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Deconstructing the intricacies of Digital Transformation from a process digitalization perspective

António Pedro Lagarto Calado Galguinho

Master's in Computer Science and Business Management

Supervisor:
PhD Rúben Filipe de Sousa Pereira, Assistant Professor,
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TECNOLOGIAS
E ARQUITETURA

Department of Information Science and Technology

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Abstract

Technology is advancing at an increasing pace, generating impact in organizations. Digital technologies are present in our daily lives and have changed the digital market and organizations' business environment. The disruptiveness of these technologies and the changes they create emphasize the concept of Digital Transformation (DT). Many organizations still have difficulties in achieving the full potential of DT as technologies now have greater diversity.

This research aims to review the literature on DT and to create a framework of its benefits, challenges, critical success factors, and digital technologies to provide organizations with a better understanding of how their processes will be affected.

Through a Systematic Literature Review, a set of 112 articles was defined after using the selected criterion. These articles were analyzed with the support of a Bibliometric Analysis that consisted of an initial performance analysis of the set's main constituents followed by the science mapping of the concepts. A framework was later defined based on the findings of the research and was supported by a conceptual map that was designed and studied.

The most cited technologies are Cloud Computing, Artificial Intelligence, the Internet of Things, and Big Data, and their impact on organizations' processes was discussed. This research also concluded that agility was the critical factor that stood out from the rest. The main benefit identified is innovation, and the main identified challenges are resistance to change and the lack of skills, and the impact of COVID-19 was also discussed.

Keywords: Digital Transformation, Process Digitalization, Digital Technologies, Business Process Management

Resumo

A tecnologia está a avançar a grande velocidade, gerando impacte para as organizações. As tecnologias digitais estão agora presentes no nosso quotidiano e mudaram o mercado digital e o ambiente empresarial. As características disruptivas destas tecnologias e as mudanças que elas criam dão ênfase ao conceito da transformação digital. Muitas empresas ainda têm dificuldades em atingir o potencial oferecido pela transformação digital, nomeadamente devido à diversidade tecnológica presente nos dias de hoje.

Sendo assim, esta investigação tem como objetivo rever a literatura sobre transformação digital e criar uma framework com os seus benefícios, desafios, fatores críticos de sucesso, e tecnologias digitais de modo a fornecer às organizações um maior conhecimento sobre como estas afetam os seus processos.

Através de uma Systematic Literature Review, um conjunto de 112 artigos foi definido, após serem usados os critérios selecionados. Estes artigos foram profundamente revistos e os resultados analisados com apoio de uma análise bibliométrica. Uma framework foi depois criada com base nos conceitos identificados e foi criado um mapa conceptual para ser estudado e discutido.

As tecnologias mais citadas são Cloud Computing, Inteligência Artificial, Internet of Things e Big Data, e o seu impacto nos processos das organizações foi discutido. Agilidade foi o fator que mais se destacou dos outros. Interoperabilidade e gestão da mudança geraram também conclusões relevantes na discussão. O principal benefício identificado é a inovação e os desafios principais apresentados são a resistência à mudança e a falta de competências, e o impacto do COVID-19 foi também discutido.

Palavras-Chave: Transformação Digital, Digitalização, Tecnologias Digitais, Gestão de Processos de Negócio

Acronyms

ACM: Association for Computing Machinery.
AI: Artificial Intelligence.
AR: Augmented Reality.

BPM: Business Process Management.
BPMN: Business Process Modelling and Notation.

DESI: Digital Economy and Society Index.
DT: Digital Transformation.

ERP: Enterprise Resource Planning.

HR: Human Resources.

IoT: Internet of Things.
IPA: Intelligent Process Automation.
IT: Information Technology.

ML: Machine Learning.

ORM: Operational Risk Management.

RPA: Robotic Process Automation.

SLR: Systematic Literature Review.
SMEs: Small and Medium Enterprises.

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CHAPTER 1

Introduction

The world is becoming more and more digital even outside the organizational environment as technology becomes part of our daily lives [**73**] and is advancing at an increasing pace, thus generating impact in organizations and the market itself. In a study made in 2018, it was expected that by 2020, 75% of all businesses would be digital [**75**] and recent studies confirm that percentage is now 91%, [**109**] which demonstrates how much the digital market was expected to evolve and how it is overcoming the expectations.

The business environment has changed into a digital one [**65**], and companies need to adapt to the changes in the business processes and the rhythm of work. New technologies that can automate processes and reduce the time required to do a certain task have caused a change in the pace of the business environment that consequently increases the demand for faster responses by organizations in the market [**98**]. As companies start to adopt these new technologies, they generate new ways to gain a competitive advantage over the competition [**75**]. This means that companies are obligated to have more agility and flexibility [**37**] in the adoption of emerging technologies to maintain their competitive level and keep up with the evolving market.

As technology progresses in a more disruptive way and the capabilities and possibilities of its use, so does its impact on organizations. Technology has always affected performance in organizations and the quality of its services and processes. Nowadays, this impact is even more significant [**20**] because of how developed the existing technologies have become and the amount of available digital tools that provide organizations with great diversity and a wide range of choices.

Different technologies are being used and implemented, leading to changes in business models and management aspects, emphasizing the concept of Digital Transformation (DT). This concept has evolved in recent years and is gaining interest among researchers and scholars [**114**]. DT is also considered the third most important issue for the way organizations manage Information Technology (IT) by surveys among European IT executives [**90**].

The phenomenon of digital transformation has an extensive area of effect, being significant to all aspects of business [**71**], human life [**100**], and society [**25**], as seen in Figure 1.1. The concept has become extremely popular [**100**], and it is now difficult to find an area not affected by it [**71**]. Its application plays a significant role in changing the consciousness of employees inside an organization and the whole of society [**110**].

Many companies still have difficulties in achieving the full potential of digital innovation and competitiveness that can be obtained by embracing DT [**114**]. Although 75% of

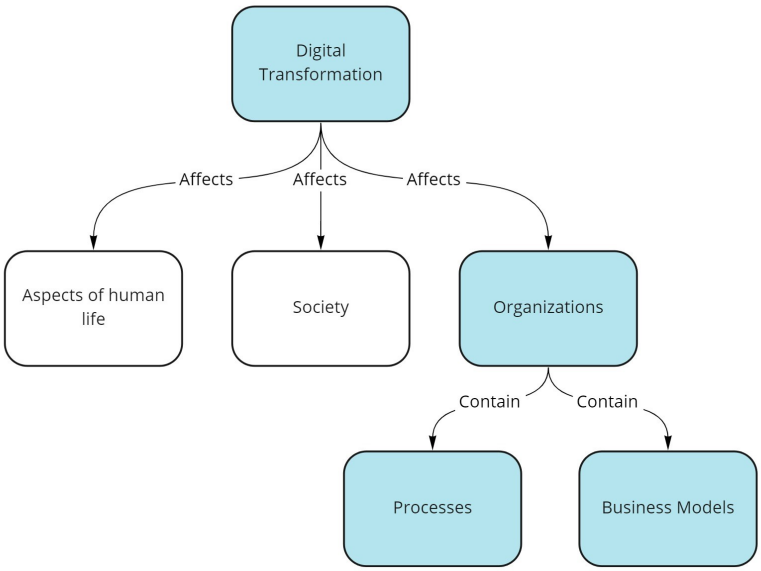

FIGURE 1.1. Digital transformation areas of effect

companies were expected to become digital by the year 2020, only 30% were expected to be successful [**75**], and a new study has confirmed that only 24% have been successful [**36**], which represents even less than expected in 2020. Another concerning statistic is that 70% of the digital initiatives taken by organizations in attempts to implement DT do not reach their goals [**57**], meaning that there are significant amounts of wasted resources and financial assets which can be prevented by having a better understanding of the concept.

Given the enormous importance and significance that the impact of DT causes [**71**] in the changes in an organization's processes and business models and the inability of organizations to successfully take advantage of it, there is a need to understand the concept in a more profound way in order to apply it correctly. The evolution and the disruptiveness of technology, as well as the increasing range of possibilities for the use of technology also enhance the importance to study the concept of digitalization which is considered the component of DT [**110**] that focuses on the impact of digital technologies in business processes.

It is crucial to understand all aspects of DT in order to provide organizations with support in implementing their transformations. There is a need to not only recognize the new technologies that are emerging, but also to better understand the benefits and value that can be created by implementing these technologies [**57**], the key ingredients, such as digital strategy that can have a huge impact on the implementation of DT [**98**], how other companies are reacting to the changes in the market, what are the critical success factors for these changes, and the challenges behind the digital transformations and digitalization in an organizational perspective.

Therefore, this research aims to deepen the study of DT from an organizational perspective, as demonstrated in Figure 1.1, to gain an understanding of the effects that these

transformations and changes have on organizations' processes and business models. The goal is to perform a Systematic Literature Review (SLR) with the support of a Bibliometric Analysis to obtain an overview of DT and its alignment with process management inside an organization. Based on the gathered information, the main concepts found will be mapped to generate a conceptual map that can serve as a framework for the understanding of the intricacies that cause an impact on organizations' business processes and models.

This research is structured into six chapters, and the document is organized as follows. The first Chapter (Chapter 1), is an introduction to how this work is structured. It answers the motivation and research problem behind the core of the research and presents the research questions and objectives for the remainder of the work. Chapter 2 presents a theoretical context for the main topics that are necessary to understand the objectives of this research. The related work is presented in Chapter 3. Chapter 4 discusses the conducted experiments and relevant results, as well as a Bibliometric Analysis of the review presented in the previous chapter. In Chapter 5 the framework that was developed during the research is presented, discussing the answers to the defined research questions. It presents the conceptual map that is the basis of the discussion and structures the main objective of this research. Chapter 6 contains the concluding remarks and addresses open issues and future research work directions.

CHAPTER 2

Theoretical Context

This section presents a theoretical context for the topics that will be discussed in this research. The main concepts are presented descriptively in the upcoming sections to provide initial guidance to the reader. Digital Transformation, Digitalization, and Digitization are connected to the basis of this study, and it is critical to understand the differences between them before proceeding to the upcoming sections of the research.

2.1. Digital Transformation

The concept of Digital Transformation (DT) is the basis of this research, and its notion needs to be fully understood in order to study its intricacies. DT relates to using digital and other technologies to create significant changes to business operations and strategies [**106**]. It has the potential to unite users and industries by not only digitizing products and services but also by creating value for the business through strategic changes [**57**].

The phenomenon of digital transformation is now significant to all aspects of business [**71**], human life [**100**], and society [**25**]. It can create a significant impact on society by affecting the digital economy, which also affects all areas of human life. Although it has an extensive area of effect it is mostly viewed from the organizational perspective, which is also the goal of this current research.

The main intent of applying a digital transformation is always to improve the operations and processes by adding new strategic value, which means that this concept cannot be used outside a strategic context [**71**]. The concept itself implies that it is constituted by a digital component, such as technologies and tools, despite not being fundamentally about technology but strategy [**17**]. Digital transformation aims to create changes in value creation by enhancing customer experiences [**118**] and improving and adapting business models [**45**] by aligning the business transformation and strategy with the digital component.

The process of digital transformation does not only refer to a unique occurrence or project but instead a continuous process [**119**] [**42**]. Digital transformation requires a specific mindset from organizations where change is the center of the process [**119**]. This process aims to combine information, computing, communication, and connectivity technologies [**90**] to create a continuous climb in the digital maturity scale and foster the digital culture of the organization [**42**].

2.2. Digitalization

The concept of digitalization is strongly connected to DT and is often used as a component of its definition. The definition of this concept stands for the implementation of digital

technology and its impact on the organization [**66**]. As digitalization implies the use of digital technologies and considering the vast range of present technologies, its impact is dependent on the digital technology that is used, which is why it is necessary to study the current technologies available in the market to understand the different outcomes of digitalization.

Digitalization is connected to the phenomenon of globalization and is highlighted as the potential that digital technologies can have in enhancing the value-creation process [**70**]. The study of digitalization includes the new and reinvented processes that are generated during the implementation of new technologies. Organizations are influenced to digitalize their processes in order to generate a positive impact externally, through its impact on value creation in the market, and internally through talent attraction with more modern processes and new roles of IT and management.

Novel ways of processing are provided by digitalization, as well as reliability, efficiency, and augmentation potentials. These benefits are provided by the technologies used in digitalization and have the potential to create value in the manufacturing industry [**3**]. Digitalization also creates opportunities to organize work and generate new business value [**121**] in the public and private sectors and small and medium enterprises (SMEs) [**6**].

2.3. Digitization

Digitization is a concept that is inserted into the spectrum of digital transformation and is often compared with digitalization. Digitization is described as a direct transformation of a process from analog to digital form [**66**] [**106**] [**96**]. It can also be described as a dematerialization process [**95**], as it removes the material part of a process, transforming it into a non-material digital form.

This concept creates a fundamental change that results in a redesign of a process [**15**], changing the behaviors of employees that interact with the same process and impacting the role and knowledge that the employee requires to understand the technology used in the "new" process.

Separating information from its physical medium is the definition of digitization and also its biggest benefit. The application of digitization has had a positive influence in the health sector, more specifically in cancer symptom management [**62**], by enabling the use of information in real-time scenarios that allow patient symptom management in collaboration with innovative health systems.

CHAPTER 3

Research Methodology

To gain an understanding of the topics and objectives of the research, a review of the existing literature was executed. This review initiates the rest of the work and is the basis of the research. The defined objectives can only be achieved by reviewing the literature on the topics involved in this discussion. Thus, this chapter presents a methodology for the review that will be executed and initiates the SLR, which was the fundamental method used for gathering and extracting the necessary information for the rest of the work.

This literature review is executed using an SLR since the goal is to gather and summarize existing evidence of a specific topic, which is one of the main reasons for conducting this type of review [**53**]. Although DT is popular at the moment, the topic is not relatively new and is of great importance, therefore, requiring the best quality scientific study that can be achieved through an SLR. This type of review provides a rigorous and thorough methodology for reviewing a set of articles, allowing for the extraction of the required information by generating organized and coherent search results. It also allows for the information to be gathered systematically which provides other researchers with a replicable and transparent process [**55**] that can be used for future research or to create improvements for the same research.

