & Carlsson, 2024; Hunková & Havierníková, 2024).

In that sense, one of the recurrent topics in the literature about Industry 5.0 is the need for training, education and learning process of the workers to be able to work alongside the new technologies (Piardi et al., 2024). Not only that, the main idea of Industry 5.0 is to create a space of automated and highly technology engineered around the skills of and respect to the human worker; hence the concept of human-centric-approach of Industry 5.0 taking into account the well-being of the employees (Pappas, Mikalef Yogesh, Dwivedi, Jaccheri & Krogstie, 2023). However, this is not an isolated decision, relegated to each company to act according to their own needs and interpretation of what they think is best for the employees; it is a debate and a concern that involves governmental regulations and societal needs and demands (Kolade & Owoseni, 2022).

### *Government and Society*

The debate around the idea of Industry 5.0 does not occur in isolation inside the companies (Carayannis, Christodoulou, Christodoulou, Chatzichristofis & Zinonos, 2022) and depends on political and societal initiatives and demands as well. In reality, since its conception, the idea of Industry 5.0 had its roots in a governmental and societal interpretation, since it can be related to the Japanese movement of Society 5.0, in which the government of Japan designed a technological vision of the future of the country centered on technologies that are conceived and implemented to serve the well-being of its population, especially taking into account the fact that Japan has and will have a considerable number of old citizens, that cannot work (Park & Shintaku, 2022). Consequently, the ideas centered around what's best for the employees in the concept of Industry 5.0 belong to a wider debate that involves the political directions of each country and its societal needs in terms of employment demands and cultural characteristics (Hazrat, Hassan, Chowdhury, Rasul & Taylor, 2023). And that leads to the next topic related to Industry 5.0, which is a growing demand for customization (Akundi, Euresti, Luna, Ankobiah, Lopes & Edinbarough, 2022).

### *Customization and Supply Chain*

Another relevant aspect of Industry 5.0 is the need for companies to meet the demands of higher products and services customization (Orlova, 2021). It's not just the factories that are becoming smart; society as a whole has become ever more digitally interconnected and it opens the opportunity for customers data collection, storage and sorting with the intention to producing products that align more precisely with what people want (Akundi, Euresti, Luna, Ankobiah, Lopes & Edinbarough, 2022). This can help industries advance from a merely push economy, to a pull economy, i.e., to move from an industry that first produces and stocks in the hopes of selling its goods, to a manufacturing system that responds on demand to customer's requests, consequently reducing waste and stock (Madhavan, Wangtueai, Sharafuddin & Chaichana, 2022).

Industry 5.0, high levels of industry digitalization and customization will have an immediate impact of the whole supply chain of industries (Fatima et al., 2022). As aforementioned, Industry 5.0 doesn't work in isolation, and in that sense it also depends on the interconnection among industries, more specifically, in the supply chain of industries (Akundi et al., 2022). Thus, Industry 5.0 is a topic that connects suppliers, industries and customers in a highly technological and digitalized network that depends on a high and reliable flow of information, most of which is

considerably sensible both for companies and individual, connecting to other concerns such as Cybersecurity and ethics (Rowan, Murray, Qiao, O'Neill, Clifford, Barceló & Power, 2022).

### *Cybersecurity, Blockchain, Cloud Computing and Ethics*

Nowadays, the supply chain is run on technologies such as blockchains, which guarantees the reliability of the information and also cloud computing, as it increases security of data from hardware corruption (Chidozie, Ramos, Ferreira & Ferreira, 2024). Nevertheless, these high-end technologies are not flawless against cyber-attacks or other criminal digital actions; thus, an increasing area of research in terms of Industry 5.0 is Cybersecurity, as a research of ways to prevent misuse of information stored by companies (De Giovanni, 2023). That also leads to the increasing concern with ethics, both in what was already discussed in terms of the relationship of work environment and workers, and the use companies make of the information that is gathered both from employees and customers (Goktas & Yumusak, 2024), and it can also be related to people's privacy (Dhirani, Mukhtiar, Chowdhry & Newe, 2023).

As already discussed, all these topics are not isolated issues that matter only to the industries, but that have a direct relation to political and societal concerns (Hunková & Havierníková, 2024). The last topics to be presented in terms of Industry 5.0 are two of its three pillars: sustainability and resilience (Pappas et al., 2023).

### *Sustainability and Resilience*

In its more didactical presentation, Industry 5.0 is regarded as being grounded on three pillars: human-centric approach in the sense the humans and technologies in general have to operate in synergy, with a focus on human well-being; sustainability in terms of industries being aware of the impact of mass production on the environment degradation; and resilience to go through and overcome challenges, which could also be understood as industries survival skills, in this new era of natural and economic tragedies and crises (European Commission, 2021; Camarinha-Matos, Rocha & Graça, 2024). Different from the pillar human-centric approach, which isn't yet clear in its definition and applicability (Ghobakhloo et al., 2024), sustainability and resilience are well understood themes that leave little room from misinterpretation (Afzal, Li & Hernández-Lara, 2024).

Indeed, different from the human-centric approach pillar, sustainability and resilience are concepts that exist apart from Industry 5.0, which were borrowed from environmental and political contexts, mainly, in order to help guide industry in this new era of ecological disruptions (Alimam, Mazzuto, Tozzi, Ciarapica & Bevilacqua, 2023). Due to environmental and economic collapses that have disturbed supply chain productions, industries have realized the need for an administration that takes into account more complex variables in its plans of survival, that go beyond competition, and it all leads to the comprehension of the industry's negative impact in the environment (Chidozie, Ramos, Ferreira & Ferreira, 2024). Such concerns connect to already existing environmental goals such as the SDG 2030, which have claimed for a broad political, societal, academic and industrial plans and actions towards curbing current environmental malpractices (Afzal, Li & Hernández-Lara, 2024; Martínez-Gutiérrez, Díez-González, Perez & Araújo, 2024).

The next chapter, Context, will help widen the understanding of the Industry 5.0 through complementary information.

### *Context*

There is a growing concern with the human aspect inside industries ((Piardi et al., 2024) and with the impact of industrial actions in the environment (sustainability), and how these consequences affect the existence of the organizations (Resilience), in something like a framework of understanding similar to a closed-loop chain-reaction of events, where human actions impact the planet and its consequences come around to disrupt the place where humans and machines come together to produce their means of survival (Carayannis et al., 2022).

