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TDK Research Article

**The evolution of Digitalization Transformation and Industry
4.0 in Supply Chain Management: A Systematic Literature
Review**

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The evolution of Digitalization Transformation and Industry 4.0 in Supply Chain Management: A Systematic Literature Review

Abstract:

The digital revolution is rapidly reshaping supply chains, driven by the confluence of Industry 4.0 and digitalization transformations. The increasing adoption of these concepts in the supply chain is explored, highlighting the various model approaches and practical applications used by scholars to aid decision making and consultation in supply chain management (SCM). Thus, this research aims to investigate the evolution of the digitalization transformation era through the integration of machine learning and big data management in SCM. A systematic literature review and mapping study are conducted, analyzing 223 open access articles from the Scopus database and 60 ones from Web of Science, selected through a PRISMA screening process and PEO framework. While some enterprises have successfully implemented methods such as Big Data management, AI/Machine learning integration, Automation, and Digitalization platforms, there is a need to organize and evaluate this transformation process for a optimal utilization and further innovation. The findings of the study provide a narrative summary, encompassing the evolution of decision-making and consultation processes, recommendation approaches and guidelines for enterprise to reach the Industry 4.0 for their SCM, and potential areas for future research of navigating the world of digitaled supply chain.

Keywords: Supply chain management, Industry 4.0, Digitalization, Transformation

1. Introduction

Nowadays, a significant wave of digitalization is currently permeating across all industries of the world. Organization try to gain competitive advantage not only in the product and services itself but also the digital environment they are building up for the company. It's driven by a momentum need to win a position in the digital world. In the meantime, scholars and researchers are also playing with the digitalization topic and digging down into this large research area. The fuzzy spots here are whether both researcher and enterprise cover all the digitalization and Industry 4.0 and whether this foreseeable evolution can go beyond what is expected.

In terms of the general background of research context, both practitioners and scholars highlight the advantages of implementing Industry 4.0 (I4.0) technology, such as increased transparency and real-time data availability in operational processes. The positive effects and transformational potential of digital technologies are frequently overemphasized in the literature currently available on Industry 4.0 technologies (Kessler et al., 2022). Some Industry 4.0 technologies-embedded to supply chain management, including five typical kinds of digital technologies: cloud services, artificial intelligence (AI), big data analytics (BDA), blockchain technology, and internet of things (IoT)(Liu et al., 2023) had implemented for demand management, transportation and delivery, and inventory management (Asst Canser BİLİR, 2020). With this broaden in the topic itself and the growing technology, digitalization and Industry 4.0 research is becoming a regular presence in journals and conferences from 2017 to 2024, studying the benefits and challenges, analyzing practical applications, and examining some conceptual models or frameworks related digitalization

and SCM such as: Multi-criteria decision making (MCDM), Decision-Making Trial and Evaluation Laboratory (DEMATEL), Critical Success Factors (CSFs), etc.

Regarding the definition of digitalization, the author add some clarification to the distinction of “Digitization” and “digitalization” which are used in association with digital technology and the innovation process. While the term “digitization” has been employed to describe to a variety of different phenomena including, the creation of a digital product (Hopp et al., 2018) and the utilization of digital technology on the process of developing new products (Marion & Fixson, 2020); “digitalization” has been used to signify the processes of data collection, generation, and analysis aiming at generating value and fostering innovation (Cappa et al., 2020). Furthermore, it encompasses the pursuit of digital innovation, which creates novel digital products (Pesch et al., 2021); and integrate digital technology into the innovation process (Lanzolla et al., 2020). To redefine the term “digitalization”, the author refer a good example for it, which is CAB2IN framework, stands for five kinds of emerging digital technologies, including cloud services (C), artificial intelligence (A), big data analytics (B), blockchain technology (B), and internet of things (IN). They go through the process from data management and organization to implementation for value creation toward a supply chain and serve different digital purposes.

The research article aims to examine the development of digitalization transformation and Industry 4.0 integration era toward supply chain management and the implementation of enterprises for supply chain operation.

Three research questions (RQ) are developed from the article objective:

RQ1. How far has the digitalization transformation developed?

RQ2. How do enterprises adopt digitalization and industry 4.0 methods to transform successfully?

RQ3. What are potential research direction in this area?

In terms of the general background of enterprise/industry, managers, who benefit the same those researches as scholars and researchers, also delve into gaining the understanding of the digitalization world, coming from both Big manufactures and Small-medium enterprises (SME). SME managers will find managerial implications particularly interesting given that they can assist them tackle collaboration concerns and enhance their readiness for Industry 4.0 for helping decision-making and policymaking in the supply chain (Kazantsev et al., 2022). For larger firm cases, identifying the limitations of the present supply chain system, adhering to a digital road map with the help of digital enablers, and maintaining an agile, flexible, and long-term in SCM are some of the primary guidance for pharmaceutical supply chain managers (Shashi, 2023). For country level analysis, the developing countries face specific challenges that require prioritizing the proper set of CSFs for sustainable digitalization (Caiado et al., 2023) but not many critical papers for this point. Or only some sections of the supply chain are digitalized, while some companies are also already far with Industry 4.0, such as the virtual factory and the physical factory work closely together (digital twin). Industry 4.0, which started in Germany among the large OEMs, seems to have not resonated much with SMEs (Addo-Tenkorang et al., 2023). So far how digital transformation has changed manufacturing in several ways is still ambiguous for both researcher and managers.

The paper will conduct the systematic literature review (SLR) throughout 5 sections. The research conceptual framework is presented in Section 2, with a detailed explanation of how the author study to satisfy the research aim. Mapping and statistic study are conducted in Section 3, which criticize the quality of the database and how they support the literature review later. Relevant

literature is reviewed in Section 4, answering some parts of RQs. Section 5 and 6 will conclude the paper and give out the insight or future direction for fellow researchers.