3.1. Systematic Literature Review

The protocol used in this review follows a classic approach developed by Kitchenham that consists of three main phases: Planning, Conducting, and Reporting [**53**], which are represented in Figure 3.1.

The following sections contain the steps designed in Figure 3.1, starting with the planning phase where the objectives, protocol, databases, strings, and criteria will be defined and discussed. The planning phase starts in the introduction section of the research where the background is laid out to establish the motivation for the research and the review. After establishing the motivation and making the objectives clear, the search protocol was defined by including the elements that constitute the search, which are the databases, search string, and selection criterion.

After agreeing on the planning elements, the conducting of the review is then initiated. The first step is to perform an initial search of the search string in all the databases and use that as a starting point for the filtering based on the search criterion. The results of the search are then demonstrated using tables to show the progression of the filtering with each filter. The final set of articles is then reached and presented.

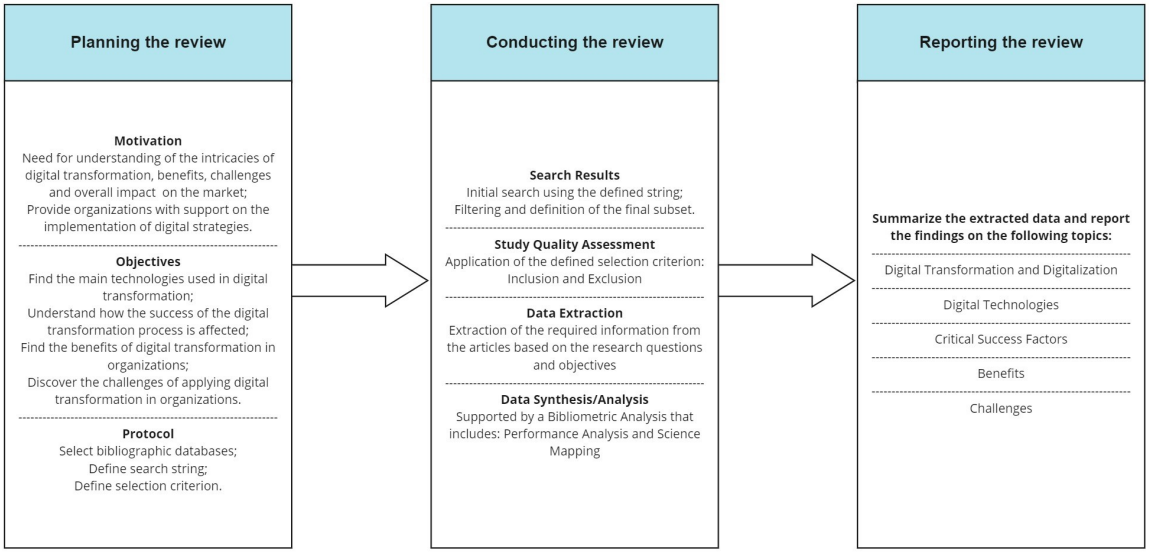

FIGURE 3.1. SLR Stages Diagram

The analysis and extraction of the data will after be discussed and presented in the upcoming sections, starting with the bibliometric analysis of the final set of articles and ending with the creation of the conceptual map and discussion of each main identified concept.

3.1.1. Research Objectives

Specifying the research questions is the most important part of a systematic review [**54**]. Because this review represents the basis of the research, the objectives are paired with the primary objectives of the research. In order to obtain the intended information, the objectives were deconstructed into four research questions. Each one of the four questions represents a branch of analysis that meets the objective of mapping the intricacies of digital transformation through gaining knowledge of the digital technologies, the critical success factors, the benefits and challenges, and are represented by the following:

- **RQ1**: What main technologies are being used in digitalization and how are they affecting processes in organizations? (Digital Technologies)
- **RQ2**: What critical factors affect the success of digital transformation and digitalization? (Critical Success Factors)
- **RQ3**: How are processes in organizations benefited by digital transformation and digitalization? (Benefits)
- **RQ4**: What are the challenges that arise from digitalizing processes through digital transformation in organizations? (Challenges)

3.1.2. Search Protocol

The protocol for conducting this review was defined only through the study-gathering technique of systematic search. The crucial elements for the search were first defined: the

databases where the search would be conducted, the strings that would serve as the base for the search, and the criteria that would be used to filter the results.

To aggregate and organize the articles, the tool Mendeley was used. It allowed the filtering of the articles by year, authors, title, and publication location, facilitating the organization of the review and bibliography management. This tool is a citation management software and was also used for the extraction of relevant data by facilitating the highlighting of the article's text and providing an annotation box.

By having a well-defined strategy, the reproducibility of the execution was guaranteed, although the filters used were defined in a manner that would not harm the comprehensibility of the review [**77**] by allowing a practical screen of the articles.

3.1.2.1. *Search Bibliographic Databases*

The strings were applied in each one of the databases, providing different results on the same topic to achieve a wider variety of articles. In this review, the following databases were used to perform the use of the search strings:

- Scopus
- Web of Science (Clarivate)
- IEEE
- Association for Computing Machinery (ACM)
- EBSCO

The first three databases, Scopus, Web of Science, and IEEE were selected by being the most popular databases for academic research, which most likely would have the finer and most trusted articles and provide a far-reaching range of areas and studies. The database

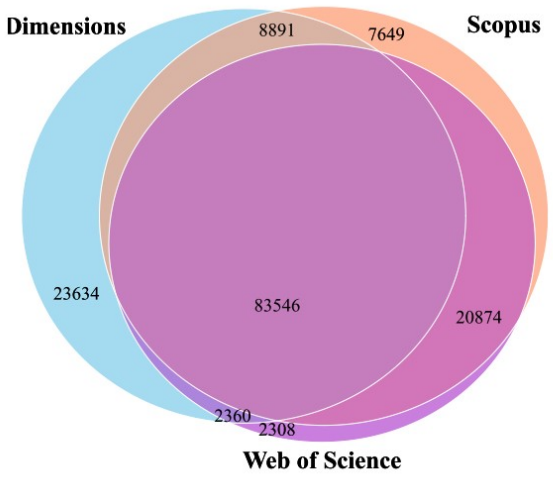

FIGURE 3.2. The number of exclusive and duplicate German 2016 publications between WoS, Scopus and Dimensions, [**105**]

Association for Computing Machinery (ACM) was also added due to being exceptionally oriented to Computer Science publications and part of ISCTE's subscriptions.

Using more than one database can benefit in obtaining the most adequate and embracing results since a single source cannot find all the primary studies on a subject [**54**]. As shown in Figure 3.2, although notably there is a large intersection between the publications among the existing databases, some articles can be missed, by using only one database, which can compromise the research.

3.1.2.2. *Search Strings*

The search string used in this review combined different keywords by grouping them with the logical operators "AND" and "OR". The use of these operators allowed for the search to be more complete and less vague by limiting the results in an organized way. The goal was to find studies on digital transformation from a process digitalization perspective and, therefore, the string is defined in a way that emphasizes the word "process".

The search was executed according to the following string:

- **("digital transformation" AND process) OR "process digitalization" OR "digital process"**

3.1.2.3. *Selection Criteria*

The exclusion and inclusion criteria utilized to select the articles are shown in the following tables:

TABLE 3.1. Inclusion criteria

Criterion	Description
IC1	Articles after 2018
IC2	Journals and Research articles
IC3	Computer Science related articles
IC4	Focused towards organizations

TABLE 3.2. Exclusion criteria

Criterion	Description
EC1	Articles not in english
EC2	Do not match any of this literature review objectives
EC3	Duplicate reports of the same study
EC4	Articles that could not be accessed
EC5	Related to business process chains
EC6	Highly focused on a certain business sector

The criteria EC2 (Do not match any of the literature review objectives) was created to assure that the search was not too strict and no studies were being excluded unreasonably, maintaining the goal of keeping the review the most comprehensive as possible.

In addition, the articles were subjected to a quality criterion based on the evaluation created by SCImago. The articles were filtered in the SCImago platform, which contains an algorithm based on multiple scientific indicators to assess the quality of the journals and conferences. The journal articles were only selected if the rank is above the Q1 and Q2 percentile and the conference articles were accepted with an A or B classification.

3.1.3. Validity Threats

As with all reviews, this systematic review has threats to its validity.

The extraction of articles and the review itself were executed by a single reviewer. Since this type of review typically has a long duration, the evolution and expansion of the literature are difficult to comb [**77**]. Having more than one reviewer could help keep up with this evolution and prevent any inconsistencies in the review. Another possible validity threat that can result from the use of a single reviewer is the existence of result bias since it does not create multiple interpretations of the review.

Publication bias can also be considered a threat to this review. It has been proven that failing to reject the null hypothesis can be considered less compelling, compared to studies that can do so [**54**]. This bias can result in a systematic bias that can be prevented by the inclusion of grey literature, for example with the application of a multivocal literature review (MLR), which is a variant of the standard SLR [**54**].

3.2. Conducting the review

After identifying the criteria to be utilized in the selection, six filters were created and mapped in the following table:

Table 3.3. Filter description

Filter	**Description**
Filter1	Abstract
Filter2	Title
Filter3	Publish date older than 2018
Filter4	Articles in english
Filter5	Content Type
Filter6	Accessibility

The third filter was created to obtain the most recent information possible on the topic by restricting the age of the articles. The more recent the article is, the better and more updated the information, that can be gathered from the article, tends to be. The publication date was limited by the year, 2018 being the latest acceptable year. The chosen date was based on the number of articles that initially appeared on the results when the string was searched in the databases. To better limit the number of articles according to the pretended subset, the year 2018 was the one that provided a more solid number of results.

Because not all articles have the same way of being accessed, an accessibility criterion was used to exclude the articles that could not be accessed. This filter did not remove many papers since most of the databases used are well-known in the investigation community and have open access to most of them.

The number of citations is a metric that tends to demonstrate the success of an article and how well-known it is in the database. Although using this metric to filter the articles could help to find the best studies, no filter was created to limit the number of

citations because of how recent the subset is. Freshly published papers tend not to have an abundant number of citations since they have not been available for other researchers to find for a lengthy period.

TABLE 3.4. Execution of search string KW1 in the chosen databases

KW	Scopus	IEEE	ACM	EBSCO	Web of Science
Initial	20914	1238	1093	23338	3515
Filter 1	4518	793	109	3652	2257
Filter 2	369	57	5	248	192
Filter 3	222	32	3	201	112
Filter 4	186	31	3	109	100
Filter 5	164	31	3	108	94
Filter 6	138	31	3	99	79

Description: Filter1: Abstract; Filter2: Title; Filter3: Publish date older than 2018;

Filter4: Articles in english; Filter5: Content Type; Filter6: Accessibility

Table 3.4 shows the results of the initial search using the defined search string and the progressive application of the filters. The initial results consist of the raw application of the search string in the databases, providing an understanding of the notable amount of literature on the topics. The first two filters (F1 and F2) had the most significant reduction in the total number of articles. The subsequent filters trimmed the rest of the articles and polished the subset. After applying the filters explained above, the sum of all the obtained articles amounts to a set of 350 articles.

TABLE 3.5. Final Filtering

	Number of Articles
Total of articles	350
After removing duplicates	166
After evaluating the relevancy	112

Because there is a massive intersection between the publications among the different databases, 183 articles were found to be duplicates and consequently removed. The duplicate articles were removed first to allow a cleaner screening of the relevancy of those articles.

On the 166 remaining articles, a practical screening of the relevancy of the articles was executed. The filter of relevancy is based on the criteria EC2 and consists of screening the article's title, abstract, and conclusion to assure the alignment of the article's content with the objectives of the review. Through the application of this filter, articles that did not match the criteria IC4, EC5, and EC6 were removed. These three criteria were defined based on the initial search and were used to limit the results by being included in the relevancy screening.

After executing the search according to the defined protocol and applying the selection criteria, 112 unique articles defined the final set for this literature review.

CHAPTER 4

Results Analysis

In this section, the results of the review are analyzed by performing a Bibliometric Analysis. To guarantee the greatest possible quality of the review, the analysis was executed profoundly with the help of a Bibliometric Analysis. The combination between the SLR and this type of analysis has demonstrated successful results due to how well they complement each other [**85**]. Bibliometrics complement the analysis of the SLR by searching for connections between the constituents of the set of articles and by creating a mapping of the key components that are present in the involved research areas.

Bibliometric Analysis is a method of scientific analysis that has been gaining popularity in the research community in recent years [**23**] and is growing in the field of strategic management, entrepreneurship, and innovation [**123**]. It is advantageous for mapping cumulative scientific knowledge of a large quantity of data and can produce a high research impact [**23**]. Because the basis of this research is a review of the digital transformation literature, there is a lot of information and concepts that need to be mapped. Having a set of more than a hundred articles also originates plentiful data, which proves the need to apply a Bibliometric Analysis.

Therefore, this analysis aims to summarize the large quantities of data extracted from the bibliography and present an intellectual mapping and the emerging trends of the main identified topics and research areas by applying quantitative techniques to the bibliometric data.

The techniques used in this Bibliometric Analysis are divided into two categories that are represented in the following sections: First, a Performance Analysis for evaluating the publication performance of the constituents (e.g. authors, institutions), and second, the Science Mapping to discover and structure the interactions and relations between constituents and concepts. These two techniques constitute the most complete analysis possible, and the ones mainly used by researchers [**23**].

4.1. Performance Analysis

This section presents the performance analysis part of the Bibliometric Analysis. It presents an evaluation of the performance of the research constituents with the use of quantitative metrics. The main constituents of the bibliometric data are Authors, Institutions, Countries, Journals, and Conferences. The analysis is performed on performance-related metrics and is divided into two main categories: publication-related metrics and citation-related metrics. These metrics were extracted from the bibliometric data with the support of the Mendeley tool for organizing the structured information on all of the

articles in the defined set. With the support of Microsoft Excel, this information was grouped and rearranged to produce the metrics and charts that summarize the data.