This idea of human-machine collaboration in harmony and respect with the environment, especially in which technologies are used to serve humans, instead of being a threat to people, is a concept that was born with Japan's plan, coined Society 5.0 (Park & Shintaku, 2022). In other words, the emergence of Industry 5.0 was already an anticipated evolution, given the natural progression of definitions from Industry 1.0 to Industry 4.0, but also due to the theoretical construction of some Japanese strands of thought, such as the concept of Society 5.0 (Keidanren, 2016; European Commission, 2021).

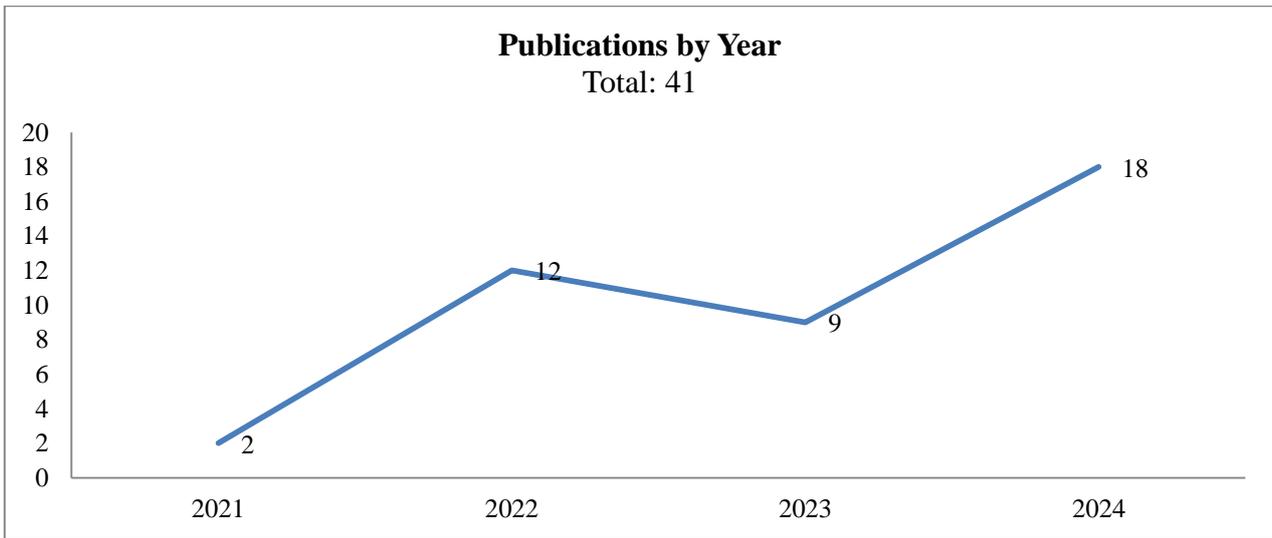
One of the first times the term Industry 5.0 was used can be traced back to the work of Sachsenmeier (Sachsenmeier, 2016; Coelho, Bessa, Landeck & Silva, 2023), in which, despite not outlining the full conceptualization of three pillars that is known nowadays, was a call for a change in the way humans work and produce, more in harmony with nature and human needs (Sachsenmeier, 2016). The first time the term Industry 5.0 was used in its currently known conceptualization can be found in a publication by Michael Rada in 2018 (Akundi, Euresti, Luna, Ankobiah, Lopes & Edinbarough, 2022; Fatima et al., 2022). Then, the term Industry 5.0 caught up momentum with the publication of the European Commission report in 2021 as conceptualization for a revamped European Industry aligned with the ideas of sustainability, human-centricity and resilience (European Commission, 2021). Some authors argue and criticize this action as only taking place due to the realization that industries were incapable of getting rid of most of the workers, as was intended in Industry 4.0, in an effort of replacement by robots and artificial intelligence (Fatima et al., 2022; Sverko, Grbac & Mikuc, 2022).

Now, it seems as though the industries are genuinely interested in the concept of Industry 5.0 and are trying to understand and implement its three pillars in their routines (Orlova, 2021; Olsson, Eriksson & Carlsson, 2024). There is a growing number of researches being developed both by academia and industries, as will be shown in the next chapter (Nazarejova, Soltysova & Rudeichuk, 2024). However, it is also understood from its inception that Industry 5.0 is not a practice that depends only on the goodwill of companies, as it relies in well-designed political directions and societal participation (as is the case with Japan, for instance), as the planning of industries, more than ever, impact society and the environment as a whole (Carayannis et al., 2022).

The next chapter will present further details on the characteristics of the current research on the topic of Industry 5.0.