2. Methodology

In this article, a Systematic literature review process is carried out on the digitalization evolution in supply chain management. The following Figure 1 illustrates the research design and the steps followed by the researchers throughout making this paper:

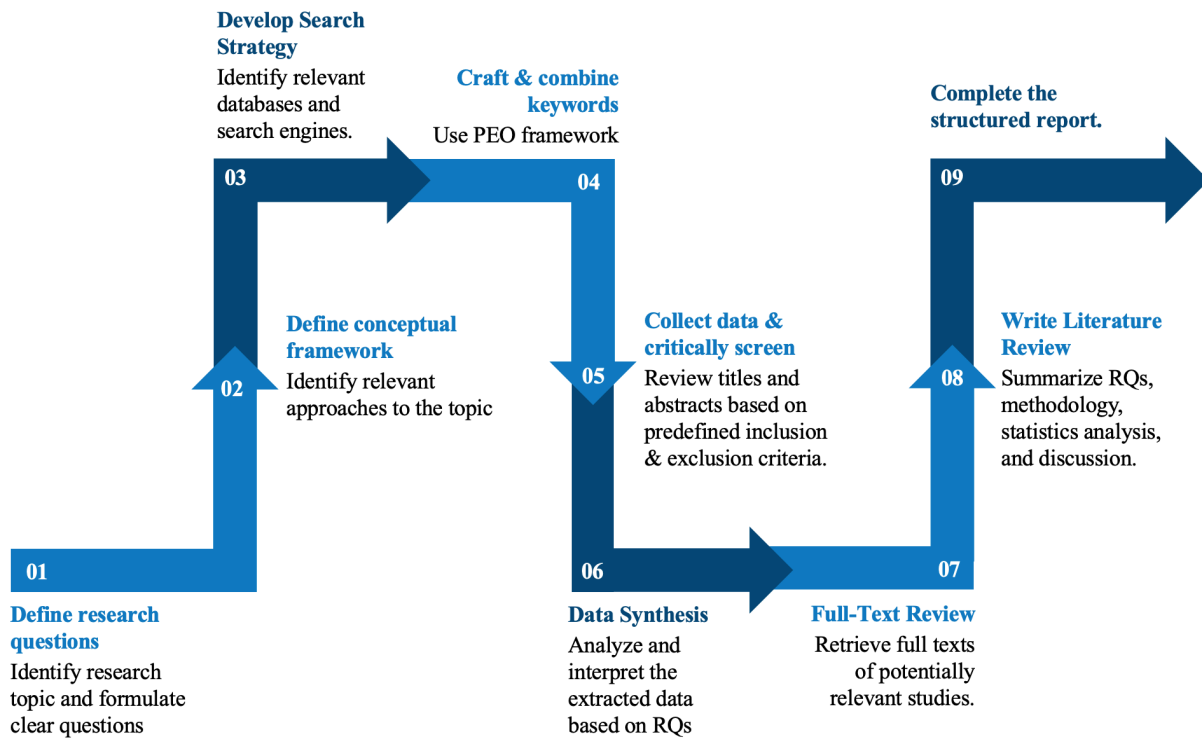


Figure 1: Research methodology process

Source: Author's own creation

The research aims to answer the following research questions:

- *RQ1. How far has the digitalization transformation developed?*
- *RQ2. How do enterprises adopt digitalization and industry 4.0 methods to transform successfully?*
- *RQ3. What are potential research direction in this area?*

In order to answer the research questions, a SLR is applied by using two creditability databases: SCOPUS and Web of Science (WoS), written in English. Regarding literature screening, the articles were selected based on their relevance to the topic. In total 284 articles were selected and used for the research. The method used for the literature screening was PRISMA method with the help of keyword selection by PEO framework – a search strategy was designed using the Population, Exposure and Outcome frames as a basis, as outlined by (Bettany- Saltikov & McSherry, 2016).

- Population (P): This refers to the specific group of individuals or subjects that the research is interested in.
- Exposure (E): This refers to the factor that the population is exposed to. The exposure could be something that the population experiences, such as environmental factor or optimization process, or it could be something that is introduced by the researcher, such as a new platform or technology.
- Outcome (O): This refers to the result or consequence of the exposure of the population. The outcome could be positive, negative, or neutral. It is important to define the outcome clearly, so that it can be measured or presented precisely.

Table 1. Keyword developed based on PEO framework

Population	Exposure	Outcome
Supply chain management	Digitalization	Recommendation
Supply chain	Industry 4.0	Evolution
		Consultation
		Decision making

Source: Author's own creation

As seen in Table 1. these eight keywords can perform comprehensively in the search engines of two sets of databases with the combination query by using some boolean connectors.

Inclusion and exclusion criteria are formulated:

- The articles have to be related four main fields: Computer Science; Business, Management and Accounting; Decision Science; Economics, Econometrics and Finance.
- The articles have to be freely accessible
- The articles have to be written in English and published between 2017 and 2024
- The articles which are presented in both databases have to be removed to avoid duplication
- The articles have to be related to the research topic.

3. Result of the mapping study

After the final keyword selection by PEO framework, the next stage is searching for the database with the quality and relevant papers from two proposed databases. Boolean expressions: These combine multiple boolean values and logical operators (AND, OR, bracket) to create more complex conditions. Both Scopus and WoS generated substantial number of articles, 786 and 587 respectively by the first initial search from this keyword combination (*"Supply chain management" OR "Supply Chain") AND ("Digitalization" OR "Industry 4.0") AND ("Recommendation" OR "Evolution" OR "Decision making" OR "Consultation"*) representing for all keywords in the paper PEO framework in table 2.