4.1.1. Publication Metrics

The metrics established in this section are based on the set of articles that were previously defined for this review during the SLR.

In Figure 4.1, a chart containing the number of publications per year is presented. A clear tendency in the increasing number of publications about digital transformation and process digitalization is visible. The set is limited by the year 2018, and that is the least represented date excluding the current year. The most represented year is 2021, which proves the tendency of increasing studies about the topics of the review. Although the latest year in the set is 2022, and it does not represent the most quantity of the studies, the tendency is still visible. This can be explained by the fact that this review was executed in the first half of the year 2022, which means that not as many studies were produced yet compared to the previous years, which had the totality of the months analyzed. Having this in consideration it is still optimistic that some studies of the same year the review was done, were found and matched the criteria of the set.

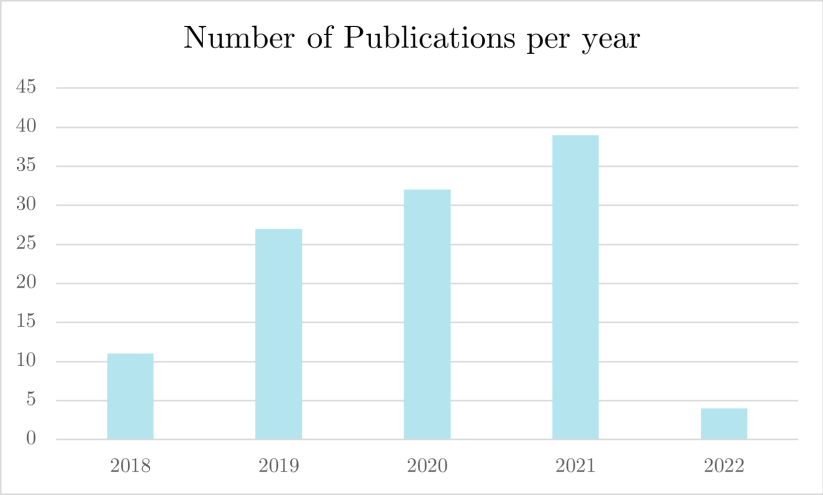

FIGURE 4.1. Number of publications per year

In Figure 4.2, it is possible to observe the distribution of the types of articles that constitute the set. The publication types are mainly distributed between conference papers and journal articles despite one of the publications, being labeled as Miscellaneous due to not having a specific type. The set embodies mostly journal articles, represented by 60 articles, although there is no considerable difference compared with the 52 conference papers involved in the set.

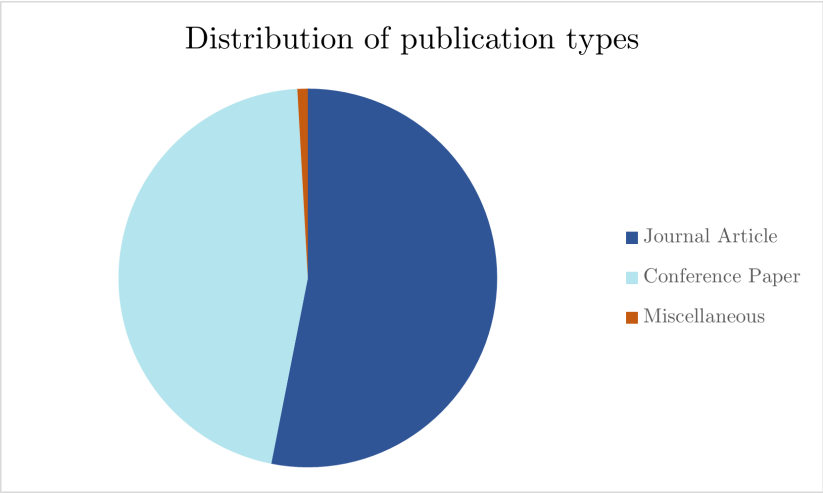

FIGURE 4.2. Distributions of publication types

4.1.1.1. *Journals*

In Figure 4.3, the journals that have more than one publication in the set are displayed. The chart is built using the journal designation and the number of publications of each journal.

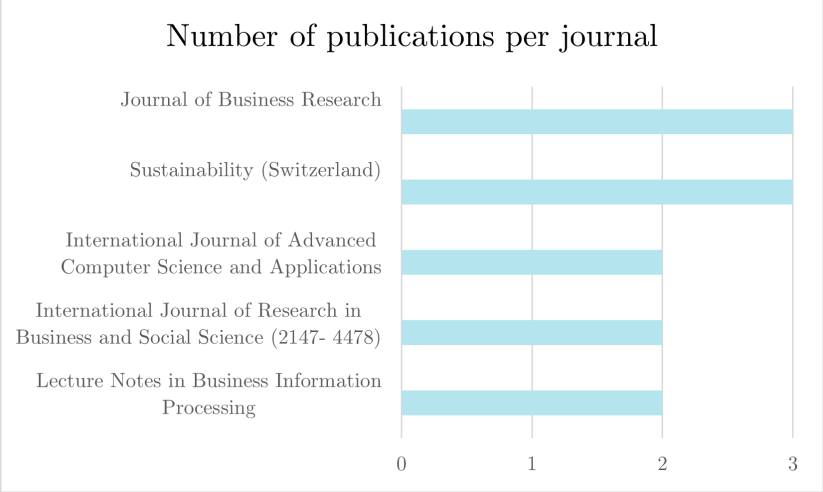

FIGURE 4.3. Most Relevant Journals (Only journals with more than one publication are represented)

From the entire set of articles, five journals have more than one publication. This means that the rest of the publications have a unique value for the journal designation. Having diverse sources of information can have a positive impact on the research. The *Journal of Business Research* and the *Sustainability(Switzerland)* journal were the preferred scholarly journals.

4.1.1.2. *Conferences*

The conferences with more than one publication in the set are shown in Figure 4.4. The chart crosses the conference designation and the number of publications from each conference.

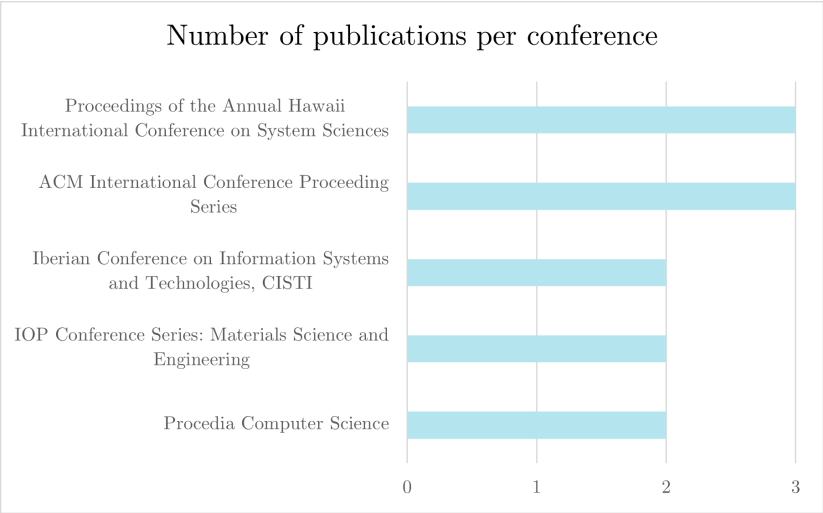

FIGURE 4.4. Most Relevant Conferences (Only conferences with more than one publication are represented)

As occurred with the most relevant journals, only five conferences are represented more than once. The preferred conference paper sources are the *Proceedings of the Annual Hawaii International Conference on System Sciences* and the *ACM International Conference Proceeding Series*, each having three papers in the set.

4.1.1.3. *Authors*

One of the main constituents of a publication is the authors, and understanding the metrics about authorship can reveal relevant information for the analysis.

TABLE 4.1. Author Statistics

Total Publications	112
Sole-authored publications	13
Co-authored publications	99
Number of Contributing Authors	329
Authors with more than one publication	14

Of the total publications, 13 were identified as sole-authored meaning they were produced by only one author. The majority of the publications, 99 publications, include more than one author, which is a positive indicator. Having more than one author provides value for the publication and the collaborations among authors furnish greater clarity and richer insights [**23**] into the research.

From the entire set of publications, 329 authors were identified as unique. A sizeable amount of unique authors was expected, considering most of the articles were co-authored. Since there is countless information on DT that is repeated throughout the different articles, having a greater amount of unique authors is essential to gather diverse insights on the same topics.

The most relevant authors are presented in Figure 4.5. The chart contains the name of the authors that contributed the most on the x-axis and the number of publications for each one of them on the y-axis.

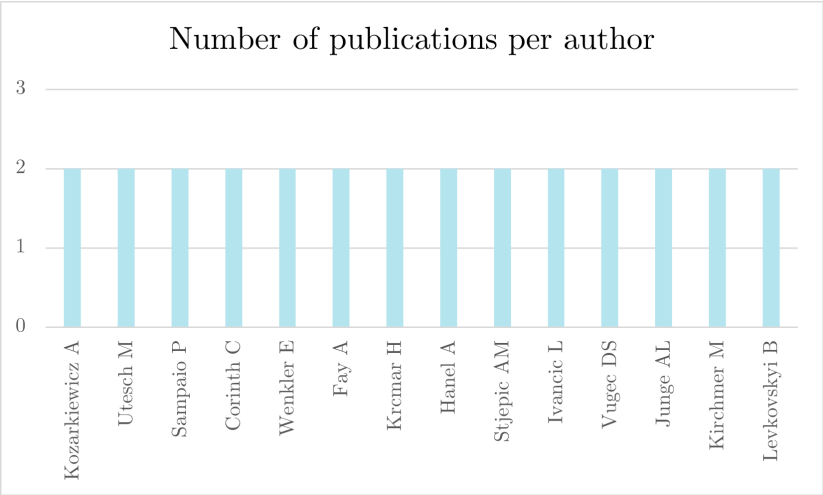

FIGURE 4.5. Most Relevant Authors (Only authors with more than one publication are represented)

As previously observed in Table 4.1, 14 of the total unique authors in this review have authorship in more than one publication and those authors are considered the most relevant. None of the authors were involved in more than two publications.

4.1.2. Citation Metrics

The number of citations is a metric that tends to demonstrate the success of an article and how well-known it is in the database. Although using this metric to filter the articles could help to find the best studies, no filter was created in this research to limit the number of citations because of how recent the subset is. Freshly published papers tend not to have many citations since they have not been available to other researchers to find for a long time. Despite the novelty of the articles it is meaningful to evaluate the impact and influence that some publications have in the research field by analyzing the citation metrics.

The sum of citations among the entire set of articles amounts to 1085. Considering that the set of articles is comprised of 112 articles, the average number of citations can be achieved by dividing the total of citations by the total number of articles, resulting in an average of 9.6875 citations per article. These results are very positive, considering most of the articles are very recent, the average of citations per article demonstrates that overall the publications are being cited and recognized by the research community.

TABLE 4.2. Citations Statistics

Total Citations	1085
Number of articles	112
Average citations	9.6875

The distribution of the count of citations is represented by a chart in Figure 4.6. This chart has the total of citations in a single article on the x-axis and is crossed with the

number of articles that have that amount of citations on the y-axis. The result of this chart is the study of the most common number of citations, that the publications have.

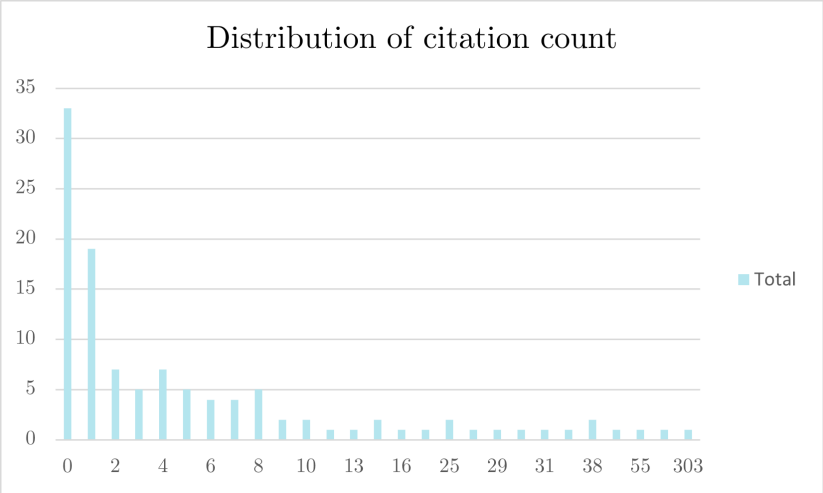

FIGURE 4.6. Distribution of the number of citations

In Figure 4.6, it is possible to identify that 33 articles are not cited by any paper. This can be seen as a possible threat to the validity and quality of the research, but considering the novelty of the article set it is normal that more recent papers have not had time to be discovered by other researchers and consequently cited. Although 33 articles do not have any citations, it is still positive to observe that the remaining 79 articles have more than 1 citation. We can identify that most values are comprised of 0 and 8 citations and that there is a very low number of articles with more than 8 citations. The maximum number of citations in a single article is 303 and is only represented by one article.

4.2. Science Mapping

This section presents the science mapping part of the Bibliometric Analysis. It presents the discoveries on the intellectual interactions and relations between the constituents and concepts in a structured manner. In the sub-sections of the science mapping, we analyze the bibliographic grouping of the main concepts identified in the review. These concepts are separated by the four vectors of the framework that are discussed later in the research. The data is summarized using concept-centric matrices that enable an understanding of the relations between the authors and the concepts and also allow the identification of the most relevant concepts of the research.

4.2.1. Digital Technologies

Table 4.3 is a concept-matrix matrix that illustrates the most referenced digital technologies and is based on the main identified concepts in the literature. It cites all the articles that referenced the concept, allowing the verification of the popularity of each digital technology.