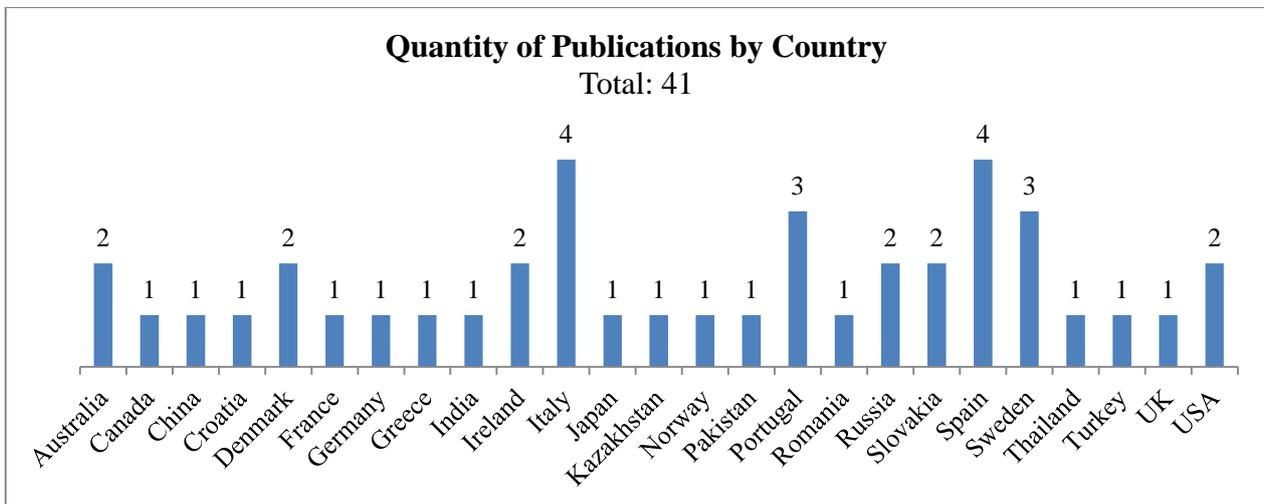
### Characteristics

As mentioned, the concept Industry 5.0 was first used in 2016 (Sachsenmeier, 2016; Coelho, Bessa, Landeck & Silva, 2023), however, when analyzed in connection with Digital Transformation, the studies began in 2021, as shown on figure 2. One more time, despite being called a Paradigm Shift, Industry 5.0 still holds a tight connection to the paradigms of interpretation and application of Industry 4.0, which, in turn, is also highly grounded in Digital Transformation (Ávila-Gutiérrez, Aguayo-González & Lama-Ruiz, 2021).



**Fig. 2.** Articles year of publication.

The image shows (Fig. 2.) that the interest in studies of Industry 5.0 is accompanied by the understanding that the topic is not isolated and that it has a connection to Digital Transformations (Carayannis et al., 2022), and this is one of the most recurrent arguments of the literature, i.e., that the Industry 5.0 is mostly about humans and technology working together, with a focus on the human aspect of this interaction (Pacheco & Iwaszczenko, 2024). In order to strengthen the understanding that Industry 5.0 is not a concept that should happen in isolation, the next image (Fig. 3.) shows how studies on the convergence of Digital Transformation and Industry 5.0 are taking place in different locations, spread evenly in different countries. Although, it is notable the absence of Central and Latina American countries, as well as African countries.



**Fig. 3.** Quantity of publications by country.

The characteristic of being spread across different borders also applies to the diversity of journals where the articles are being published, as can be seen on the following table 2. One reason for that is the fact that this research has broadened its scope of scooping to 6 different areas of research, which are: 1. business; 2. engineering; 3. economics; 4. social sciences; 5. environmental sciences; 6. computer science. The journals with the highest number of publications are: Sustainability (8); Sensors (4), and Information Systems Frontier (2); all the others journals share the same quantity of publications, i.e., one per journal.

**Table 2**

Number of publications by journals.

Total	Journal	Publisher
8	SUSTAINABILITY	MDPI
4	SENSORS	MDPI
2	INFORMATION SYSTEMS FRONTIERS	SPRINGER
1	ANNUAL REVIEWS IN CONTROL	PERGAMON-ELSEVIER SCIENCE LTD
1	APPLIED SCIENCES (SWITZERLAND)	MDPI
1	APPLIED SYSTEM INNOVATION	MDPI
1	ASIAN JOURNAL OF SHIPPING AND LOGISTICS	KOREAN ASSOCIATION OF SHIPPING AND LOG., INC.
1	COMPUTERS \& INDUSTRIAL ENGINEERING	PERGAMON-ELSEVIER SCIENCE LTD
1	DIGITAL BUSINESS	ELSEVIER B.V.
1	ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES	ENTERPRENEURSHIP & SUSTAINABILITY CENTER
1	EUROPEAN JOURNAL OF INNOVATION MANAGEMENT	EMERALD GROUP PUBLISHING LTD
1	IEEE ACCESS	INSTITUTE OF ELECTRICAL AND ELECTRONICS ENG.
1	IEEE OPEN JOURNAL OF THE COMMUNICATIONS SOCIETY	INSTITUTE OF ELECTRICAL AND ELECTRONICS ENG.
1	IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT	INSTITUTE OF ELECTRICAL AND ELECTRONICS ENG.
1	INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH	TAYLOR & FRANCIS LTD
1	INTERNATIONAL JOURNAL OF TECHNOLOGY	UNIV INDONESIA, FAC ENGINEERING
1	JOURNAL OF INTELLIGENT MANUFACTURING	SPRINGER
1	JOURNAL OF KING SAUD UNIVERSITY-COMPUTER AND INFO. SCIENCES	ELSEVIER
1	JOURNAL OF MANUFACTURING SYSTEMS	ELSEVIER SCI LTD
1	JOURNAL OF MANUFACTURING TECHNOLOGY MANAGEMENT	EMERALD GROUP PUBLISHING LTD
1	JOURNAL OF OPEN INNOVATION: TECHNOLOGY, MARKET, AND COMPLEX.	MDPI
1	JOURNAL OF THE KNOWLEDGE ECONOMY	SPRINGER
1	MATERIALS TODAY COMMUNICATIONS	ELSEVIER LTD
1	MATHEMATICS	MDPI
1	PRODUCTION ENGINEERING ARCHIVES	WALTER DE GRUYTER GMBH
1	ROBOTICS AND COMPUTER-INTEGRATED MANUFACTURING	ELSEVIER LTD
1	SCIENCE OF THE TOTAL ENVIRONMENT	ELSEVIER
1	SOCIAL SCIENCES	MDPI
1	SYSTEMS	MDPI
1	TECHNOLOGY IN SOCIETY	ELSEVIER LTD
1	TRANSFORMING GOVERNMENT: PEOPLE, ...	EMERALD PUBLISHING

Another characteristic that this research tried to analyzed was the quantity of article studies that took a more practical/applicable approach to the concept of Digital Transformation and Industry 5.0, for those interested in knowing how to implement these topics in the routine of industries and social/political actions; and what it found was that of the 41 articles retrieved, 17 have the characteristic of being concerned with the applicability of the constructs. The other 24 were regarded as conceptual or review studies.