Table 2. Number of Article selection after 3 initial searches

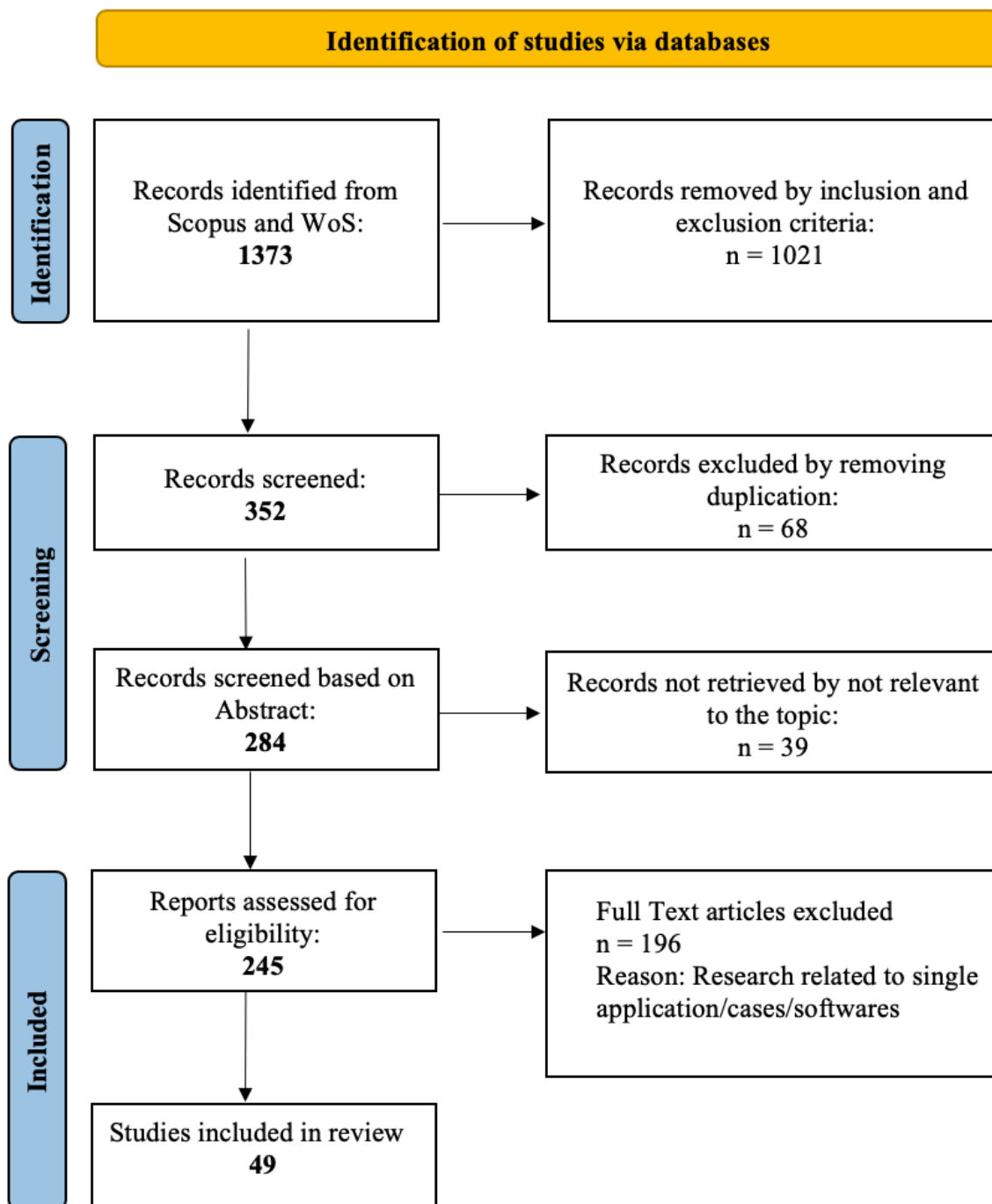
	Keyword queries in Scopus	Keyword queries in Web of Science
Initial Articles	786	587
Subject Areas (Computer Science; Business, Management and Accounting; Decision Science; Economics, Econometrics and Finance)	600	326
Open access	234	120
Publication year (2017-2024) and Language	233	119
Removal of duplication articles	233	51
Final paper to review	284	

Source: Author's own creation

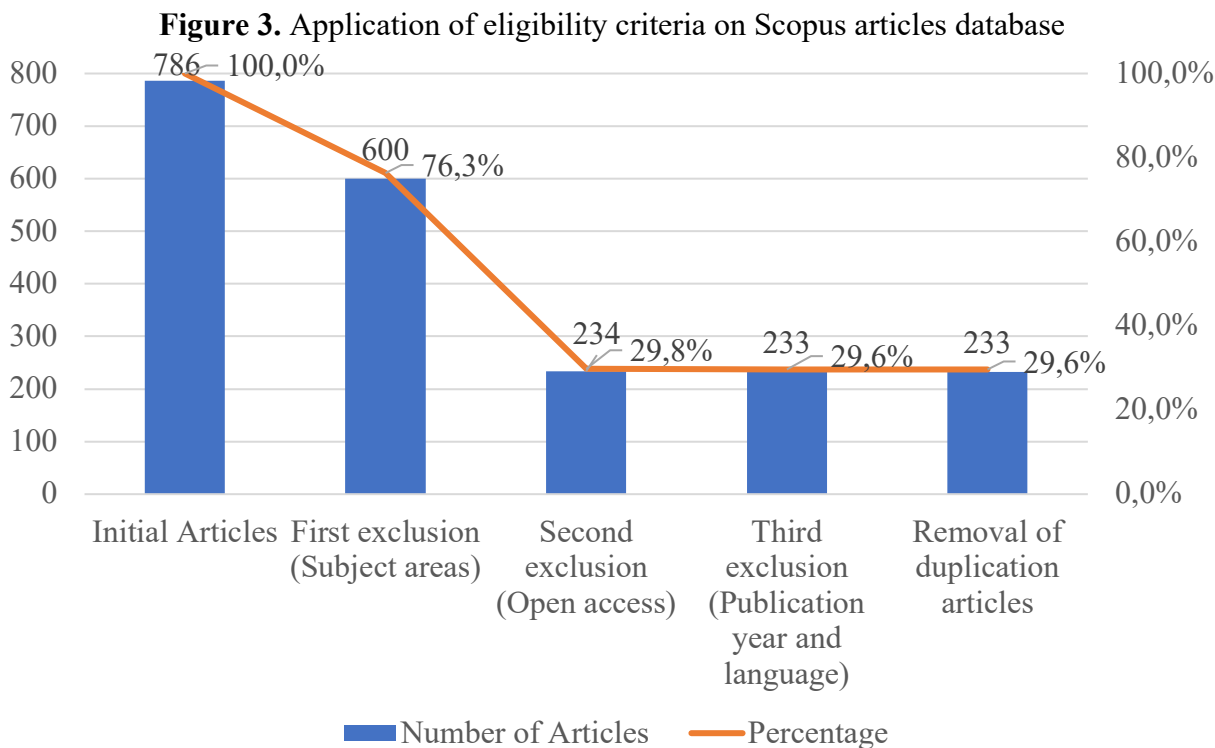
After applying the first filter, which limited the subject areas to four main ones: Computer Science; Business, Management and Accounting; Decision Science; and Economics, Econometrics and Finance, resulted in a decrease in articles for both databases. The author focus on these realms to reach the closest and most relevant to SCM. The number of collected and selected articles is visualized in Figure 3 and Figure 4, which can be seen that half of WoS database drops after narrowing down by first criteria. Further refinement occurred after filtering for open access articles and those published between 2017 and 2024 in English (Scopus: 233; Web of Science: 119). Both Figure 3 and Figure 4 demonstrate the same patterns with the author filter inclusion and exclusion criteria, which the percentage of papers decline significantly after the second and the third conditions. Only 29,6% from Scopus databases and 20,3% from WoS compared to the beginning.