The most referenced digital technology in the literature is Cloud Computing, being referenced in 47 different articles. Through the examination of Table 4.3, it is possible

TABLE 4.3. References of the main identified technologies

Technology	References	Total
Cloud Computing	[98] [58] [80] [73] [116] [31] [33] [25] [59] [57] [71] [115] [88] [29] [22] [102] [68] [114] [79] [7] [18] [38] [32] [50] [37] [75] [113] [46] [101] [45] [63] [74] [117] [112] [6] [28] [90] [42] [106] [96] [27] [3] [12] [95] [24] [51] [118]	47
Artificial Intelligence	[73] [110] [34] [81] [25] [59] [107] [4] [71] [100] [92] [86] [29] [97] [2] [114] [66] [7] [38] [50] [1] [113] [19] [101] [39] [17] [63] [74] [117] [119] [112] [65] [42] [111] [106] [20] [96] [14] [3] [12] [95] [51] [33] [118] [11] [122]	46
Internet of Things (IoT)	[98] [80] [116] [34] [25] [59] [120] [57] [71] [100] [88] [29] [22] [9] [68] [30] [114] [66] [7] [18] [32] [37] [75] [113] [19] [101] [39] [63] [74] [47] [43] [65] [90] [42] [106] [14] [91] [3] [12] [95] [33] [118]	42
Big Data	[80] [81] [57] [71] [100] [88] [92] [86] [29] [97] [2] [68] [30] [114] [7] [18] [37] [75] [113] [39] [63] [74] [78] [43] [119] [65] [6] [90] [42] [106] [20] [3] [12] [103] [118] [11]	36
ERP	[73] [116] [31] [34] [84] [115] [22] [9] [89] [38] [83] [52] [75] [46] [101] [67] [70] [74] [47] [90] [42] [99] [106] [24]	24
Blockchain	[116] [104] [57] [29] [102] [18] [38] [113] [46] [101] [45] [39] [74] [96] [14] [3] [118] [34] [59] [92] [2] [111]	23
Augmented Reality	[73] [110] [34] [25] [8] [88] [29] [9] [114] [38] [113] [46] [101] [45] [17] [42] [106] [20] [96] [12]	20
Machine Learning	[73] [34] [71] [29] [2] [89] [38] [50] [1] [19] [101] [17] [63] [20] [3] [103] [118]	17
Digital Twin	[80] [107] [13] [40] [68] [89] [1] [19] [39] [63] [43] [20] [12] [35]	14
RPA	[38] [50] [52] [101] [117] [112] [20] [96] [103] [42] [51]	11
Cybersecurity	[34] [104] [88] [86] [29] [18] [50] [113] [42] [20] [12]	11
Data Mining	[93] [81] [48] [106] [3] [51]	6
Deep Learning	[116] [34] [50] [42] [106]	5
Business Intelligence	[31] [81] [5] [114]	4

to identify four main technologies that present a massive gap in the number of references among the other identified technologies. Those four technologies are Cloud Computing with 47 references in the literature, Artificial Intelligence with 45 references, Internet of Things with 42 references, and Big Data with 36 references. According to this analysis and the number of identified references, these four technologies can be considered the most popular, all having more than 35 references, in the literature on DT.

Although some technologies, such as Robotic Process Automation, are not as referenced as others, they present essential and valuable studies with well-structured information on the topic. Thus, it is possible to conclude that the most referenced technologies are not necessarily the ones with the most information and theories.

4.2.2. Critical Success Factors

The critical success factors identified in this research are illustrated in Table 4.4. These concepts are considered extremely significant to the success of digitalization and DT, and their impact on organizations' processes is highly studied in the literature.

TABLE 4.4. References of the main identified factors

Factor	References	Total
Agility	[80] [73] [121] [110] [16] [60] [88] [69] [29] [5] [9] [7] [50] [56] [37] [113] [19] [67] [45] [70] [17] [47] [117] [65] [6] [28] [106] [20] [96] [27] [91] [12] [95] [51] [33] [118] [11]	37
Interoperability	[73] [48] [13] [102] [26] [83] [47] [90] [106] [12] [88] [104] [63] [68] [74] [117] [37] [116] [107] [39] [20] [95] [114] [46] [3] [50] [101] [43]	28
Digital Maturity	[93] [98] [73] [15] [29] [22] [68] [37] [75] [113] [46] [101] [63] [74] [47] [43] [112] [6] [42] [91] [3] [95] [24] [118]	24
Digital Economy	[98] [110] [81] [25] [41] [88] [92] [86] [29] [56] [72] [75] [113] [17] [74] [10] [111] [106] [118] [11] [59] [61] [34]	23
Change Management	[93] [49] [59] [68] [7] [38] [83] [52] [43] [119] [65] [28] [42] [99] [96] [14] [27] [3] [103] [33]	20
Business Process Management	[93] [116] [31] [84] [44] [9] [102] [76] [50] [52] [75] [101] [67] [117] [99] [106] [27] [12] [103] [51]	20

Agility is the most referenced critical success factor. It is a concept that is referenced multiple times in the literature, and the origin and definition of the word may surface questions about its interpretation as a critical success factor or as a benefit. The present literature suggests that agility is seen as a factor instead of a benefit. This concept also appears multiple times with the reference to Agile methodologies that are also a considerable factor in the topics of DT and digitalization.

The second most referenced factor is interoperability. Some articles reference interoperability by explaining its meaning and highlighting its necessity in the application of multiple digital technologies. Other articles approach interoperability more objectively by referencing interconnections between certain technologies and examples of how they can be combined.

4.2.3. Benefits

Digitalizing processes and embracing DT can bring several benefits to organizations. It is important to identify the main benefits that can be created by these transformations to set expectations for their results. Identifying these benefits supports the decision to embark on digital changes and allows the adjustment of the digital transformation strategy with the organizations' expected improvements in their processes. Four main benefits were identified in the literature and are presented in Table 4.5.

Among all the publications and concepts, innovation was by far the most referenced benefit with a total of 62 references. Innovation relates to technological and digital innovation. It is one of the principal purposes that lead organizations to digitalize their processes [**57**], and it can be related to several factors such as innovative business models, innovative business processes, and innovative technologies, which explains the number of references that it accumulated among the set of publications.

Competitiveness is the second most referenced benefit, with 49 references, and translates to the competitive advantage in the market that organizations can achieve by implementing digital transformation and digitalizing their processes. Flexibility and value

TABLE 4.5. References of the main identified benefits

Benefit	References	Total
Innovation	[14] [24] [119] [73] [18] [60] [81] [114] [11] [69] [21] [115] [62] [44] [33] [82] [91] [3] [98] [80] [6] [88] [97] [42] [106] [17] [75] [110] [47] [58] [120] [63] [71] [101] [66] [10] [39] [25] [20] [57] [113] [9] [95] [65] [52] [117] [56] [34] [8] [96] [7] [111] [93] [90] [118] [27] [59] [29] [5] [16] [79] [43]	62
Competitiveness	[17] [102] [50] [59] [29] [46] [24] [56] [34] [96] [58] [9] [65] [30] [73] [69] [64] [39] [60] [6] [70] [3] [110] [88] [86] [100] [63] [91] [112] [22] [98] [12] [10] [20] [76] [47] [115] [42] [119] [111] [106] [92] [118] [27] [14] [37] [84] [16] [78]	49
Flexibility	[9] [98] [47] [49] [82] [115] [121] [95] [12] [50] [66] [118] [106] [32] [114] [45] [24] [5] [113] [37] [51] [111] [3] [103] [27] [117] [13] [39] [6] [81] [17] [60] [63] [56] [88] [69] [87] [64] [46] [34] [73] [31] [65] [96] [116]	45
Value Creation	[34] [84] [16] [59] [88] [29] [22] [66] [76] [38] [60] [83] [56] [52] [46] [87] [101] [45] [39] [70] [17] [63] [47] [119] [6] [42] [111] [106] [96] [27] [21] [3] [12] [95] [103] [33] [118] [20] [24] [9] [18] [64]	42

creation are the other two concepts that are considered benefits and were referenced in the literature.

4.2.4. Challenges

Although process digitalization has distinct benefits for organizations, no enjoyment comes without ease. Implementing DT is accompanied by several challenges that were identified in the literature. These challenges are presented in Table 4.6.

TABLE 4.6. References of the main identified challenges

Challenge	References	Total
Lack of Skills	[68] [38] [61] [72] [113] [101] [45] [70] [10] [6] [90] [96] [21] [95] [11] [5] [73] [110] [31] [84] [88] [86] [66] [56] [75] [63] [42] [111] [20] [27] [12] [33]	32
Resistance to Change	[98] [34] [49] [15] [5] [7] [38] [96] [14] [12] [24] [119] [37] [88] [87]	15
COVID-19 Impact	[110] [84] [16] [78] [112] [3] [12] [103] [70] [104] [66] [29] [108]	13

Although there is no considerable difference in the total number of references among the two least referenced challenges comprehended in Table 4.6, the most referenced challenge and the one that stands out from the rest is the lack of skills. As opposed to digital technologies, the challenges are more vague concepts and are not as easily distinguishable. This results in a more challenging task to identify these concepts among the articles.

CHAPTER 5

Discussion and Framework

In this section, the main results of the analysis will be presented. The following sections provide four different vectors of analysis on process digitalization and its connection to digital transformation.

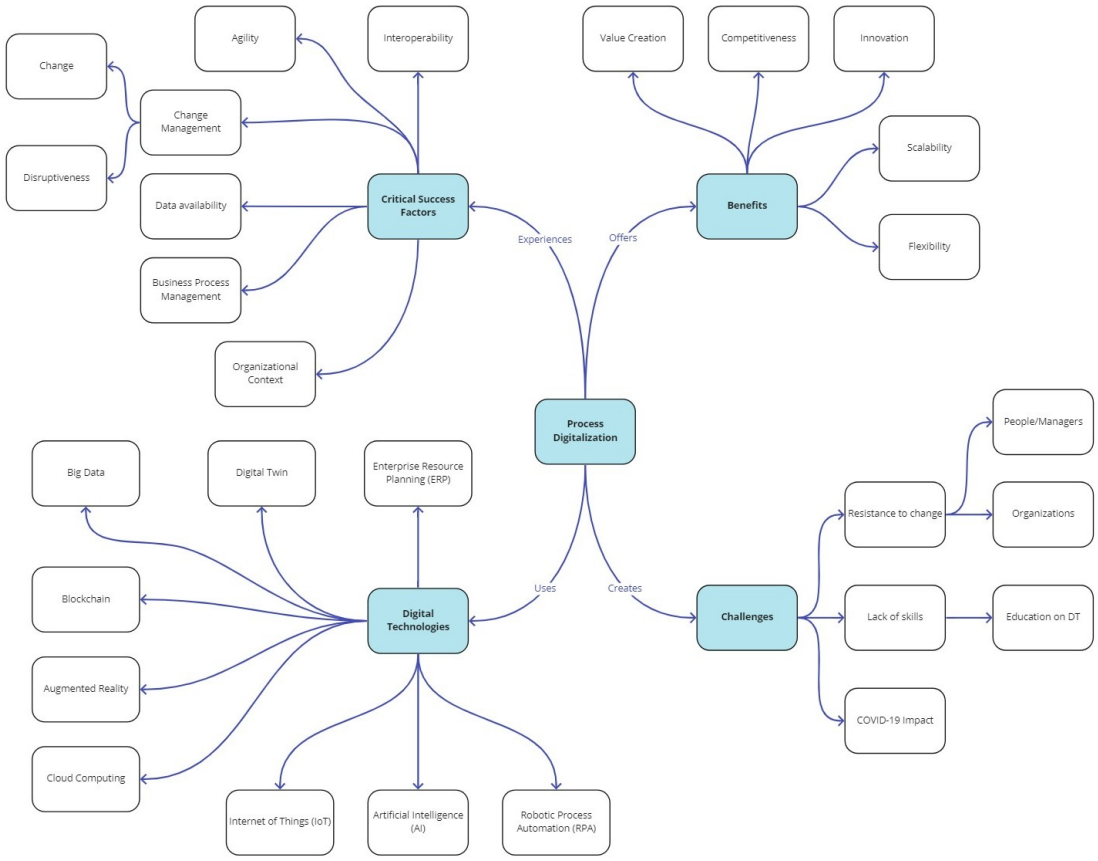

FIGURE 5.1. Framework for the four vectors of analysis

The general concept map presented in Figure 5.1 was created and designed based on the main concepts that were identified during the review process explained in the last section. The goal of this map is to achieve an initial visualization of the main concepts present in each branch, therefore it is presented with a more general approach. The four branches are then deepened in the next sections and contain the sub-concepts that are included in each concept.

5.1. Digital Transformation and Digitalization

In the literature, three main concepts: Digital Transformation, Digitalization, and Digitization, are often identified, and there is a need to differentiate them as its critical to recognize the differences. These concepts are strongly connected [**66**] and the most simple among them is digitization. Digitization can be described as a simple concept that relates to the direct transformation of a process from analog to digital form [**106**] [**96**]. The other two concepts are wider and more complex.

There is often a comparison between digital transformation and digitalization, and it is necessary to correctly differentiate the two concepts. Beer, J. et al affirmed that recognizing these differences is critical for the design of modern software [**19**]. As digital technologies are the main component of both concepts, there are certainly some similarities, although they are studied differently. Digital transformation views digital technologies as an enabler for major business improvements in strategic changes and business models [**118**] while on the other hand, digitalization is more suitable to describe the sole impact of those technologies in organizations' processes. Therefore, digital transformation can also capture the strategic dimension in the context of value creation that is not included in the concept of digitalization [**119**]. The definition of digital transformation includes much more than digitalization, although digitalization can be considered part of it [**110**].

5.2. Digital Technologies

During the research, several technologies were identified as being the key drivers of digital transformation. Although only a few were considered by authors as the main technologies that are changing the market. In Figure 5.2 the main technologies are represented and deconstructed.

DT could not be possible without digital technologies. They allow organizations to expand numerous aspects of business and digitize their processes. Their use is what makes the concept of digital transformation digital and not just a normal transformation of business. Some authors affirm that the implementation of new technologies started in the 1980s with the creation of systems to manage customers and develop sales forces [**119**], and since then, their use has been increasing as their capabilities evolve.