**Table 3**  
Articles study applicability.

Author	Title	Year	Practical
OLSSON	MANAGEMENT TOWARD INDUSTRY 5.0	2024	Yes
GHOBAKHLOO	GENERATIVE ARTIFICIAL INTELLIGENCE IN MANUFACTURING	2024	Yes
GOKTAS	APPLYING THE DELPHI METHOD	2024	Yes
PIARDI	ROLE OF DIGITAL TECHNOLOGIES	2024	Yes
NAZAREJOVA	REQUIREMENTS AND BARRIERS FOR HUMAN-CENTERED	2024	Yes
MARTÍNEZ	TOWARDS INDUSTRY 5.0 THROUGH METAVERSE	2024	Yes
PACHECO	UNRAVELLING HUMAN-CENTRIC TENSIONS TOWARDS INDUSTRY 5.0	2024	Yes
DOSSOU	A CONCEPTUAL FRAMEWORK FOR OPTIMIZING PERFORMANCE	2024	Yes
DE GIOVANNI	SUSTAINABILITY OF THE METAVERSE	2023	Yes
ZHANBAYEV	DEMOETHICAL MODEL OF SUSTAINABLE DEVELOPMENT OF SOCIETY	2023	Yes
HEIN-PENSEL	MATURITY ASSESSMENT FOR INDUSTRY 5.0	2023	Yes

ORSO	EMPLOYEE-CENTRIC INNOVATION	2022	Yes
ROWAN	DIGITAL TRANSFORMATION OF PEATLAND ECO-INNOVATIONS ('PALUDICULTURE')	2022	Yes
MADHAVAN	THE PRECIPITATIVE EFFECTS OF PANDEMIC ON OPEN INNOVATION OF SMES	2022	Yes
KOLADE	EMPLOYMENT 5.0	2022	Yes
ÁVILA-GUTIÉRREZ	FRAMEWORK FOR THE DEVELOPMENT OF AFFECTIVE AND SMART MANUF.	2021	Yes
PAPAS	RESPONSIBLE DIGITAL TRANSFORMATION FOR A SUSTAINABLE SOCIETY	2023	Yes
CHIDOZIE	THE IMPORTANCE OF DIGITAL TRANSFORMATION (5.0)	2024	No
CIUCU-DURNOI	BEYOND INDUSTRY 4.0: TRACING THE PATH TO INDUSTRY 5.0	2024	No
HUNKOVA	EXPLORING THE INTERSECTION OF STRATEGIC HUMAN RESOURCE	2024	No
MARTIN-GOMEZ	A FRAMEWORK FOR SUSTAINABLE MANUFACTURING	2024	No
HANSEN	TECHNOLOGY ISN'T ENOUGH FOR INDUSTRY 4.0	2024	No
CAMARINHA	COLLABORATIVE APPROACHES IN SUSTAINABLE AND RESILIENT MANUFACTURING	2024	No
AFZAL	THE INNOVATION JOURNEY AND CROSSROADS	2024	No
GHOBAKHLOO	FROM INDUSTRY 4.0 DIGITAL MANUFACTURING TO INDUSTRY 5.0 DIGITAL SOCIETY	2024	No
BENDAVID	THE RISE OF PASSIVE RFID RTLS SOLUTIONS IN INDUSTRY 5.0	2024	No
SAI	GENERATIVE AI FOR INDUSTRY 5.0	2024	No
ALIMAM	THE RESURRECTION OF DIGITAL TRIPLET	2023	No
HAZRAT	DEVELOPING A SKILLED WORKFORCE FOR FUTURE INDUSTRY DEMAND	2023	No
ALIMAM	INTELLIGENT RETROFITTING PARADIGM FOR CONVENTIONAL MACHINES	2023	No
KONSTANTOPOULOS	MATERIALS CHARACTERISATION AND SOFTWARE TOOLS	2023	No
DHIRANI	ETHICAL DILEMMAS AND PRIVACY ISSUES	2023	No
BABKIN	A FRAMEWORK FOR DIGITAL DEVELOPMENT OF INDUSTRIAL SYSTEMS	2022	No
PARK	SUSTAINABLE HUMAN-MACHINE COLLABORATIONS IN DIGITAL TRANSF.	2022	No
CARAYANNIS	KNOWN UNKNOWN IN AN ERA OF TECHNOLOGICAL	2022	No
SHAHBAKSH	INDUSTRIAL REVOLUTIONS AND TRANSITION OF THE MARITIME INDUSTRY	2022	No
AKUNDI	STATE OF INDUSTRY 5.0	2022	No
SVERKO	SCADA SYSTEMS	2022	No
FATIMA	PRODUCTION PLANT AND WAREHOUSE AUTOMATION	2022	No
HU	INSIGHT INTO THE BALANCING EFFECT OF A DIGITAL GREEN INNOVATION	2022	No
ORLOVA	DESIGN OF PERSONAL TRAJECTORIES FOR EMPLOYEES	2021	No

And, lastly, an average of article citation was analyzed to establish a hierarchy of importance of article beyond journals quartiles. In that sense, 15 articles stayed above the average of 49 citations. The next table (Table 4) presents the articles that fit into that characteristic of analysis.