The final stage involved removing duplicates, which resulted in a slightly lower number of articles for Scopus (233) but a substantial decrease for WoS (51). This highlights that a significant portion of the articles retrieved from WoS were duplicates, only 8,7% of total number of articles at the end. While Scopus yielded a considerably higher number of relevant articles after filtering compared to WoS. This PRISMA method gave a final result of 49 papers to be reviewed in below Figure 2.

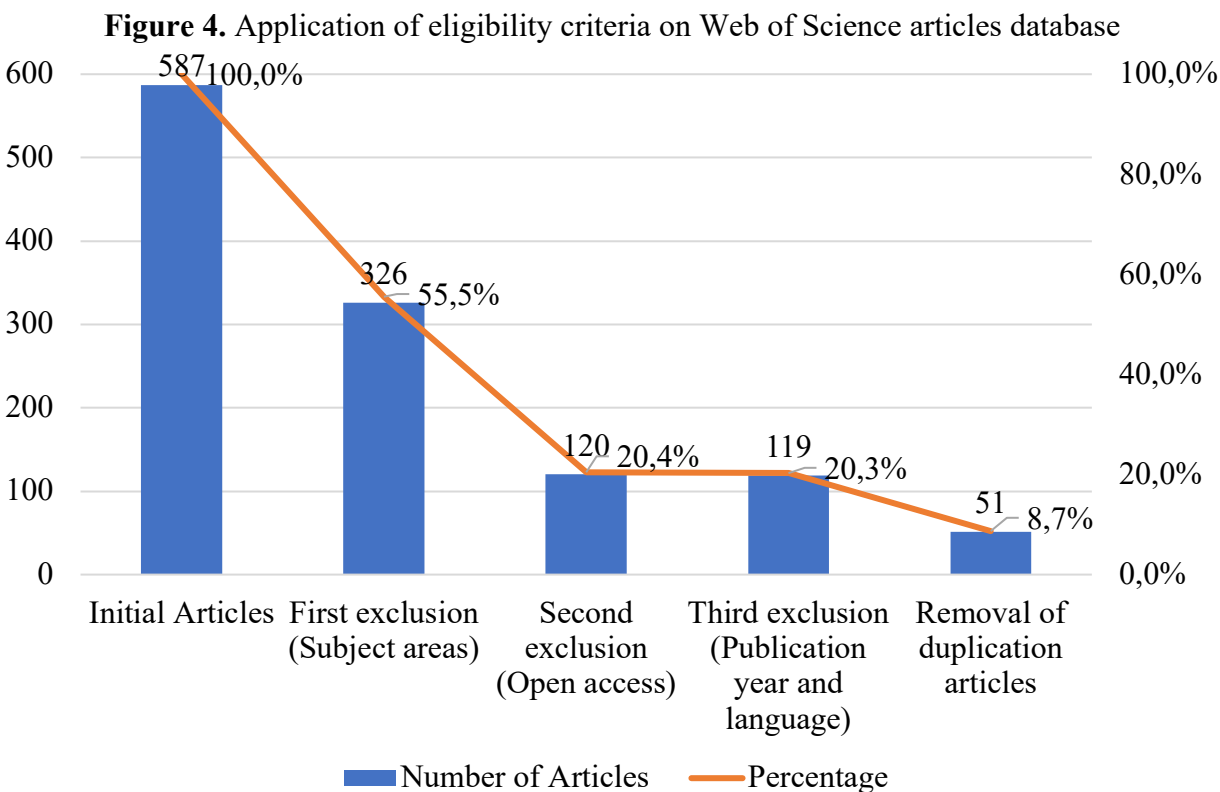
Figure 2. Systematic literature review based on PRISMA method.



Source: Author's own creation



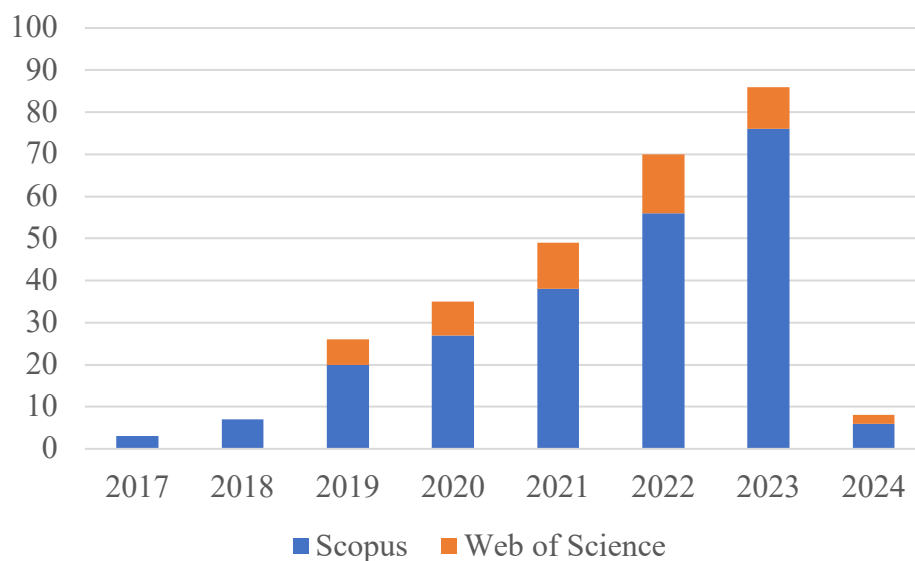
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From Figure 5, the number of articles published in Scopus and Web of Science journals over the past eight years were analyzed by their publication year to examine the research trend of scholar toward digitalization development in SCM. Overall, the number of articles published in Scopus has been steadily increasing from 2017 to 2023, whereas the number of articles published in WoS has fluctuated and just published since 2019, starting 2 years later than Scopus. At the end of 2023, Scopus shown a double increase in its database compared to 2021, reaching a peak of 76 papers. In the meantime, WoS database fluctuated around over 10 articles, but one of the affected factor is the duplication removal from WoS instead of Scopus. Over the year, both journals witnessed an upward trend by their published research, which expressed an increase in interesting in digitalization transformation in SCM.