The use of these technologies has also been proven to be effective, as over 73% of industry leaders recognize the power of digitalization to accelerate and provide sustainable operational excellence [**43**]. The main positive effects that digital technology can have are improvements in the efficiency of operations and also some organizations' capabilities, such as connectivity and automation [**60**].

These technologies are described as being able to create disruptive innovations that can be considered game changers in the market. Automation processes can reduce the time needed to do a certain task and have also caused a change in the pace of the business environment that consequently increases the demand for faster responses by organizations in the market [**98**]. They produce data that is crucial to the organization, therefore, making its management a crucial factor [**51**]. To manage these technologies, it is vital to

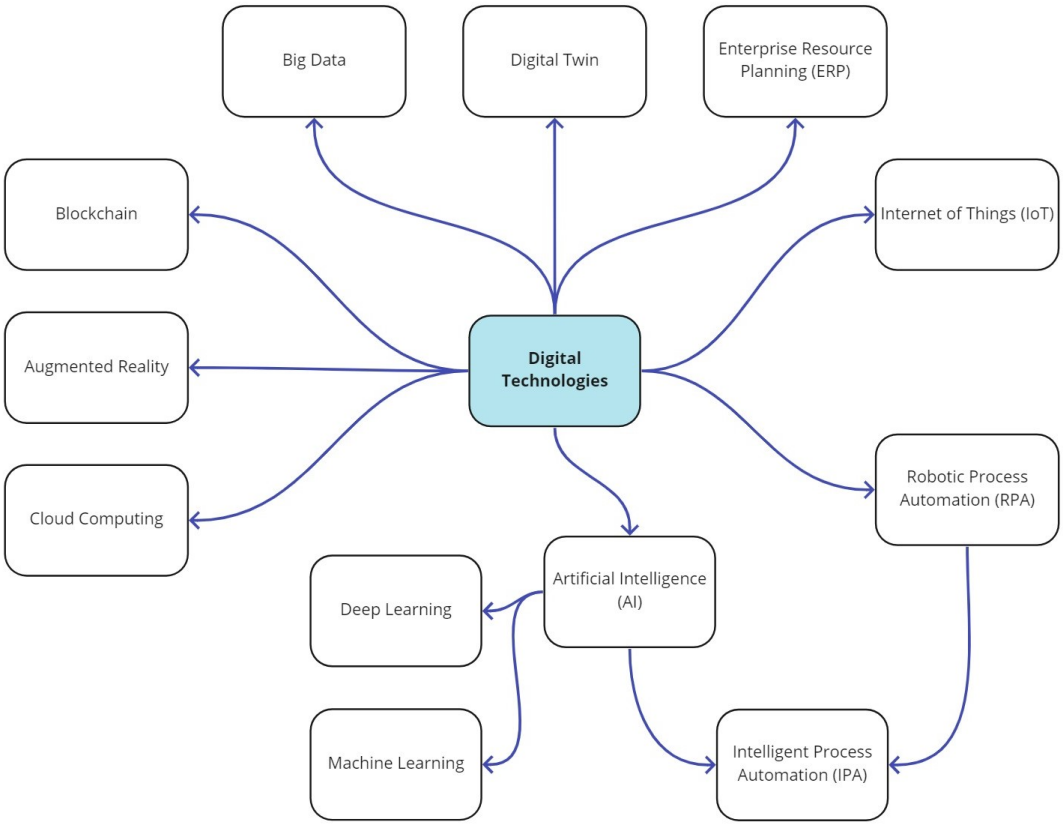

FIGURE 5.2. Main digital technologies used in digitalization

understand the intricacies behind how they operate and the complexity of their implementations. In order to correctly collect the benefits of their use, gaining knowledge about them is key to a successful digital transformation.

Some authors believe that digital technologies can be separated as primary and secondary [**106**] [**42**]. Primary technologies include well-established technologies that have been available in the market for a longer time, such as mobile technologies, social networks, Cloud Computing, Big Data, sensors, and the Internet of Things. Secondary technologies can also be denominated as emerging, and some examples are wearable technologies, Augmented Reality, and Artificial Intelligence.

5.2.1. Cloud Computing

The impact of Cloud Computing on process digitalization and digital transformation has been identified by many authors, making it the most referenced technology in the analyzed literature. It is considered one of the agents [**7**] and driving factors of DT [**113**] [**117**]. Other authors consider Cloud Computing as the main driver for business change [**71**] that presents game-changing opportunities and existential threats [**32**] in the digitalization ecosystem [**25**].

This technology has been growing and helping young digital firms by providing them with new tools for rapid scaling [**118**]. Increasingly, firms are recognizing the ability

of Cloud Computing to transform their businesses which has caused a rapid increase in market spending on cloud infrastructures from USD 3.5 billion in 2011 to USD 120 billion in 2020 [**116**]. Cloud infrastructures may be used to deploy 40% of complete enterprise workloads by the year 2023 [**50**].

Removing the need for sophisticated hardware is one of the main reasons many organizations are adopting Cloud Computing [**12**]. Through on-demand access to a shared pool of configurable computing resources [**29**], this technology allows a more flexible and convenient collaboration between geographically distributed infrastructures [**12**]. The resources can be rapidly accessed in different locations, and there is minimal effort for the release of the information providing opportunities to reduce costs and increase scalability at a global scale and with high speeds and reliable exchanges of data, thus enhancing performance and productivity. Internal processes can be connected to intelligent business process sequences with the integration of cloud-based services, which creates great value for the organization [**106**]. Cloud-based services are also useful for integrating data and making it visible [**46**]. These services can be accompanied by other technologies, such as Big Data, enabling the collection, storage, and analysis of data [**114**] [**60**] through a shared pool of resources.

Cloud Computing is highly involved in the definition of the concept of Industry 4.0 [**95**], thus being considered one of its key technology trends [**12**]. It is one of the most relevant technologies in the digital transformation of logistics and supply chain processes [**45**] which explains its impact on Industry 4.0. The integration of cloud computing services in the manufacturing sector originated the concept of Cloud Manufacturing. This environment prevents some constraints that can occur with digital processes in the industry, such as application dependencies and operating environments. Cloud Manufacturing is proven to increase the efficiency of the overall production process [**116**].

5.2.2. Artificial Intelligence

The second most referenced technology in the literature is Artificial Intelligence (AI). This technology has not only become relevant in the context of the digitalization of organizations' processes but has had a major impact on the digital transformation of businesses [**71**] [**14**] and society [**63**]. Some authors consider it one of the obvious agents of digital transformation [**7**] [**113**] and a key component in the digitalization ecosystem [**25**]. The increasing interest and use of AI are mainly directed toward the changes that it can provide for business processes. Since the arrival of the age of digitalization, this technology has changed traditional business practices [**14**] and is involved in contemporary businesses [**65**]. AI can create effective and quick solutions to solve complex entrepreneurial problems and increase every organization's productivity [**34**] which is a major game-changer in every sector if the assets needed for its use are well implemented.

AI refers to intelligence demonstrated by a non-human form or by organisms that can be referred to as virtual assistants [**17**] or robots [**101**]. It is designed to mirror human intelligence with algorithms that utilize data and are able to perform functions

that are usually performed by real humans. AI can learn new skills and perform decision-making tasks [**101**]. Through rule-based action, the algorithms can reach conclusions that otherwise would be reached by humans. An important aspect of these intelligent software systems that constitute AI, is constantly learning, which means that they are continuously improving [**113**] and achieving better results over time.

Automation is considered one of the main advantages of AI. It is used by some authors in the definition of automation of work and self-regulatory systems. Automation enabled by AI can reduce error rates, increase speed and reduce operating costs of several processes [**111**] and is connected to several other technologies that make use of automation, such as RPA. This capability is crucial for the manufacturing sector and makes authors consider AI the main enabler for Industry 4.0 [**39**] [**20**]. Intelligent manufacturing, intelligent products, and intelligent supply chains are some of the opportunities that AI can provide in Industry 4.0 [**3**].

Business processes in several areas, such as Marketing, Human Resources (HR), Finance, or Logistics, require powerful strategic tools to improve and utilize the vast amount of data produced, and AI is one of the best options [**17**]. In the HR department, AI has created value in the process of candidate analysis [**17**]. By assigning scores to the job position and the candidate, an algorithm can perform a semantic analysis of the candidates' curriculums and compare the responses with the intended selection criterion. It can be used as a pre-selector and reduce the number of curriculums that continue in the hiring process.

Other influences of the use of AI occurred in the medical sector to find cures and vaccines [**110**] and in the control and management of seed processing [**107**]. Seed processing has changed thanks to an artificial cognitive system that can be used through a tablet or smartphone and allows the operator to control the seed treatment process. The intelligent built-in system allows the adjustment and regulation of the entire process, reducing difficulties and simplifying the operator's job while increasing the safety and quality indicators of the process.

5.2.2.1. *Machine Learning*

AI includes other fundamental functions such as Machine Learning (ML) [**38**] [**34**]. ML is the leading function of AI that is referenced in the literature. Some authors even consider it as one of the drivers for business change [**71**] paired with other main technologies. The base of this concept lies in the autonomous training of the algorithms. In machine learning algorithms, vast amounts of data are fed to the computers or software, and the algorithms train themselves by practicing multiple iterations [**34**], which means that the algorithms will get better as more time passes and more data is input.

As observed in Figure 5.3, Larsson, O, differentiates the different stages for algorithmization and separates these stages into computerization and digitalization. In the digitalization phase, the concept of AI, mainly oriented toward ML, is the next significant

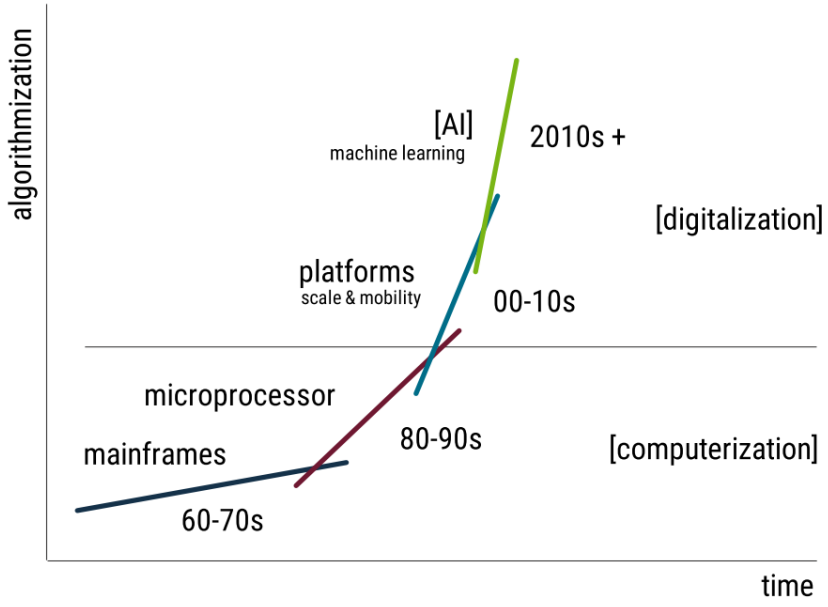

FIGURE 5.3. Impact of algorithmization through time [**63**]

and emerging phase and is referenced as the fundamental element for the transformation of industrial processes. Considering the continuous advances through the years in computational speed, data storage, quantity, and algorithms, the predictions made by the machine-learning-based systems are now more accurate and create a way for organizations to circumvent cognitive limits and discover new trends in the data [**118**]. This allows for the improvement in decision-making [**103**] inside organizations and the significant creation of value [**63**] in the business processes.

The supply chain is one of the areas of application of ML presented in the literature. Organizations can improve their supply chains by applying machine learning algorithms in processes such as demand planning, scheduling of warehouse picks, analyzing weather data to improve transportation management, rerouting vehicles to avoid congestion, predicting time delays, or optimizing routing for delivery vehicles [**38**]. The efficiency of these processes can improve by providing the data of previous interactions and occurrences to the machine learning algorithms thus allowing the algorithm to learn and make new predictions.

5.2.2.2. *Deep Learning*

Another subset of AI is Deep Learning. This technology is related to ML and takes advantage of neural networks with many layers to process the data received as input [**34**]. Although it is not as referenced as its parent technology, Deep Learning still presents a significant amount of references considering that it is not one of the ruling technologies and is inherent in another technology.

5.2.3. Internet of Things

The Internet of Things (IoT) is among the most referenced digital technologies in the literature and is recognized as having a game-changing potential [**32**] overall. IoT is a

new technology that has been growing with the arrival of the era of digitalization [**65**], and some authors acknowledge it as being one of the agents [**7**] and a key trend of digital transformation [**12**]. Its effect from a business perspective has also been recognized as a driver for business change [**71**], and some authors affirm that the technology has caused serious disruptions to various business models [**3**] and practices [**14**].

The concept can be described as a system of interconnected devices implanted with other digital components such as sensors, software, and electronics [**12**]. The devices have the purpose of initiating exchanges and collation of data that is transferred over the internet [**113**] into another system. By integrating several technologies and communication solutions, this digital technology can provide interaction that leads to identification and tracking of the collected data [**114**].

With the emergence of new concepts in the manufacturing sector, such as Industry 4.0, IoT earned new potential and was immediately considered by some authors as one of the leading technologies in the development and uprising of the concept of Industry 4.0 [**3**] [**12**]. The use of IoT in an industrial setting is also beneficial for Operational Risk Management (ORM) and is considered a critical innovation for this department by providing a source of data from devices in the field that can effectively affect operational decisions [**43**]. In the manufacturing sector, IoT can be used to educate mechanical and industrial engineering students [**66**] by providing real-time data on manufacturing components such as machines, allowing students to have practical examples and actualized data to learn about the industry.

This technology can also be used to create opportunities to solve several problems and aid in the digitalization of bicycle rental processes [**30**]. An organization had successful results in increasing the popularity of their service by implementing sensors in the rental bicycles that were able to generate data about problems with the bicycles and subsequently analyze the data. This generated faster responses and decision-making.