**Table 4**  
Articles with citations above average.

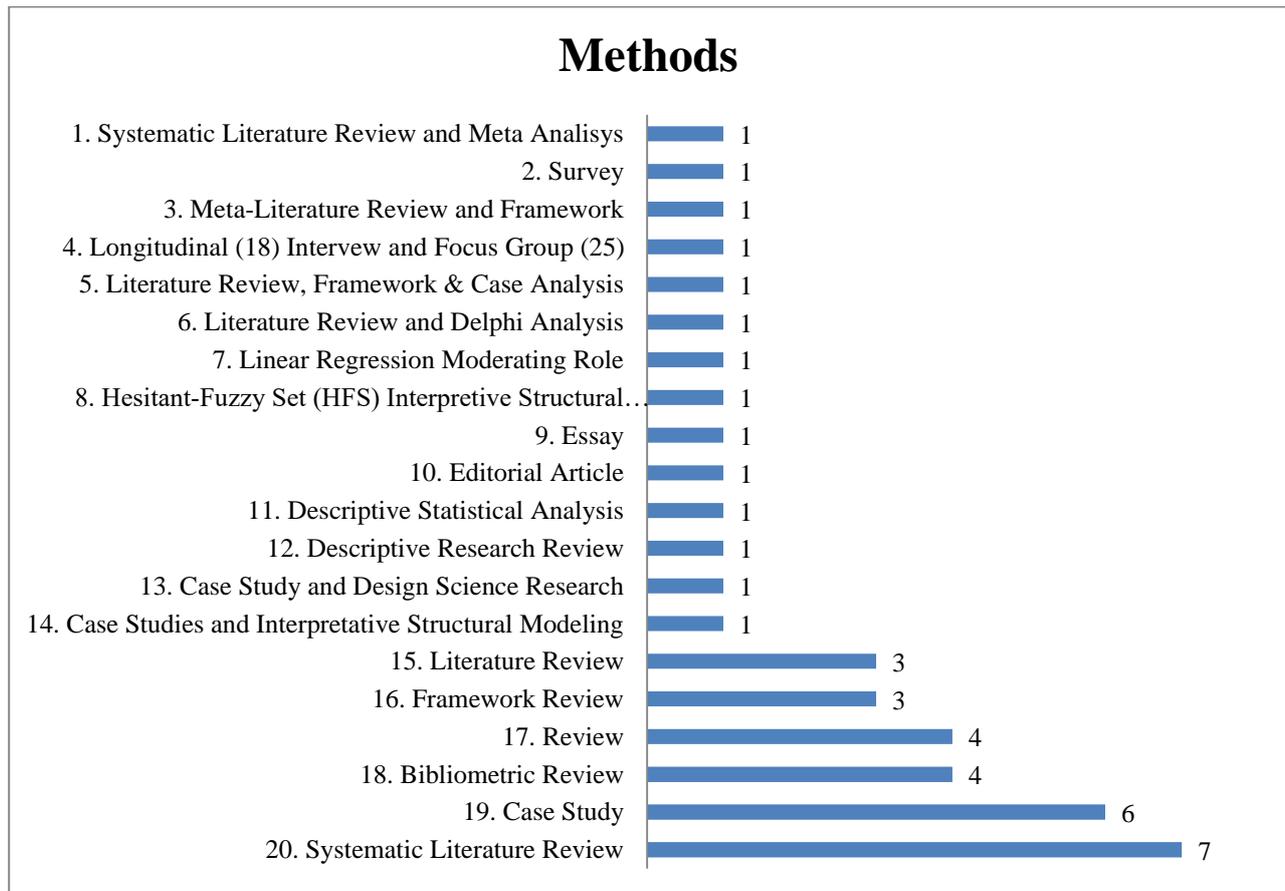
Author	Title	Year	Citations	Type	Method	Country
AKUNDI	STATE OF INDUSTRY 5.0	2022	327	Quali	Review	USA
KOLADE	EMPLOYMENT 5.0	2022	201	Quali	Review	UK
DHIRANI	ETHICAL DILEMMAS	2023	170	Quali	Review	Ireland
HEIN-PENSEL	MATURITY ASSESSMENT	2023	128	Quali	Review	Germany
DE GIOVANNI	SUSTAINABILITY OF THE METAVERSE	2023	120	Quali	Review	Italy
FATIMA	PRODUCTION PLANT AND WAREHOUSE	2022	100	Quali	Descriptive	Pakistan
SHAHBAKSH	INDUSTRIAL REVOLUTIONS	2022	94	Quali	Review	Australia
CARAYANNIS	KNOWN UNKNOWN	2022	93	Quali	Essay	USA
ROWAN	DIGITAL TRANSFORMATION OF PEATLAND	2022	90	Quali	Case Study	Ireland
PAPAS	RESPONSIBLE DIGITAL TRANSFORMATION	2023	83	Editorial	Editorial	Norway
MADHAVAN	THE PRECIPITATIVE EFFECTS OF PANDEMIC	2022	68	Quali	Review	Thailand
ZHANBAYEV	DEMOETHICAL MODEL	2023	66	Quali	Review	Kazakhstan
CAMARINHA	COLLABORATIVE APPROACHES	2024	60	quali	Review	Portugal
ORLOVA	DESIGN OF PERSONAL TRAJECTORIES	2021	51	mixed	Descriptive	Russia
SVERKO	SCADA SYSTEMS	2022	49	Quali	Survey	Croatia

The next chapter will delve into the analysis of the methods used in the researches.

## Methods

The analysis of the methods employed by the researches on the topics of Digital Transformation and Industry 5.0 shows a variety of choices, with a total of 20 different methods; in other words, it shows that researches are already spreading the methods of research, which helps in

better understanding the convergence of these two topics from different perspectives. The method of choice for most researchers is the Systematic Literature Review, with 7 studies in total. Figure 4 offers a quantitative interpretation of the methods used.



**Fig. 4.** Analysis of quantity of methods.

The following table (Table 5) expands the interpretation of the previous image to offer a deeper look on the details of the studies researched in terms of the methods used, year of publication, impacts regarding citation and type of study, and whether it is qualitative or quantitative.

**Table 5**  
Analysis of methods of research by article.

Author	Year	Cited	QLQT	Type of Study
HUNKOVA	2024	0	Mixed	Bibliometric Review
AFZAL	2024	5	Mixed	Bibliometric Review
CIUCU	2024	1	Quanti	Bibliometric Review
NAZAREJOVA	2024	1	Mixed	Bibliometric Review
GHOBAKHLOO	2024	7	Mixed	Case Studies and Interpretative Structural Modeling
HANSEN	2024	13	Quali	Case Study
PIARDI	2024	7	Quali	Case Study
MARTÍNEZ	2024	15	Quali	Case Study
ORSO	2022	28	Quali	Case Study
ROWAN	2022	90	Quali	Case Study
PARK	2022	13	Quali	Case Study
BENDAVID	2024	6	Quali	Case Study and Design Science Research
FATIMA	2022	100	Quali	Descriptive Research Review
ORLOVA	2021	51	Mixed	Descriptive Statistical Analysis
PAPAS	2023	83	Quali	Editorial Article

CARAYANNIS	2022	93	Quali	Essay
ALIMAM	2023	12	Quali	Framework Review
ÁVILA	2021	31	Quali	Framework Review
DOSSOU	2024	0	Mixed	Framework Review
GHOBAKHLOO	2024	24	Quali	Hesitant-Fuzzy Set (HFS) Interpretive Structural Modelling (ISM)
HU	2022	26	Quanti	Linear Regression Moderating Role
PACHECO	2024	0	Quali	Literature Review
SAI	2024	5	Quali	Literature Review
ZHANBAYEV	2023	66	Quali	Literature Review
GOKTAS	2024	0	Quali	Literature Review and Delphi Analysis
CHIDOZIE	2024	8	Quali	Literature Review, Framework & Case Analysis
OLSSON	2024	14	Quali	Longitudinal (18) Interview and Focus Group (25)
DE GIOVANNI	2023	120	Quali	Meta-Literature Review and Framework
HAZRAT	2023	15	Quali	Review
KONSTANTOPOULOS	2023	4	Quali	Review
DHIRANI	2023	170	Quali	Review
BABKIN	2022	36	Quali	Review
SVERKO	2022	49	Quali	Survey
MARTIN	2024	11	Quali	Systematic Literature Review
CAMARINHA	2024	60	Quali	Systematic Literature Review
HEIN-PENSEL	2023	128	Quali	Systematic Literature Review
SHAHBAKHSH	2022	94	Quali	Systematic Literature Review
AKUNDI	2022	327	Quali	Systematic Literature Review
MADHAVAN	2022	68	Quali	Systematic Literature Review
KOLADE	2022	201	Quali	Systematic Literature Review
ALIMAM	2023	27	Mixed	Systematic Literature Review and Meta Analysis