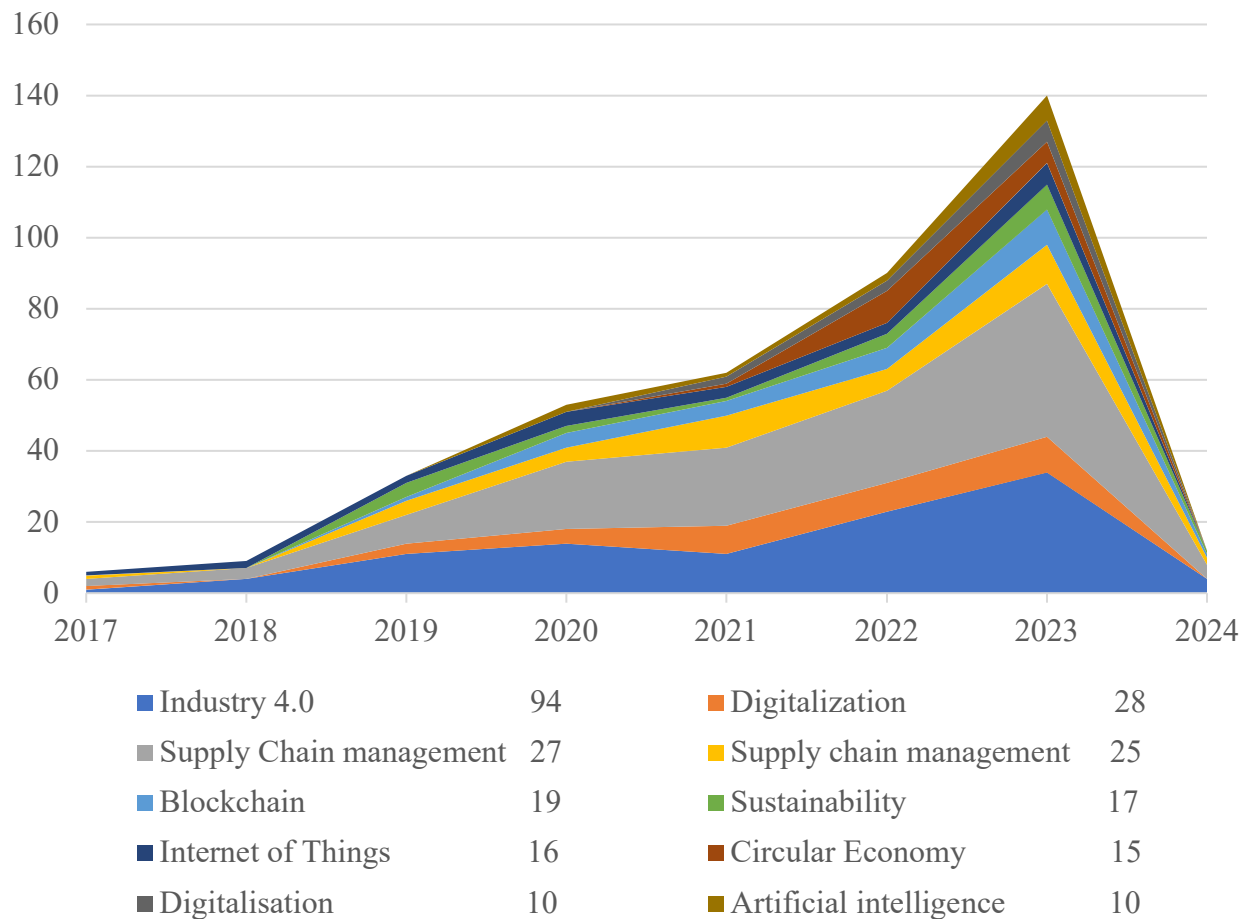
Figure 5. Number of articles (Scopus and WoS) – year based



Source: Author's own creation

Continuing by the increasing in number of articles over the time is the keywords evolutions related to the current topics. After crafting all keywords from 284 article database, top ten keywords are depicted in the stacked area chart in Figure 6 and analyzed based on seven-year period from 2017 to 2024. The chart illustrates a dynamic shift in the prominence of these keywords: Industry 4.0, Digitalization, Supply Chain, Supply chain management, Block chain, Sustainability, Internet of Things, Circular Economy, Digitalisation, and Artificial intelligence. The total number of repeated times of the keyword are visualized next to them in the chart, which three dominant ones come from Industry 4.0 with 94 articles using, Supply Chain management or Supply chain management also account for 52 articles in total, and Digitalization with 38 articles (including 10 from the wording of "Digitalisation"). Overall, the landscape of Industry 4.0 keywords has shifted remarkably during the past six years. While foundational terms like "Industry 4.0" and "Supply Chain" have receded, there has been a surge in interest in areas like "Digitalization", "Artificial intelligence", "Blockchain", "Internet of Things", and "Circular Economy". This suggests a growing focus on the digital transformation and sustainable practices within supply chain.

Figure 6. Top 10 keywords and keywords evolution



Source: Author's own creation

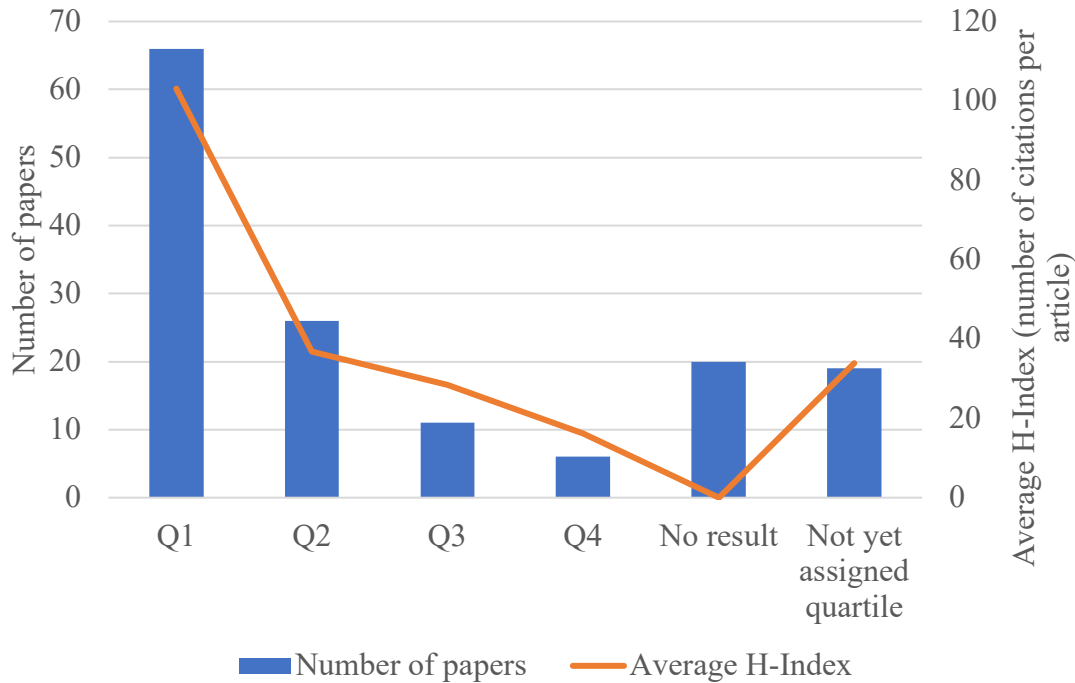
To validate the quality of papers from the database used for the SLR, the author use the SCImago Journal & Country Rank (SJR) which is a publicly available portal for examining journals and assess scientific domains with sets of indicators. In this case, H-index and Quartile scores will be two selected indicators for analyzing the source title of articles' creditability and quality. The H-index demonstrates the journal's number of articles (h) that have obtained at least (h) citations, thereby quantifying both journal scientific productivity and scientific impact. While the concept of Quartile Score (Q Score) of scientific journals is interconnected with impact factor (IF), SJR measure the value of journal by four quartiles accounting for equal number of papers as following:

- Q4: Last 25% slice, low impact
- Q3: Middle 25% slice, middle impact
- Q2: Middle 25% slice, middle impact
- Q1: high 25% slice, high impact (Asan & Giray, 2021).

As the IF value of a source increases, the source quartile score approaches to Q1 category, vice versa, its IF value decreases, it approaches to Q4 category. A glance at Figure 7 reveals a positive quality of papers since Q1 had by far the highest number of sources, 66 out of 150 sources

consolidated from 284 articles. Along with that is the high H-index reaching average 103 citations per articles. The figure of Q3 and Q4 are negligible portions, 17 sources for both. Regarding the “no result” and “not yet assigned quartile”, SJR portal can have issue of calculating IF value which related to Q score or in some cases the source or journal not yet up to date in the portal but occupied a small shared.

Figure 7. Paper quality based on source title’s H-index and Quartile score



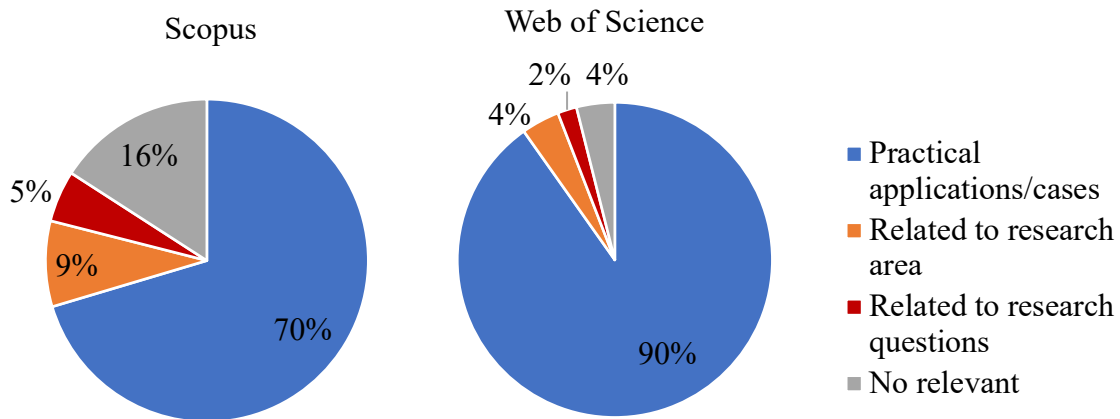
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4. Discussion

To evaluate and synthesize the existing research on this topic, the narrative summary was conducted by using the critical literature review to gain a thorough understanding on the current state of knowledge, identify gaps in the literature, and navigate the research questions. According to the detailed analysis of 284 papers, it can be divided into four categories as below figure 8.

- Blue sector: group of articles focusing on practical application of digitalization and different research methods in the specific cases applying Industry 4.0
- Orange sector: group of articles focusing on the decision making and operation management process when expose to digitalization and Industry 4.0
- Red sector: group of articles focusing on the evolution of digitalization transformation and Industry 4.0
- Grey sector: group of articles are out of topic.

Figure 8. Article category after critically appraising title and abstract



Source: Author's own creation

4.1. Blue sector, occupied by far the largest proportion of the articles in both databases. 70% of journals in Scopus and 90% one in WoS research the practical cases and application of Industry 4.0 and digitalization in supply chain.

From 2017, scholars starting with some research of the integration between supply chain and advanced technology explored in niche realms such as smart shipping, logistics 4.0, automatic guided vehicles (AGV), etc. (Feibert et al., 2017), one of the very first group of researchers in this field, studied about the integrated digitalization and business process management (BPM) perspective to boost supply chain performance for maritime transport companies, contributed to the goal of achieving efficient supply chain to deal with the volatile fuel costs and competitive freight rates. Or AGV study is not a new topic and reached an age of maturity, however, (Bechtsis et al., 2017) would tackle the network optimization and sustainable problems, with the finding of the integration decision-making framework to AGVs. Moving to 2018, the emerging of technologies continue spread in different part of supply chain such as conceptual design for procurement 4.0 by (Pause Daniel and Blum, 2018), the complexity proposals of Barcode, QR, Internet of Things for traceability of food supply by (Introini et al., 2018). In the first two years of the survey period, the widespread of Industry 4.0 are still sporadic with variety of application as well as the chosen research businesses.

Till 2019 and 2020, the number of papers exploring a wide range of technology enablers including block chain, simulation tool, Machine learning algorithm, digital twin, and data analytics, which were delved into common industries: healthcare, food chain, agriculture, as it can be understood how Covid-19 event hit all manufactures to a digitalization world. In the meantime, the journals in this stage also seek for the decision making and consultation in SCM, along with the tech-savvy transformation era. (Drakaki et al., 2019) examined the Multi Criteria Decision Making (MCDM) approaches and multi-objective programming in order to satisfy sustainability requirements regarding a number of supply chain problems detected during this period including supplier selection, order allocation and routing. A study by Mostafa and colleagues presented new framework for warehousing enabling the collecting of real-time data and sharing them which support automated decision-making process (Mostafa et al., 2019). Adoption of digital twin tool

scrutinized by Latif and Starly proposed to production managers the possibility of making more informed early decisions even when disruption in supply chain occur. The paper examined not only the tool and process itself but also exemplified the whole proposed framework in an appropriate industrial case study (Latif & Starly, 2020).