5.2.4. Big Data

Big Data is one of the primary technologies [**42**][**106**] found in the literature and is considered an agent [**7**] and a driving factor [**113**] of DT. The increasing flow of information created by the digital era provides a challenge for the successful implementation of digital transformations, especially in organizations where several departments need to collaborate with the same data that flows between them. Big Data can bridge this challenge [**75**] by having the ability to change the entire business. This technology fosters growth, performance, and competitiveness [**78**] and has been having a significant impact on Industry 4.0 [**12**].

Paired with intelligent business processes, taking advantage of new technologies such as Big Data and IoT is what defines the concept of digitalization [**37**]. It is clear in the literature that the use of Big Data capabilities has increased the performance of organizations' processes [**103**]. The concept is also associated with knowledge management [**11**]

and demonstrates a positive correlation with other influencing factors in the management of information by providing abilities to collect and analyze substantial quantities of data.

There are opportunities for the application of Big Data in ORM [**43**]. The software that is used for risk management in organizations seeks safe and effective operational decisions. Many authors agree that Big Data can have a great beneficial impact on decision-making [**114**] which makes this technology the right candidate for changing the process of ORM by providing actionable insight into operational risks and the ability to analyze trends among a substantial quantity of data [**43**].

As Russia is evolving in DT, the agricultural sector is one of the targets to implement technology. At a national level, Big Data is being used to perform predictive analysis in agriculture [**74**]. In quality management, there is a need for reliable and accurate data, and the use of Big data provides the ability to better assess customer needs in order to improve the quality of products and services. The analytic capabilities of Big Data can also be used to create opportunities to solve bicycle rental problems [**30**].

5.2.5. Enterprise Resource Planning (ERP)

Enterprise Resource Planning (ERP) has been used in companies to manage business processes for many years [**34**] and is considered the backbone of DT [**106**]. An organization incorporates a vast amount of business processes that require an adequate information flow [**106**] and needs quality ERP systems [**42**] that can guarantee the efficiency of those processes. ERP systems can provide a monolithic business process development environment [**31**] that represents core components of the digital infrastructure of today's companies [**90**] and is an imperative part of the background platforms that provide the efficient functioning of a company.

ERP systems focus on relatively stable back office processes, such as finance, HR, or warehouse management [**52**]. This technology plays an important role in the HR department of many enterprises, more specifically in talent management [**70**]. ERP systems were identified as the most frequently used tools in talent management and have a significant impact on improving the selection process of an organization. This tool is mainly utilized in organizations with a bigger number of employees in comparison with organizations with fewer employees, where simple databases such as Excel or Access are mainly used.

Universities have started integrating the study of ERP into learning activities. Since ERP is a complex topic, its learning has been integrated with virtual environments [**84**]. HEC Montreal has developed a simulation game called ERPsim that allows students to operate a firm based on a real integrated ERP system [**67**]. This simulation game is helpful for students in providing insights into how information systems are connected inside enterprises, how business strategies are implemented, and how these systems and technologies can affect the decision-making that is involved in the design of business processes.

5.2.6. Blockchain

Another well-referenced digital technology discovered in the literature is Blockchain. This technology is considered one of the drivers of DT [**113**] and its use has been intensely discussed [**116**] in several areas such as IT [**39**], Business Management [**39**], Business Processes [**104**] [**96**] [**14**], Supply Chain [**38**] [**45**] [**39**], Logistics [**45**], and Finance [**39**] [**104**]. Some articles that reference this new technology recognize its ability to foster innovation [**39**], impact entrepreneurial processes, and change business practices [**14**]. The novelty of this technology is transparent, and it is believed that the growth of its use will continue at a pace of 42.5% per year, meaning that it will reach a market cap of USD 1.29 billion by 2024 [**104**].

Blockchain functions as a secure ledger to record transactions between parties [**116**]. It utilizes a distributed ledger technology which means that even if there is no centralized institution involved, the many participants involved can still reach a consensus on the correct documentation [**39**]. The blockchain stores transaction data in the form of tables that can be verified by the participants of the system in every part of the world [**104**].

Security is the main reason for the use of blockchain technology [**39**]. The data is stored in a way that is impossible to be removed or replaced, allowing the transactions between the participants to not rely on trust [**102**], making them more secure. This solution protects the validity of the data [**116**] by providing traceability [**39**] to the transactions executed by the participants, which increases their security.

One of the applications of the blockchain found in the literature was in e-voting. The e-voting process requires centralized supervision by a certain authority which creates the opportunity to be changed into a decentralized and distributed technology that can improve the security of the voting process [**102**]. The article proposes an approach that includes a standardized process modeling notation using an Ethereum-based blockchain for the digitalization of processes, which demonstrates the ability of blockchain to be combined with other applications.

Blockchain also encounters countless opportunities in the manufacturing sector, especially in the supply chain processes [**39**]. One process that was found to benefit from the technology was the management of orders. All the information about the orders can be stored in the blockchain, including the damage to goods, which allows for the inspectors to have secure and transparent access to the information ahead of time and improve the logistics process.

Although blockchain is considered to have great benefits and is very promising in several areas, one article claims that the technology is still not fully matured due to the complexity that it withholds. The article defends that there is a lot more research to be done before considering adopting and fully depending on this technology [**102**]. There are also other challenges stated on the difficulty of calculating the cost of the upgrades generated by blockchain and on ensuring confidentiality and encryption [**104**].

5.2.7. Augmented Reality

As was proven by the analysis done in the last section, this technology is not the most recognized in the literature, and although it had a consistent representation, it is not as important as the main identified technologies. It is considered a secondary technology by some authors such as Stjepic, A [**106**] and Ivancic, L [**42**]. Despite having fewer references, it is still considered one of the driving factors for digital transformation [**113**] and one of the key technology trends of Industry 4.0 [**12**]. Researchers also recognize it as an enabler of changes [**73**] when incorporated into the ecosystem of digitalization [**25**].

Augmented Reality (AR) has been researched since the 1960s [**12**], and the development of activities related to this technology started with the implementation of 3D technology when researchers developed a see-through display that could show 3D graphics in a helmet [**12**]. The concept of AR is described in the literature as the extension of physical reality by adding several layers of information that are generated by a computer into a real environment [**113**]. Therefore, this technology allows information to be consumed more interactively [**113**], opening a variety of opportunities to change processes and services inside organizations and for the development of new products. Virtual reality is associated with AR but has the ability to create an artificial environment that is accepted by the user as a real environment [**12**].

AR has an immense impact on the acceleration of the manufacturing sector, which is one of its main applications [**12**]. It can support autonomous logistics paired with additive manufacturing [**46**]. Some examples of processes that can be changed by this technology in the manufacturing sector are product development, equipment maintenance, workforce training, production floor issues, process flow, and quality assurance [**12**]. AR has the potential to raise the efficiency of these processes and to have a positive impact on their execution by providing flexibility, rapidity, and quality.

Another application of AR is in the freight industry. It can be used to improve the loading of trucks [**38**] by providing the drivers with the ability to assess problems with the vehicle through visual insights without the presence of a skilled technician. Breakdowns and glitches can also be identified with this technology, changing the process of truck loading. AR is also being used in the medical sector, being adopted preoperatively and intraoperatively to assist medics in a virtually assisted visualization of the operation [**12**].

5.2.8. Digital Twin

One important concept that emerged from the literature as a digital technology being used for process digitalization is Digital Process Twin. This concept has been growing in the topic of Industry 4.0 [**39**] and is useful for the simulation of machining processes. This technology has been used in multiple sectors due to the wide range of possibilities for its use [**12**] and its capabilities for interoperability with other technologies.

The main definition of the concept of a Digital Twin is the digital representation of a real object or system through a virtual component [**89**]. A Digital Twin represents, in the digital world, the digital copy of a physical product in the real world [**89**] and combines

the behavioral and physical attributes of the product, providing synchronization of the data and facilitating the engineers' jobs in data analysis [**19**]. These virtual systems are examples of augmented simulation capabilities fostered by the evolution of computational power and technological solutions [**20**]. Other definitions of digital twins highlight the importance of the live component of the models [**63**], which refers to their capability to transmit live data to digital platforms allowing for its immediate use.

Digital Twins are considered data-centric [**19**], which means that their most relevant factor is data. The main benefit of using this technology is the ability to plan and process the data that results from the execution of the machining processes [**35**]. The data collected and produced by a process is referred to as digital shadow and needs to be integrated into the digital twin models [**13**]. By having a lot of real-time data analyzed, it is possible to identify bottlenecks and deviations in the production process [**89**].

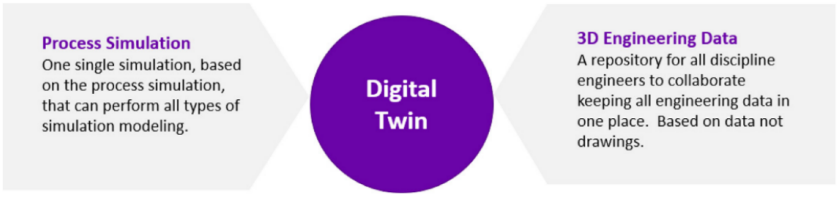

FIGURE 5.4. Digital Twin components in engineering [**19**]

The use of digital twins can serve a variety of purposes. It can minimize risks when organizations are trying to integrate new processes by allowing an analysis of the cost overruns and delays that it would cause, thus making process simulation a key ingredient of this system [**19**], as seen in Figure 5.4. For the simulation to be successful, the models need to perform calculations based on the raw data received. To ensure safe integration, several models can be created and used while having their results saved separately, which avoids data overwriting and prevents mistakes when studying the various possibilities for the process being created [**35**]. Robust digital twins can have great effects on the manufacturing sector. A study in the literature showed positive results on these effects, providing a framework based on how digital twins improved energy efficiency by 84% and reduced 93% of the machines queuing time [**1**].

5.2.9. Robotic Process Automation (RPA)

Robotic Process Automation (RPA) is not as referenced as other technologies in the literature but it is considered by many authors as one of the most important digitalization technologies and one of the main enablers of Industry 4.0 and DT [**101**]. Studies show that implementing this technology is often a company's first step into DT [**38**] and that the trend for its use remains persistent [**50**]. The value of the RPA market has been increasing every year in various fields [**101**] [**112**] at a rapid pace, and it was acknowledged in 2020 as the fastest-growing segment of the global software market [**101**] [**103**] for the second straight year [**112**]. Its value rose 38.9% during those same years reaching USD 1.9 billion

in 2020 [**103**] [**112**]. This increase is even more significant when compared with the year 2016 when the RPA market was only valued at USD 250 million [**101**]. The RPA market will continue to increase, as large organizations seek to digitally empower their business processes, and it is expected by Transforma Insights to reach USD 13 billion in 2030 [**112**].

The attention that RPA has been getting in the digital economy over the years is explained by its enormous potential to automate multiple business processes and activities [**96**]. This technology is used to automate data-intensive and repetitive tasks [**94**] for improved process efficiency [**101**]. RPA is also defined as preconfigured software that uses rule-based activities and allows for the automated execution of a combination of processes in one or more software systems without human operation [**112**].

The automation of processes can reduce manual work performed by employees [**112**] which enables them to perform other tasks that are more complicated, creative, and not automatable [**101**]. Although the employees can be relieved from some tasks, they still need to be actively involved with the automation process, which has led to major reskilling demand from organizations in order to teach the operators about RPA.

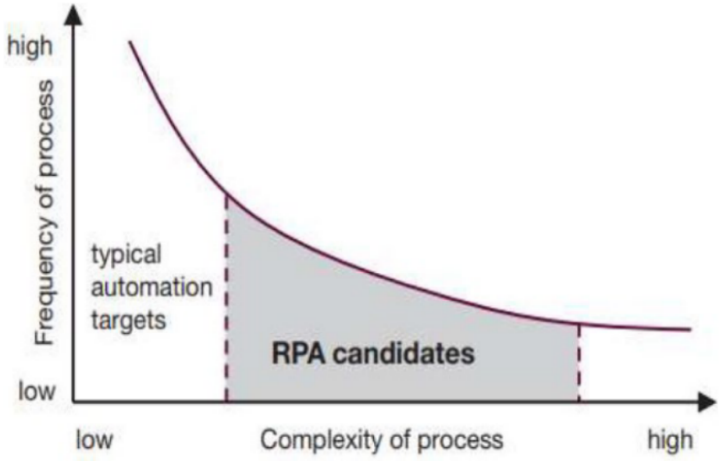

FIGURE 5.5. Selection of candidate processes for RPA [**101**]

One fundamental risk when implementing process automation is the incorrect interpretation of its goals [**103**] for the organization, causing an inappropriate approach that many times is associated with incorrect identification of the processes that are to be automated [**101**]. Thus, it is critical to assess the right processes to be automated in order to extract the most benefit from the implementation of RPA [**101**]. As seen in Figure 5.5, the selection of the candidate processes to be automated is based on the frequency of the process and its complexity. Processes with a high frequency of occurrence are typically the best targets for automation, especially if their complexity is low. Although these processes are the typical targets, their automation can be achieved through other simpler automation methods. The intermediate section of the chart represents the ideal candidates for automation that can take the most benefit out of RPA. The factor of complexity of the processes includes the cognitive requirements for its function [**101**]. The processes must require low cognitive skills and focus on more rule-based requirements.

Supply chains from various organizations benefit from RPA due to having many repetitive tasks. Some processes that can be improved are: creating and sending requests, creating purchase orders, processing payments, setting up supplier systems, and sharing documents [**38**]. These operation and logistics processes are easily automated and benefit from the implementation of RPA. RPA is also being implemented in HR departments where it can reduce the manual work involved in the screening of employment candidates by filtering resumes, scheduling interviews, and simplifying the integration process [**112**].

5.2.9.1. *IPA*

One author proposes a variation of RPA that is considered its evolution and is called Intelligent Process Automation (IPA). IPA guides businesses to automate processes by using various types of data. It combines process enhancements and next-generation tools to reduce repetitive and regular processes by imitating human behavior [**50**].