The analysis shows that there is a preference for qualitative studies, with 32 out of 41 being of that type (78%) and only 7 being quantitative studies (17%). The remaining 2 studies are a mixed of quantitative and qualitative studies (5%). Another way of looking at this information is that of the 41 studies, 19 of them are some sort of review, which represents 46% of the studies. With 7 of these reviews being specifically Systematic Literature Reviews, which represents 17% of the total amount of researches.

It is worth mentioning that it doesn't mean that all the 19 reviews (46%) are analyzing the connection between Digital Transformation and Industry 5.0, as is the goal of the present research. It means, though, that the terms Digital Transformation and Industry 5.0 are core concepts investigated by the reviews, in other words, that these concepts are present in the researches analyzed.

This chapter concludes the presentation of the results of the analysis. The next chapter will discuss these results.

## DISCUSSION OF RESULTS

The first observation to be mentioned is that there are already a considerable number of reviews, as the last result presented in the previous chapter has shown. In part, it serves to show the interest of the researchers for the topics of Digital Transformation and Industry 5.0 as a portion of the topics researched (Pacheco & Iwaszczenko, 2024). Despite approaching these topics, neither of the other review articles had the same goal of this study of analyzing the relation between Digital Transformation and Industry 5.0, though. Even so, as a complement to the interpretation, it is apparent that there is a considerable number of reviews for a topic that is recent and with not many researches, yet. Even though, there is criticism to be made in terms of the quantity of reviews.

However, it serves to bring forth one problem that should be aimed at being solved since the beginning, and that is the proper definition and interpretation of what is meant by the concept industry 5.0, as most articles failed to propose a congruent definition (Ghobakhloo, Fathi, Iranmanesh, Vilkas, Grybauskas & Amran, 2024). To be more specific, Industry 5.0 is a recent

terminology that is grounded on three pillars: human-centric approach; sustainability; and resilience. Although the concepts sustainability and resilience are borrowed from other areas of research and well understood; the idea of human-centric approach, however, is not yet clearly understood. And it is a concept of contend since the concern with the well-being of employees in the workplace is a longstanding struggle that hasn't been completely solved as of yet (Engels & Marx, 1997; Marx, 2009; Fatima et al., 2022; Ciucu-Durnoi et al., 2024).

Despite the high number of reviews already developed, they tend to offer a summary of the studies already produced in terms of their problem of investigation, instead of a critical approach ((Nazarejova, Soltysova & Rudeichuk, 2024; Afzal, Li & Hernández-Lara, 2024). One such criticism that is not proposed is related to the term Paradigm Shift, which is frequently associated with Industry 5.0 (Hunková & Havierníková, 2024). A Paradigm Shift is a specific concept developed by Thomas Kuhn which states a group of new theoretical assumptions in science that ruptures with previous established theories (Kuhn, 1970). Industry 5.0, however, is regarded by most authors as a continuum, or a complement, of Industry 4.0, and both concepts rely heavily in Digital Transformation to their implementation (Olsson, Eriksson & Carlsson, 2024).

One common ground of understanding is that the Digital Transformation ushered in by the Industry 4.0 Revolution brought with it the realization that not all humans are replaceable or disposable (Hansen, Christiansen & Lassen, 2024). Some authors go even further in that interpretation and affirm that Industry 4.0 was a failed attempt to replace human worker as much as possible from the workplace and that, therefore, Industry 5.0 is not an honorable mindset shift from industries, but just a necessary step in the process of Digital Transformation (Fatima et al., 2023). That's where Industry 5.0 seems to come into play with the complement understanding that companies need to train and develop their employees in order for them to be able to work alongside the new technological disruptions (Olsson, Eriksson & Carlsson, 2024). In this case, a human-centric approach in Industry 5.0 is about creating a business culture of learning process inside the organizations in order that employees develop the necessary skills to work with robots and machines (Shahbakhsh, Emad & Cahoon, (2022).

However, implementing the ideas proposed by Industry 5.0 and the inevitable changes brought by the Digital Transformation don't seem to be a concern that regards only the businesses, but that should be thought of and implemented side by side with governmental guiding plans to work effectively (Ghobakhloo et al., 2024). As the example of Japan's Society 5.0 shows, Industry 5.0 and Digital Transformation are organizational changes that impact not only the industries, but the society as a whole, and should be planned having in mind the impact of these concepts into a wider picture. Besides, as the historical struggle between workers and organizations have already shown, the solutions to businesses problems is one the goes through governmental efforts as well, and should not be ignored (Marx, 2009; Camarinha-Matos, Rocha & Graça, 2024).

One such concern that encompasses Industries and Governments is the ethical use of peoples' information gathered via digital technologies (Nazarejova, Soltysova & Rudeichuk, 2024). There is a growing preoccupation that companies and governments might not use the workers' and citizens' information in the best interest of these parts and that would mean a trespassing of ethical boundaries (Sai, Sai & Chamola, (2024). Not only that, but there is also a justifiable argument for the increasing necessity of Cybersecurity systems to prevent storage data from cyber-attacks (Hazrat, M. A., Hassan, N. M. S., Chowdhury, A. A., Rasul, M. G., & Taylor, B. A. 2023). Therefore, Cybersecurity is a topic of increasing interest for companies, governments, citizens and academia (Alimam, Mazzuto, Ortenzi, Ciarapica & Bevilacqua, 2023).