The topic was later expanded since 2021 with more transformation come from two main exposures Industry 4.0 and digitalization to various business contexts. According to the research done by (Tseng et al., 2021), they utilized Delphi method and decision-making trial and evaluation laboratory (DEMATEL) for examining human decision making and the complexity and uncertainty in the supply chain. One of highlighted result is that labor conditions are important to sustainable supply chain management. Similarly, Munien and Telukdaire's finding showed that employment is boosted by digitalization and localization but constrained by skills scarcity (Munien & Telukdaire, 2021). While the majority journal analyzed the application of advanced technologies, the minority focus on how enterprise successfully adopt the transformation with their labor conditions and managers' decision-making process. Both also affected the evolution if facilitating digitalization without skills or strategic guideline and recommendation.

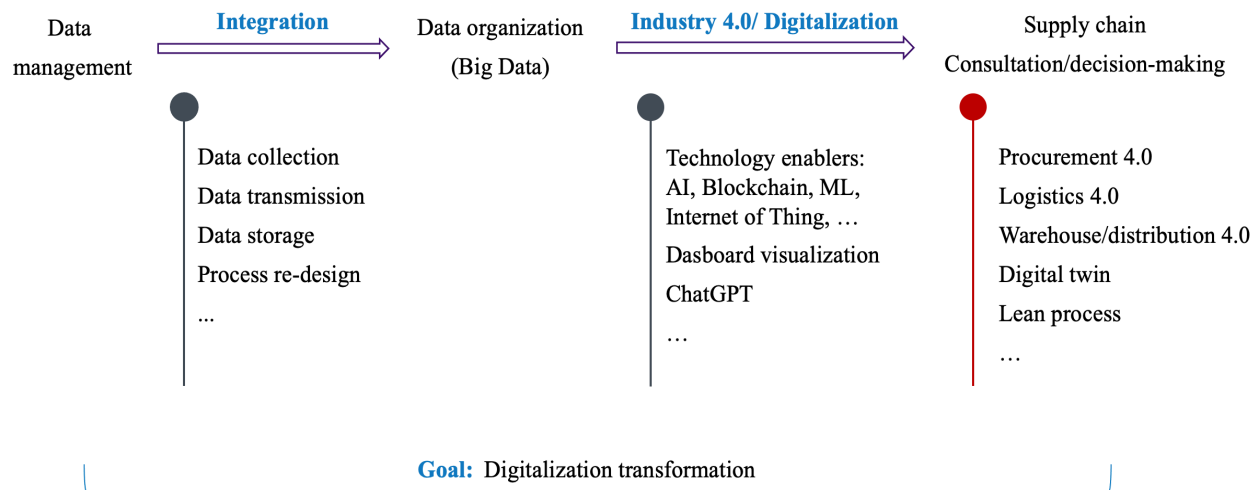
From 2022 up to now, there are more and more fields for scholars and researchers to study thanks to the speed of industry evolution and digitalization transformation. (Chavez et al., 2022) discussed the importance of data-driven decision-making (DDDM) model, bringing the findings that while all businesses acknowledge the potential of data utilization for sustainability purposes, most of them had not completely transition towards a data-driven environment as the fuzzy of data readiness from the organization. That's why later several articles are dealing with the critical success factors (CSFs) for sustainable I4.0 in operations and supply chain management. Caiado and his researcher group delved into those developing countries that require prioritizing the proper set of CSFs for sustainable digitalization and provide solution for organizations stay current in I4.0 adoption and integrate sustainability in SCM (Caiado et al., 2023).

4.2. Orange sector, occupied a small percentage of articles in both databases. If the blue category articles focused on different Industry 4.0 and digitalization evolving in SCM, the orange one is exploring what results can be expected from the exposures of supply chain management.

Evolution: Both digital supply chain integration and enterprise adoption process developed throughout the research period time. A majority methodology such as MCDM, DEMATEL, BWS, are examined in this topic to evaluate the digital tools or data processing for the transformation. Alkan and Kahraman, explored the most important strategy and criteria, calculated the criteria weights and ranking the alternatives, which finally develop a comprehensive framework of digital transformation in the supply chain. By utilizing this framework, enterprise can navigate themselves in the evolution process and analyze suitable strategy for their digital supply chain. (Alkan & Kahraman, 2022).

Regarding the outcome of the evolution analyzed year-based, the author develop a process for digitalization transformation, fulfill answering partially RQ3 by suggesting one potential research direction which need to be examined further in Figure 9.

Figure 9. Proposed novel digitalization transformation process from author's view point



Source: Author's own creation

Recommendation: (Saad et al., 2023) probed the key influence factor for reconfiguring of Supply chain design by the emergence of digital environment along with mitigating risk level. The research had shed light to one of the hidden spot in the whole transformation process. As most of enterprises stuck in entering this environment to enhance their supply chain network's efficiency and responsiveness, this recommended reconfiguring model expanded new approach realms for them. One paper from Mahmood, Rehman, and Naeem questioned the challenge of selecting the finest strategy of the Supply chain digital transformation for organization and later using the Multi-attribute decision-making model (MADM) procedure to assess the strategy (Mahmood et al., 2023). However, the recommendation review has not developed much with one to two papers in the database, thus any recommendation approach should be reviewed more in some other kinds of organizations as well as the digital platforms to reach further maturity level of the field.

Consultation and decision making: The journals had a tend to combine data science and decision science in any model or system in this topic. Reis and Saraiva, contributed to the research world by his conceptual framework on a Data-driven Process Systems Engineering and Process Analytics, which support a good decision-making workflow (Reis & Saraiva, 2022). Similarly, (Fagundes et al., 2020) also had a literature review in decision science to deal with supply chain disruption delving into a supply chain risk management area: three groups of risk decision support models and seven future research with additional insight associated with data analysis, data management, data validation, etc.

4.3. Red sector, smallest occupation with only around 13 articles in Socpus and WoS. Nevertheless, these papers come with the highest quality and closest to the author research aim, which some can fulfill the research questions. Below Table 3 are some selected literature reviews in red sectors.