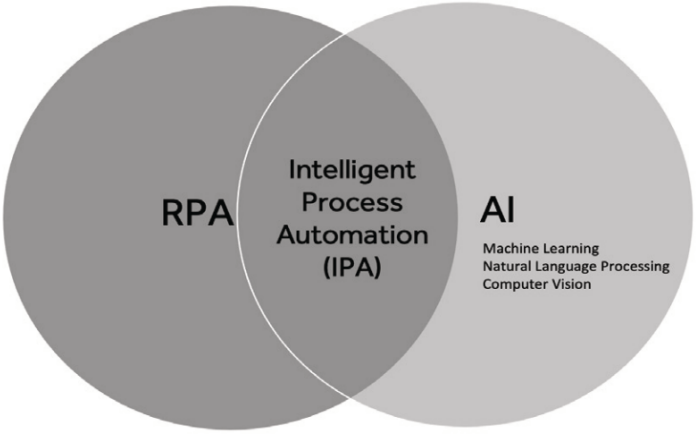

FIGURE 5.6. Integration of RPA with AI [**50**]

Figure 5.6 represents the integration between RPA and AI that constitutes IPA. These two technologies are the main pillars of IPA, along with Business Process Management which is also considered a pillar due to the possibility of automating workflows and improving interactions. The element of AI is crucial to provide meaningful predictions with the available data leveraged by RPA when automating complex processes [**50**].

One major advantage that IPA offers compared to RPA is the possibility to handle structured and unstructured data while also being able to support decision-making, which is not possible with the solo use of RPA. Another substantial advantage is that it can learn and understand context, thus performing better than humans, compared to the simple mimicking of human behavior that RPA provides.

5.3. Critical Success Factors

In this research, six concepts were found to have a significant impact on DT and digitalization and are considered in this section as critical success factors.

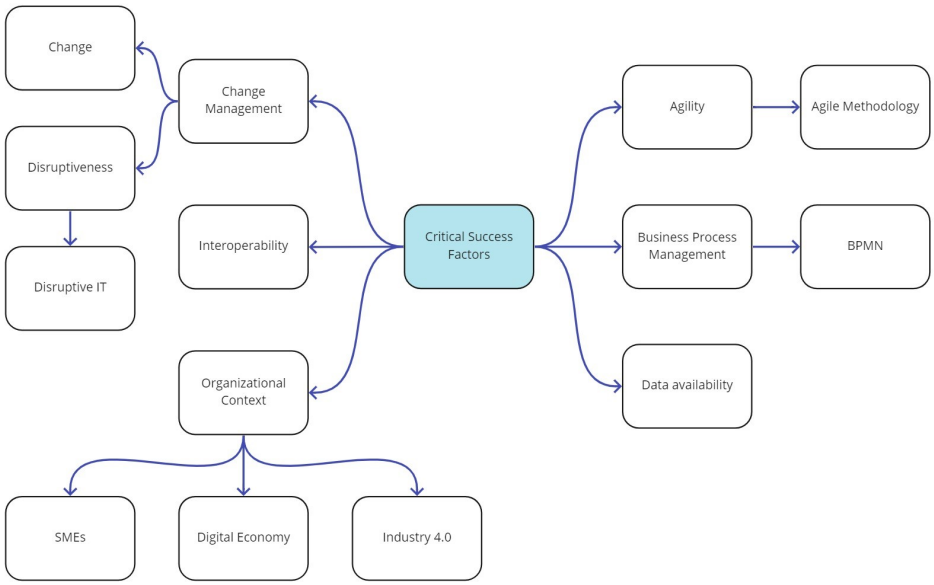

FIGURE 5.7. Critical success factors that affect DT and digitalization

In Figure 5.7, the critical success factors are represented and expanded according to the intricacies that emerged from their concepts in the literature. As previously concluded, agility was the most referenced factor, and the agile methodologies derived from its concept. Change management was also a well-referenced factor based on the change that occurs in DT and digitalization, and highlighted the emergence of the disruptiveness of these changes. These six factors are critical to the application of digitalization, and the success of DT is highly dependent on them, which is why they present extreme significance to this research.

5.3.1. Agility

Because DT is a continuous process that requires profound changes over time, agility is considered by many authors as one of the requirements for its success [**27**] [**5**]. Few authors, such as Dias, A. M. et al, also recognize agility as a characteristic that can be enhanced through digitalization [**20**], which means that it can also be viewed as a benefit. The ongoing characteristics of transformation and the dynamic characteristics of the digital environment [**27**] require agility as a core mechanism for strategic renewal [**118**] and for coping with continuous changes inside organizations.

Agility is defined as the capacity that an organization has to be effective and efficient when creating value while being faced with external and internal circumstances [**118**]. It translates to the ability to identify and anticipate changes [**65**] and includes other concepts such as alertness, flexibility, adaptability, and responsiveness. Organizations need to be responsive to detect market changes and notice opportunities to gain advantages, which

translates to alertness and a necessity to perform the proper activities that respond to the changes in the environment, which translates to the responsiveness component of agility.

5.3.1.1. *Agile Methodology*

With the importance of agility in the success of DT, more agile teams and approaches are required, and agile methodologies are gaining interest in organizations. Applying digitalization also requires skills for multiple digital technologies, and workers need to foster agility for the interoperability of different technologies through agile methodologies [**33**].

Agile practices have become common, especially in software development, and offer hybridization of project management methodologies [**59**]. Traditional waterfall approaches have been replaced by agile methods. These practices represent an iterative development approach that is best applied in environments with quick changes [**28**], where uncertainty and speed are essential [**91**], which is why agile methodologies are relevant and appear in the digital transformation literature.

5.3.2. Interoperability

Interoperability emerged in the literature as a factor that affects DT, which consists of the connections between technologies, information, and systems, that need to operate together to provide the most value for the organization. The definition of interoperability is stated in the literature as the established connectivity to open the exchange of information between systems. Interoperability is also considered one of the design principles in Industry 4.0 [**12**].

As organizations implement new technologies and adopt new systems, the information sources must be connected, and the systems that already existed in the enterprise must interoperate harmoniously with the new ones [**48**]. The flow of information between systems must occur safely, as theft of individual data from databases is usual inside organizations [**12**], which means that assuring interoperability is not only assuring the flow of information between systems but also its safety.

There are several examples in the literature of how different technologies can interoperate. In the seed processing industry, a system for control and management of the technological process was developed involving an AI system that interacts with tablets and smartphones [**107**]. IoT is used to complete the flow of information generated by the AI algorithm that constitutes the intelligent control system. Cloud computing is viewed as another enabler of interoperability [**46**], as it allows for the information to be available without a physical connection and integrated with several other technologies.

The main example of interoperability presented in this literature and described in this research is IPA. This technology allows organizations to create systems that can integrate RPA and AI technologies, with a complex flow of information that can create considerable value for the organization. RPA is a technology that shows great potential for interoperability with existing systems, and some authors recognize it as being able to automate

increasingly complex processes when integrated with complementary technologies such as AI, ML, or BPM [**101**] [**50**].

5.3.3. Data Availability

Data is the common element for all technologies and is the base of organizations. Digital technologies rely on the data that derives from the information that circulates inside the organization to create the most value. Larsson, O. et al consider data as a keyword of digitalization [**63**] and emphasize that the platforms that support digital technologies rely on the collection of relevant information that needs to be computed and distributed among the systems and models. Omar, A. et al also reference data as one of the most critical elements in all of the digitalization processes [**78**], which enhances the relevance to consider the availability of data as a critical success factor for digitalization and consequently for digital transformation.

5.3.4. Organizational Context

Digital Transformation has different outcomes throughout different market sectors and is highly dependent on the context of the organization in question. In this research, there were multiple appearances of the clear impact of digitalization on industrial processes, making it relevant to the manufacturing sector. There is also relevancy in the differences between the impact of digitalization between big established firms and small and medium enterprises (SMEs).

5.3.4.1. *Digital Economy*

The digital economy is a concept that is yet to be fully defined at an international level [**25**]. It is considered a complex phenomenon which explains the lack of clear definitions. Some authors say that it can be considered as being placed higher in the digital hierarchy than the concept of DT, which means that DT is a subset of the digital economy [**11**]. In attempts to define and quantify this concept, some European countries have used an index called the Digital Economy and Society Index (DESI) that summarizes important indicators of digital performance and is used to track digital progress and competitiveness [**86**].

The concept of the digital economy can also be interpreted as the stage or platform where digital transformations happen. This means that it's an environment that is constantly changing [**98**] and where digital transformations need to happen for organizations to continue to be competitive.

The digital economy is not only a business environment for DT, the concept also includes other characteristics that define the digital evolution of organizations, including institutions, laws, human capital [**88**] [**75**], Research and Development (R&D), and digital infrastructures [**25**], and is also mainly affected by the evolution and utilization of digital technologies. These technologies are considered by some authors as the main factor that affects the digital economy [**106**] [**29**] since they can affect not only the competitiveness

of organizations in the market but also the way firms are internally organized and how they use the technologies to change their internal functions [**111**].

5.3.4.2. *Small and Medium Enterprises*

SMEs stood out in the literature as part of the organizational context that deserves the attention of the research. When studying business processes, there is a notable difference that affects digitalization between big organizations and SMEs.

Due to their organizational complexity, big companies are usually better prepared than SMEs [**70**]. SMEs typically have a more sizeable human component [**11**] and are run by individuals, households, or small business entities [**69**]. According to the literature, these organizations have adopted fewer technologies [**47**] and lack organizational initiative for digital transformation [**27**] due to having fewer capabilities, limited resources, and less technically skilled employees [**6**]. Implementing digital technologies also requires financial investments that SMEs might not have access to [**111**] compared to larger organizations, which can also present a challenge when implementing digitalization.

Therefore, the size and resources of the organization impact the digital strategy when trying to implement digitalization, which enhances the relevance of analyzing organizational context as a critical success factor.

5.3.4.3. *Manufacturing Sector*

Several references to the manufacturing industry are also found in the literature, especially with the growth of the concept of Industry 4.0. Industry 4.0 was a term introduced in 2011 [**66**] that is also named the fourth industrial revolution [**88**]. This concept refers to the complex and digital evolution of the industrial sector [**95**] and represents the fundamental changes that have occurred in manufacturing organizations.

Manufacturing processes can benefit from digitalization with the use of technologies such as Cloud Computing [**95**], AI [**39**], IoT [**3**], Big Data [**12**], Blockchain [**116**], AR [**12**], Digital Twin [**39**], and RPA [**101**]. These technologies provide numerous possibilities for the existing structures, machining, and production planning phases [**66**], such as the intelligent interconnection of machines [**66**], connection of sources of information, and automation [**35**], that can increase the productivity of processes in the entire product life-cycle [**97**].

5.3.5. Change Management

Implementing change management is a requirement for a successful digital transformation [**93**] and has a significant impact on digitalization. The basis of transformation as a concept implies changes. The technologies being implemented in organizations have a direct impact on their business processes by causing changes that can bring improvements and create value for the organization. Change management can be considered a collective term for the approach of helping individuals, teams, and organizations prepare for organizational changes [**3**].

This concept is highly connected to resistance to change, one of the challenges identified in this review, which describes a natural phenomenon that will occur when trying to

implement the changes needed for transformation. This phenomenon can be diminished by having proper change management, allowing the people affected by the changes to feel cared for and rightly instructed [**7**]. For change management to be well performed, the motivation for the change needs to be highlighted, stakeholders must have a proactive opinion, the impact must fit the strategic goals, and data about previous changes must be taken into account [**3**]. This fosters a mindset of acceptance of the changes and contributes to less resistance to change.

Digital technologies are considered to have a disruptive nature [**14**]. This disruptiveness is mostly identified in the literature as having a negative connotation, with some authors describing it as "surprises" that cause unstable execution and functioning [**3**]. This elevates the need for proper change management that can strengthen these changes and provide an adequate response and strategy [**59**]. Although these disruptive changes will happen during a digital transformation and digitalization, they can provide a major benefit to organizations. One important conclusion related to change management is that organizations strive more in changing environments [**3**]. A study about the disruptive changes created by transformation concluded that changes act as motivators for finding new ways to innovate [**3**]. Organizational changes that are created by external and internal factors lead the organization to respond and adapt to those changes by finding ways to improve and become more efficient, and the tool to achieve this is innovation, which fosters an environment where companies are constantly improving and innovating in response to changes.

5.3.6. Business Process Management

Business Process Management (BPM) is viewed in the literature as being directly and highly correlated to the successful delivery of digital transformation [**106**] [**84**], being able to present a baseline for it [**27**], which highlights the presence of BPM as a critical success factor. BPM has become so relevant that the lack of knowledge on it presents a problem for organizations, and universities have started incorporating its study [**84**]. The market for BPM is expected to grow 14% between 2017 and 2023 [**106**].

BPM refers to a management discipline [**12**] that can support process-oriented organizations by providing governance through several defined principles, methods, and tools [**102**]. These methods include the discovery, analysis, redesign, implementation, and monitoring of business processes and aim to improve operational performance [**12**]. The use of BPM has changed from a strategic focus to improving modeling techniques [**9**] that can have a significant impact on creating value through digitalization [**51**].

In today's market, multiple vendors provide software solutions for BPM. These solutions are evolving to fix existing issues in traditional BPM approaches, such as lack of information fusion, model-reality divide, and loss of innovations. The loss of innovations is associated with not including employees in the BPM model, giving birth to the concept of social BPM, which represents the integration of people into the business process lifecycle to foster engagement and communication [**117**]. There is also a reference to BPM

platforms, BPM suites, and iBPMS. These three concepts represent different platforms associated with BPM software solutions and are ordered by their level of complexity, where iBPMS is the most complex and includes advanced analytics, and operational intelligence tools that bring great benefit to organizations. Only 50% of organizations are satisfied with their BPM software solution [**117**], and given the importance that these models have for their digital transformations, it is crucial to study and select the best possible option.