Regardless of all the criticism and fragilities related to the Industry 5.0 conceptualization and the Digital Transformation threats, these topics also rise up in a convenient moment when the world as a whole has shown an increasing consciousness regarding environmental risks (Camarinha-Matos, Rocha & Graça, 2024). By tackling environmental issues in two of its pillars, i.e., sustainability and resilience, Industry 5.0 shows good potential for being a theory to lead the industries into a more sustainable and human modus operandi, and Digital Transformation can help achieving these goals (Piardi et al., 2024; Martín-Gómez, Agote-Garrido & Lama-Ruiz, 2024).

Therefore, it seems as though, besides not being understood as a Paradigm Shift, in the sense of the concept, as a decoupling/disruption from Industry 4.0; Industry 5.0 is also, actually, a necessary human and ecological complementary view of the former 4.0 Industrial Revolution.

As a complement of this chapter on the discussion of the results, the next chapter will dedicate some effort into bringing forth suggestions for future researches.

## SUGGESTIONS FOR FUTURE RESEARCH

After the analysis, the presentation of the information and the discussions, this research now summarizes a list of suggestions of future researches (Table 6). The suggestions are organized in a table in order to better visually present the arguments for the readers. In total, 17 problems or questions to be further investigated were compiled by this research based on the review of the 41 articles and the question of investigation from this study.

**Table 6**

Suggestions of future research.

N°	Suggestion	Authors
1	One of the main characteristics, and the one that calls for better comprehension, is the human-centric approach. That being so, more studies should be carried out in order to comprehend its applicability better. One such investigation that is needed is the training and learning process in the organizations related to Digital Transformations. One problem of investigation could be: how can companies train employees to better work with the new technologies? The aim of such studies should be to identify the best training and learning models inside organizations.	Hunková & Havierníková, 2024; Piardi et al., 2024
2	Still on the previous ground of concern, studies should be carried in trying to identify and understand the skills needed from the employees in the Industry 5.0 and Digital Transformation. A problem of research could be framed like that: what are the main skills required from the workers in the Industry 5.0 and Digital Transformation?	Hunková & Havierníková, 2024; Alimam et al., 2023
3	A great challenge for businesses in the Industry 5.0 is the Human Resource activities, such as recruitment, assessment and talent management process. With that in mind, one possible area of research is the impact of artificial intelligence in Strategic Human Resources and how to best implement Digital Technologies, and especially Artificial Intelligence, in its routines. One possible problem of research could be: how has Artificial Intelligence been impacting Human Research practices?	Hunková & Havierníková, 2024; Hansen, Christiansen & Lassen, 2024; Kolade & Owoseni, 2022
4	On a broader research approach on the impacts of Industry 5.0 and Digital Transformation, a problem of research question might be: what does the work of the future look like from a perspective of Industry 5.0 and Digital Transformation, a challenge for Human Resources Management?	Kolade & Owoseni, 2022
5	As this Systematic Literature Review has shown, researches are well spread on different countries and using a great variety of methods, therefore it is about time to target more specific cases which lack understanding. One such situation is the impact of Industry 5.0 and Digital Transformation on Small and Medium Enterprises (SMEs), especially through the lenses of Industry 5.0' resilience, mainly when taking into account the fact that SMEs represent an overwhelming majority of business and job providers. A suggested question of research could be: what are the challenges for SMEs in the era of Industry 5.0 and Digital Transformation? This problem of research could be included in any of the other future research suggestions mentioned in this study, due to its relevance for society.	Hansen, Christiansen & Lassen, 2024; Madhavan et al., 2022; Nazarejova, Soltysova & Rudeichuk, 2024
6	For companies, one of the main challenges is related to the supply chain management with regards to big demands such as sustainability, ever shorter customer demands for delivery, cost reduction, etc; therefore, a problem of research suggestion is: how can Digital Transformation support industries to overcome supply chain challenges in the era of Industry 5.0?	Goktas & Yumusak, 2024; Ghobakhloo et al., 2024

7	<p>One the same center of analysis of the previous suggestion, it could be investigated how Digital Transformation technologies such as Blockchains can help companies improve supply chain management and improve industries sustainability tracking. One possible research question could be: how has Blockchain technologies helped organizations implement Industry 5.0 practices regarding supply chain management and sustainability challenges?</p>	<p>Goktas &amp; Yumusak, 2024; Ghobakhloo et al., 2024; Dossou, Alvarez-de-los-Mozos &amp; Pawlewski, 2024</p>
8	<p>There is a topic that is frequently mentioned in the literature about Industry 5.0 and Digital Transformation which is lacking in research, though, and that is the role of government in the implementation of Industry 5.0, especially when taking into consideration the impact of Digital Transformation on workers' rights and privacy. One question of research could investigate the following problem: what is the role of government in the challenges of Industry 5.0 and Digital Transformation guaranteeing that workers' rights are preserved in the face of the fast pace of technological transformation?</p>	<p>Pacheco &amp; Iwaszczenko, 2024; Nazarejova, Soltysova &amp; Rudeichuk, 2024; Camarinha-Matos, Rocha &amp; Graça, 2024</p>
9	<p>Another recurrent problem observed in the literature is the matter of Cybersecurity. With the ever increasing of computational power comes the rising threat to industry information. Therefore studies should be aimed at understanding what are the challenges faced by organizations in dealing with this challenge. A problem of research could be stated as follows: what are industries doing in terms of Cybersecurity to guarantee its information safety?</p>	<p>Chidozie, Ramos, Ferreira &amp; Ferreira, 2024; Martínez-Gutiérrez et al., 2024</p>
10	<p>On a more theoretical note, that also has practical implications, there is the debate around the topic of ethics, which, according to the studies analyzed, is of high demand of comprehension and safeguarding in a changing society that keeps pushing the limits of interpretation of this topic. Therefore, a question of research is: what are the main ethical challenges on the era of Industry 5.0 and Digital Transformation?</p>	<p>Ghobakhloo, Mahdiraji &amp; Iranmanesh, 2024; Zhanbayev, Irfan, Shutaleva, Maksimov, Abdykadyrkyzy &amp; Filiz, 2023; Dhirani, Mukhtiar, Chowdhry &amp; Neue, 2023</p>
11	<p>Throughout this review, it was found that there is still a lack of understanding, inside the topic of Industry 5.0, of what it means to say, as one of its three pillars, that industries will have a focus on the well-being of workers, as a human-centric approach. Therefore, studies should investigate and list a set of clear characteristics that would indicate to companies if those goals were reached. A question problem of investigation could be: what are the points that characterize a human-centric approach in Industry 5.0?</p>	<p>Ciucu-Durnoi et al., 2024; Pacheco &amp; Iwaszczenko, 2024; Park &amp; Shintaku, 2022; Carayannis et al., 2022; Fatima et al., 2022</p>
12	<p>That last question of research gets even more importance when observing the cases of worsening conditions and inequalities of workers due to digital transformations that are replacing employees in the industries, creating overload of work because of the acceleration of processes in the digital era, and also, diminishing value of workers' salaries as a consequence of positive qualification of workers skilled to operate the new technologies versus the ones who are being left behind. Hence, a problem of research that is suggested is: what is the impact caused in the inequalities in the workplace due to Digital Transformation?</p>	<p>Kolade &amp; Owoseni, 2022</p>
13	<p>All of these demands and suggestions for future research show the relevance of a specific method of research to help accomplish these goals, and that is the case study. A few authors have pointed out the need of case studies to help clarify many of the questions raised by this nascent concept, i.e., Industry 5.0. Also, this study has identified a concentration and preference, for review studies, which is comprehensible, due to the interest for understanding this new concepts, but it also has shown where gaps now need to be filled, and case study researches could be one such gap filler.</p>	<p>Nazarejova, Soltysova &amp; Rudeichuk, 2024; Afzal, Li &amp; Hernández-Lara, 2024</p>