Table 3. Selected research papers answer the author research question

Literature	Outcomes	Limitation
(Liu et al., 2023): Leveraging digital capabilities toward a circular economy: Reinforcing sustainable supply chain management with Industry 4.0 technologies	CAB2IN Framework: This research proposes a novel framework named CAB2IN, which integrates five key digital technologies (Cloud services, AI, Big Data Analytics, Blockchain, and Internet of Things) with the various stages of a product lifecycle (design, manufacturing, delivery, use, and end-of-life). The author relied on these five technology enablers to analyze the digital world.	The paper only presents one case study (the healthcare company's supply chain) to illustrate the application of CAB2IN. The limited case study has not strengthened the framework's generalizability in the diverse industry context nowadays.
(Nitsche & Kusturica, 2022): Modelling Advanced Technology Integration for Supply Chains	The paper critically provided four supply chain modeling approaches, highlighting their strengths and limitations for incorporating digital technologies, going from classic one to the digital one. The evolution of the digitalization shown more clearly by the roadmap for Future Research related to more advanced technology model in supply chains.	The paper analyzes only four existing supply chain modeling approaches, potentially missing other relevant models
(Addo-Tenkorang et al., 2023): Industrial Transformation Roadmap for Digitalisation and Smart Factories: The Danish SMEs Model	This journal proposes a transformation roadmap for Danish SMEs to transition to smart factories, addressing the fuzzy challenges for SME to adopt Industry 4.0 and digital evolution, while others only focus on large corporates.	The potential of the conceptual framework in other countries can be wondered by fellow scholars and researchers.
(Perano et al., 2023): Embracing supply chain digitalization and unphysicalization to enhance supply chain performance: a conceptual framework	This research proposes a novel three-dimensional conceptual framework to analyze the relationship between digital technologies, business processes, and supply chain performance. Each dimension is interconnected to the	The model is one-way forward, which each dimension includes a wide range of variables. The paper can consider the interconnection among variables and the mapping of the variable from this

	author's framework in Figure 7, which can be a literature review for author to develop and rely on.	dimension with the variable from another dimension. Also there is no study for the direction of three dimensions interaction.
(Frazzon et al., 2019): Toward Supply Chain Management 4.0	The paper consolidates a historical review of Supply Chain Management (SCM) concepts, tracing its evolution to the current stage of SCM 4.0. The author can retrieve the evolution information from 1780 to 2020, with detail applications and events from Industry 1.0 to Industry 4.0, Logistics 1.0 to Logistics 4.0 and SCM 3.0 to SCM 4.0.	The research was carried out in 2019, so the database has not been updated after 2020, and limit to only Scopus source.
(Casella et al., 2023) Cases of application of blockchain on the supply chain: a literature review	The SLR of the paper provide an overview of the evolution of blockchain in supply chain throughout the year, using the same research methodology to the topic as author's paper.	The narrative summary is limited and the practical applications is not clear.
(Herold et al., 2021) Digitalization in Logistics and The emergence and adoption of digitalization in the logistics and supply chain industry: an institutional perspective	Similarly, as Frazzon et al. (2019), the journal offers an overview of the emergence and adoption of digitalization from 1960 to 2020, but with specific actors: different survey countries, research applications; and proposed benefit and outcome of digitalization process.	The research was carried out in 2021, so the database has not been updated after 2021, which decision making and consultation supply chain emerge in recent years.

Source: Author's own creation

5. Future research directions

With the current technology development era, the global supply chain can be immensely fostered as long as the businesses target facilitating digital accessibility to their industry operation, directly responding to any crisis or disruption. The goal of this paper is aiming to examine the evolution of digitalization transformation and Industry 4.0 integration to SCM and technology adoption of enterprises by conducting a systematic literature review. However, the author perceived that the evolution has not reached its comprehensiveness and excursively presented in different applications and different industries, since these populations coming from the researched firms/industries pursued the term "digitalization transformation" and "Industry 4.0" in many segmentations for their SCM. Thus, the future research direction could be delineated in two

following commands: Data collection for empirical viewpoints and process examination for author suggested process in Figure 8. The former approach is conducting deeply analysis from organizations' point of views, which can be retrieved from survey or interview's responds of managers. The latter one is testing the feasibility of the model that could be adopted to digital world, in which the fellow researchers can investigate and evaluate all kinds of factors related to the digitalization transformation process such as enterprise level, country/legal entity level, production line, internal and external environment of the supply chain, etc.

6. Conclusion

In conclusion, looking ahead the future, the evolution of Digitalization transformation and Industry 4.0 in SCM will continue going beyond what can be expected at a rapid pace. The present research paper had immensely proved it throughout the systematic literature review with the database of 284 articles from Scopus and WoS sources by PRISMA method. The PEO framework along with boolean connectors were applied to help for precise keyword selection and organization, which enhances the database search effectiveness. After predefined inclusion and exclusion criteria, the detail analysis of 245 relevant and qualified articles, accounting for 86.26% of the article database, was carried out to fulfill three research questions. The whole process of mapping study and structured literature review had satisfied the research aim to some extent.

From the remaining 245 articles, the author categorized them into three colors corresponding to three research areas: the blue one for practical applications, the orange one for demonstrating the expected outcome (O) in PEO framework, and the red one for directly answering the RQs. Regarding the percentage divided among three categories, it can be seen that there is a few papers that can close the research gap (from the red sector) and a plenty of application or cases can be taken into consideration when analyzing the population (P) and exposure (E) (the blue and orange sectors).

Recalling the RQs listed in the introduction sections, the author can come up with some closing result for each of them:

RQ1. How far has the digitalization transformation developed? This question can be satisfied by the increasing number of articles in the topic and keyword evolution throughout the research period from 2017 to 2024. Additionally, the literature review provides a big picture of transformation in the development of advanced technologies using in practical applications and cases.

RQ2. How do enterprises adopt digitalization and industry 4.0 methods to transform successfully? The success of those organizations entering the digital world can be noticed in some cases which firms invested in digitalization for supply chain management and operation, enabled the benefits of using some key digital tools and utilizing Big data for decision-making model. Nevertheless, it can be denied that to select a finest transformation strategy for organization is still a big challenge to integrate it to the business.

RQ3. What are potential research direction in this area? The future research directions section has proposed some limitations of the presented paper and the author would tackle it by two conceivable paths: collecting secondary data from company points of view and examining the digitalization transformation flow from self-proposed model.

In summary, this systematic literature review emphasizes the development of Digitalization transformation and Industry 4.0 in Supply chain management. By embracing this evolution, organization can position themselves at the forefront of the digital era and drive their sustainable growth in ever-changing market of supply chains. And fellow scholars can utilize this paper for their deeper analysis of this revolution era in any circumstances.

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