5.3.6.1. *BPMN*

Included in the concept of BPM is the modeling of the business processes. One well-referenced method of process modeling is Business Process Modelling and Notation (BPMN), which helps set up models or simulations of business processes [**99**] and evaluate possible adjustments, thus making the use and impact of digital technologies more transparent [**51**]. This method has become a widely used standard for process modeling [**102**] by organizations to create and overview their structures and operations [**27**].

5.4. Benefits

Digitalizing processes and embracing digital transformation can bring several benefits to organizations.

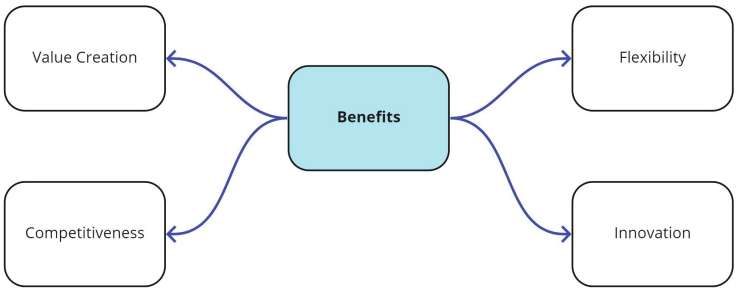

FIGURE 5.8. Benefits of DT and digitalization in organizations

The benefits represented in Figure 5.8 are the most referenced in the literature and are therefore considered by this research as the main benefits that concern DT and digitalization.

5.4.1. Innovation

Much like agility, the concept of innovation is also viewed in the literature as a requirement for DT [**27**] despite most of the authors viewing it as a benefit that arises from it. Innovation is referenced as one of the characteristics of the digital economy [**25**], and embracing innovation is considered one of the main areas of DT [**106**]. DT functions as a core driver for innovation [**33**] in organizations, especially with the digitalization of business processes [**81**].

The definition of innovation includes more than the creation of new products [**98**]. It includes a continuous process of improvement that involves renewing the organization itself by transforming knowledge [**69**] to create and improve products, services, and most

importantly business processes [**33**]. Digital innovation is also depicted in the literature as a tool that contains reprogrammability, data homogenization, and the self-referential nature of digital technology [**118**] as characteristics that allow the organization to reply to the changes in the digital environment [**3**].

Many organizations face the challenge of engaging in digital innovation [**114**], which can be facilitated by digitalization. By introducing new technologies, digitalization becomes the key to fostering innovation in the organizations' business processes [**82**] by providing capabilities to innovate and consequently giving them the flexibility to improve products and meet the expectations of the changing market in the digital economy [**69**]. Technology orientation is viewed as an enabler for increasing innovation capabilities, which explains how digitalization can foster innovation [**69**].

5.4.2. Value Creation

Value creation is not only the aim of DT [**60**] but it is inserted into its concept in a way that DT presupposes value creation [**45**]. This concept is also considered one of the four dimensions of DT [**106**] [**33**]. The creation of value is extremely relevant to the topic of process digitalization since integrating value-adding activities is the central action of process management [**98**].

Digital technologies are the enablers of value creation [**46**]. Their potential enhances processes in a way that creates and adds value to the organization [**70**]. These new technologies are constantly creating value for customers [**98**], which is recognized as a strategic response to the market for companies to remain competitive [**59**]. The full potential value that technology can provide is however a struggle for organizations to achieve [**88**], which creates the need to understand how to use it correctly.

Value creation is studied in the literature from different perspectives. It can be depicted as the value added to the final product with the help of digital technologies [**22**], or it can be seen from the perspective of the value chain. Improving the business processes of an organization with digitalization will also create value for each stage of the production line and the entire functioning of the organization. Improving the flow of information, collaboration, and teamwork can also be considered value creation activities that directly affect the organization's performance [**7**].

5.5. Challenges

Although process digitalization has distinct benefits for organizations, no enjoyment comes without ease. Implementing a digital transformation is accompanied by several challenges that were identified in the research and are pictured in Figure 5.9.

The three challenges identified in Figure 5.9 are the lack of skills, which translates into the need for organizations to improve the skills of their employees in order to digitalize their processes, and the resistance to change, which can be applied to DT in general as employees and managers tend to reject the changes in processes and business models. The last identified challenge, COVID-19 Impact, is a single occurrence challenge that opened

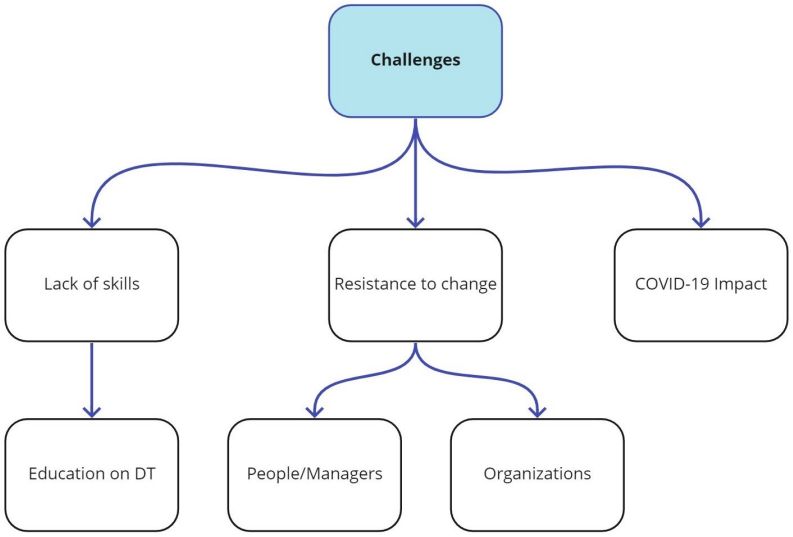

FIGURE 5.9. The Challenges of digitalization

several possibilities and changed the view on many organizations' problems, forcing them to digitalize their processes at a faster pace.

5.5.1. Lack of skills

The workforce of organizations needs to be prepared for the changes in the skills that are necessary. The lack of skills is considered by many authors as one of the major challenges of DT [**38**] [**21**]. Some authors also consider the digital skills of employees as one of the crucial elements for DT [**73**], which in contrast, also refers to the lack of skills. The importance of the lack of skills can be explained by the fact that DT implies the implementation of digital technologies, which requires new skills and capabilities to be able to benefit from them [**68**]. Organizations need to include the acquisition of new skills and capabilities that match the requirements of their new technologies when developing their digitalization strategies [**45**].

Some authors recognize people as one of the main resources of the digital transformation process [**42**] [**12**], which is described as the socio-technical character of the transformation [**90**]. Human capital is also considered one of the five dimensions of the DESI [**86**]. It refers to the skills and advanced skills of internet users, including them in the calculation of the index to track digital performance in Europe.

Implementing digital technologies to digitalize processes, directly affects the workers of an organization in several ways. Automation technologies like RPA can reduce repetitive tasks, which reduces the involvement of workers in the automated tasks and allows them to focus on more complicated and creative tasks [**101**]. Although this is a positive benefit created by this technology, it implies a major reskilling of the workforce [**96**] in order to have a set of skills capable of executing the new tasks.

Digitalization also affects workers by changing the capabilities that they need to continue their work in organizations. One necessary capability is flexibility [**45**], as the workers have to be able to match the evolution of technology over time. This factor is referenced by some authors along with the concept of knowledge management. Knowledge needs to circulate inside the organization for new skills to be developed dynamically [**111**]. Other skills like adaptability, creativity, resilience, innovation, skills related to information, communication, collaboration, critical thinking [**10**], creativity, and problem-solving [**20**] are also newly required in organizations to cope with changes in processes. Many other authors also reference the need for new leadership skills [**5**] [**63**].

The necessity of technical skills such as programming was also identified in the literature. A study with a sample of 120 companies showed that 43.7% require programming skills, with the leading languages being Visual Basic, C/C++, Javascript, and Pyhton [**96**]. In the same study, 43 companies requested skills for RPA, mostly on tools such as Blue Prism (28.6%), UiPath (25.2%), and other automation tools (18.5%) [**96**]. Companies also requested expertise in AI or ML.

5.5.2. Resistance to change

Managers and employees need to be willing to change for transformation to occur. This poses one of the biggest challenges to DT and digitalization [**98**] since change is needed when improving processes and implementing new technologies. Resistance to change has been studied in the context of change management as teams can provide the required knowledge on the changes that will occur in order to alleviate the anxiety imposed on the employees that can lead to a decreased willingness to adopt the changes [**7**]. There is a need for measurements to assess the impact of change resistance [**49**].

Resisting change has been studied throughout the literature as a natural phenomenon that is unconscious to human beings in general [**12**]. Human beings first enter a phase of resistance before understanding and accepting transformations, which leads researchers to consider this concept as a behavioral, emotional, or cognitive reaction [**49**]. Having this idea in mind, organizations cannot avoid an initial resistance to change but instead should focus on providing accurate elements to reduce the intensity of the resistance.

When previous projects fail, people start showing resistance to implementing more changes [**119**]. Which enhances the importance of having well-defined strategies when implementing digitalization and having sufficient knowledge to implement the necessary changes accurately.

Automation technologies can also cause resistance to change by presupposing the idea that having fewer processes due to process automation will reduce the number of jobs in the organization [**88**]. This creates a fear that is connected to the lack of skills in the organizations as discussed in the last section. New jobs emerge from automation, and workers need to be informed and educated to perform more challenging jobs.

5.5.3. COVID-19 Impact

The COVID-19 pandemic recently created and affected the entire world, and its impact was also studied in the literature and is relevant to the challenges of DT and digitalization. Although DT was already growing and evolving, this spontaneous event accelerated its growth by forcing companies to change and react, causing significant changes in the business environment [**12**].

The pandemic obligated people to stay home which changed the course of action for most enterprises. The economy could not entirely stop, and organizations had to find different digital ways to do business. Since digital technologies allow businesses to function in a non-physical manner, organizations forcingly began embracing DT [**110**] [**3**] at a rapid pace [**84**] to fight the challenge created by the pandemic. Naturally, organizations with already automated digital processes had an easier response to the outbreak [**103**] than companies that were not already engaged in DT.

CHAPTER 6

Conclusion

Through an SLR, it was possible to obtain and analyze a set of 112 articles on the topics of DT and process digitalization. A Bibliometric Analysis was performed to complement the SLR. The enormous amount of data that originated from the large set of articles required a rigorous analytical approach, and the bibliometric analysis deepened the knowledge of the constituents of the set. Through an initial performance analysis, the main constituents of the bibliometric data were analyzed: Authors, Institutions, Journals, and Conferences, as well as the publication and citation metrics.

The publication metrics show an increasing number of publications over the years and found the Journal of Business Research, and the journal Sustainability(Switzerland) to be the most relevant journals, and the Proceedings of the Annual Hawaii International Conference on System Sciences and ACM International Conference Proceeding Series to be the most relevant conferences in the set.

This research identified the most relevant digital technologies used in digitalization inside organizations and discovered that four technologies stood out in the number of citations. The four most cited technologies are Cloud Computing, AI, IoT, and Big Data, which this research concludes as the ruling digital technologies used in digitalization. Other technologies such as ERP, Blockchain, AR, Digital Twin, and RPA were also identified as relevant to the literature on digital transformation, and their impact on organizations' processes was discussed.

This research concluded that the following concepts are the critical success factors for DT and digitalization: agility, interoperability, organizational context, change management, and business process management. Agility stood out as the most cited factor and was defined as the capacity that an organization has to be efficient when creating value. Although Agility is viewed from different perspectives in the literature, this research concluded that it should be viewed as a success factor instead of a benefit due to its components of alertness, flexibility, adaptability, and responsiveness, which constitute imperative requirements for organizations to digitally transform their businesses.

The sources of the digital technologies' data must interoperate in a connected and harmonious way to guarantee the best flow of data, making interoperability a critical success factor. Guaranteeing correct management of the interoperability between technologies was deemed critical.

From the concept of change management, important conclusions emerged. The disruptive changes caused by digitalization can also be positive to the organization, as they

strive more in changing environments. Therefore, disruptive changes should be considered as a motivation to implement DT as it forces firms to innovate and adapt.

The most cited concept throughout the literature was innovation, which along with flexibility and competitiveness, are considered the benefits of digitalization. Although process digitalization has disparate benefits for organizations, there are several challenges that organizations need to be mindful of when preparing for digitalizing processes and embarking on DT. This research concluded that the main challenge for organizations is the lack of skills. Organizations' workforces need to be prepared for the changes in the necessary skills. Skills like adaptability, creativity, resilience, innovation, communication, collaboration, critical thinking, creativity, and problem-solving are newly required in organizations to cope with changes in processes.

The impact of the COVID-19 pandemic was also studied and deduced as a challenge that impacted organizations' processes in DT. Another identified challenge was the resistance to change which is described as the lack of willingness that workers and managers show in the face of change. Important conclusions emerged from this concept that organizations need to be aware of. DT and process digitalization involve changes that managers and employees need to be willing to accept. The resistance that they demonstrate is explained by the natural tendency that humans have to unconsciously reject change. Failing projects are also a source of change resistance, as people start showing resistance to implementing changes after previous changes have gone wrong. The literature also showed that different generations might be more easily susceptible to changing and performing in DT.

Digital technologies can change processes in organizations, but the examples found were obtained from several sources and represent different companies and processes. Analyzing the impact of digital technologies on a single organization's processes by using real scenarios and implementing divergent technologies in the same firm could create a better understanding of that impact.

Regarding the concept of interoperability, there are opportunities to develop a system of full digitalization. Utilizing several technologies interoperating among each other in a large organization with several different business processes could achieve a 100% digitally transformed organization, which could provide an understanding of what technologies could achieve this creation and how the flow of data would work between processes and technologies.

Having into consideration the identified concepts, which can be considered the most popular, and the framework created, there are possibilities for future research. The information contained in this research can be used to produce questionnaires or other methods for organizations, that can cross the information obtained and generate new conclusions about the popularity of the concepts identified.

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