14 As one of the pillars of Industry 5.0, sustainability is a topic that has called for urgent actions, as shows the deadlines of the Sustainable Development Goals for 2030 and Prince Williams' Earthshot Prize that takes place every year from 2021 until 2030. Therefore, studies should analyze how Industry contributes and can contribute to achieve those goals.

Hunková & Havierníková, 2024; Earthshot Prize, 2024; Camarinha-Matos, Rocha & Graça, 2024

15 This study has identified the loose use of the term Paradigm Shift to refer to Industry 5.0, as though Industry 5.0 was a disruption from Industry 4.0, which the term Paradigm Shift would suggest, but, in fact, it doesn't seem to be the case, because the studies have shown that Industry 5.0 should be regarded more as a complement than a disconnect from Industry 4.0 and other complementary theories and concepts. In that sense, theoretical studies, such as essays, for instance, could help clarify these conceptual misunderstandings.

Suggested by the authors of this Review

16 One of the reasons that makes authors regard Industry 5.0 as a Paradigm Shift is its focus on the well-being of workers, as a new approach from industries, which in the past, although it didn't aim to harm the worker, on the one hand, it didn't aim to create a propitious environment centered on the interest of the workers, on the other hand, and that is a debate that has been going on since Karl Marx's first studies on the struggle between the Owners of the means of production on one side, and the Proletariat (the workers) on the other side. With that background in mind, it is clear that Industry 5.0 presents a good opportunity for companies and governments to come to terms with old problems that should have long been solved. Therefore, studies should analyze how Industry 5.0 can help change the mindset and the practice in which the owners of business perceive their relationship with the workers and society at large.

Suggested by the authors of this Review

17 And lastly, although resilience is one of the three pillars of Industry 5.0, little was said about it in the 41 articles reviewed. That being so, a suggestion for future research is to explore case studies to illustrate what it means for industries to be resilient and how Digital Transformation can contribute to industries' resilience.

Suggested by the authors of this Review

All in all, Industry 5.0 combined with Digital Transformation seems to indicate a relevant topic for research and applicability that is growing in academic investigation, with themes that have shown to be of the utmost urgency, as is the case with sustainability (Park & Shintaku, 2022; Hunková & Havierníková, 2024), and of long standing debates, as is the situation with the problem of workers interests being taken into consideration by organizations (Fatima et., 2022; Ghobakhloo et al., 2024).

However, given the characteristic of Industry 5.0 to be divided in three pillars, and given the fact that this research has shown inconsistencies in the presentation of the term human-centric approach, studying Industry 5.0 and its three pillars at one go could be a strenuous effort for any future research, therefore it is understood that future researches should focus their efforts of studies in topics of research, instead of trying to approach all three pillars at the same time. Perhaps it would bring more clarity to each of the three concepts and shed more light on the pillars that haven't been much debated so far, as is the case with resilience.

The next chapter will conclude this research with the final considerations, which will include the contributions and limitation of this study.

## FINAL CONSIDERATIONS

The problem that this research aimed at approaching was: *what is the state-of-the-art scientific production in terms of Digital Transformation and Industry 5.0?* This goal was accomplished through the review of 41 articles of considerable quality which have shown a growing interest for the topics of Industry 5.0 and Digital Transformation.

The main contributions of this article is to bring criticism to the debate around these themes, shedding light on already existing criticisms and disrupting a pattern in the literature of just repeating previous information, as was the case with the concept Paradigm Shift, and also, with the lack of comprehension of the topic human-centric approach, due to the aforementioned just repeating of explanations, that compromise the real understanding of a concept. Besides, this research has helped in proposing guidance for future research, with 17 topics proposed in alignment with the previous researches found.

Among the limitation of this research, is the small quantity of practical studies around the themes of Industry 5.0 and Digital Transformation, as the majority of studies analyzed by this research were of review studies. Another limitation is the time frame of this research, which consisted of the period between 2021 and 2024, a short period for a systematic literature review, which is recommended to be conducted using longer periods of analysis (Paul, Khatri & Duggal, 2023). Another limitation was the use of only two databases for the collection of articles, that is, Scopus and Web of Science, considering that there are other reliable sources of database for selection. As a limitation, it can also be considered the short time of only around 2 months in which this analysis was conducted, which can be justified as needed due to the fast pace of change of Digital Transformation, but that can compromise a deeper and more careful interpretation of the facts. And lastly, the fact that this research was conducted by three researchers from the same university can create some sort of geographical and cultural biases in the interpretation of the data, considering that systematic literature reviews can be enriched by the participation of more researchers from different institutions.

Despite its limitations, the information presented in this research has the value of being critical and valuable for future researchers who are looking for guidance in their studies. Besides, especially the concept of Industry 5.0 with its pillar of human-centric approach shows potential for clarifying a long standing debate and struggle around the issue of interest between owner of enterprises and the workers of these institutions.

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