

## Article

# Organizational Agility in Industry 4.0: A Systematic Literature Review

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**Abstract:** Agility is the dynamic capability of an organization which helps it to manage a change and uncertainties in the environment. The purpose of this research is to review the literature from the perspective of agility in Industry 4.0. This paper systematically reviews 381 relevant articles from peer-reviewed academic journals in the period of the last five years. The results show that agility is important for an organization to adopt Industry 4.0 technologies as it helps companies to cope with the changes that arise along with the adoption of Industry 4.0 technologies. Further, it also indicates that by adopting Industry 4.0 technologies, companies can significantly enhance their agility capability into various aspects with different technologies. The technologies which enhance the agility are: smart manufacturing, internet of things, cyber-physical system, big data and analytics and cloud computing. On the other hand, important aspects of agility include supply chain, workforce, information system, facilities, management, manufacturing and technology agility.

**Keywords:** Industry 4.0; agility; agile; organizational agility; I-4.0 ecosystem; environment



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## 1. Introduction

The world is about to enter into the era of Industry 4.0 manufacturing and production [1]. This era is dominated by an amalgamation of mechanical and digital technology, which refers to a transformation from machine-dominant to digital- and services-dominant production of goods and services [2]. The Industry 4.0 provides immense opportunities to industries in efficiency of resource utilization and achieving strategic goals [3]. However, a radical change is about to be witnessed in the organization with respect to culture, work system and operations, with immense opportunities to come with implementing and adopting Industry 4.0 [4]. It is supposed that company's external and competitive environment will become more uncertain with wide-ranging adaptation of Industry 4.0 across the different industries [5]. The pressure from areas such as mass customization and managing supply and value chain more quickly and efficiently than it is today will be evident [6]. This kind of external pressure will also influence the resource allocation priority within organizations [7], where companies will be mired with decision constraints to channel resources to a particular chain of value creation and supply, as well as quick designing, testing and commercialization of products and services [8]. Thus, organizations in the Industry 4.0 need to be quick to manage such uncertainties and pressure both outside and within the organization, although Industry 4.0 ecosystem, which refers to a combination of Industry 4.0 technologies adopted by a company, will significantly help in managing such uncertainties and pressure. A dynamic capability will help companies to use Industry 4.0 ecosystem to respond to such changes and pressure quickly and efficiently [9]. The literature refers to such dynamic capability as organizational agility [10].

The organizational agility is defined as a "learned, permanently available dynamic capability that can be performed to a necessary degree in a quick and efficient fashion, and

whenever needed in order to increase business performance in a volatile market environment" [11]. The researchers have long argued about the positive impact of organizational agility on various aspect of business performance [8]. However, agility in the era of Industry 4.0 has a special place [12]. It is claimed that agility provides a necessary capability and guideline to companies to efficiently configure their Industry 4.0 technologies [13], so that the company is able to manage the external uncertainty effectively [14]. The research on the relationship between agility and Industry 4.0 is in the initial stage, but it is gaining pace as organizational agility is positioned as a must-have dynamic capability to realize the full potential of adopting Industry 4.0 ecosystem and to gain and sustain the competitive advantage [15]. Moreover, it is noticed that the agility of organizations can enhance the resilience of the organization, which is defined as the ability of the organization to bounce back from crises due to any internal and external or environmental changes [16]. It is pointed out that as agility is going to be impacted due to the adoption of Industry 4.0, organizational resilience can also be a result of the enhanced agility [17]. Furthermore, it can be noted that the adoption of Industry 4.0 technologies can be a result of the motivation of organizations to develop resilience. For example, the current pandemic situation due to a novel coronavirus pushes various organizations to develop resilience to all kinds of unexpected events [16–18]. Thus, the organizations increasingly look for the adoption of Industry 4.0 technologies as they can offer the organization the ability to become both agile and resilient. Moreover, the contemporary organizations strive for the corporate sustainability performance [19], where the drivers and motivations for aligning business goals with sustainability are customers, government regulations, environmental activists and suppliers [20]. There are various measures of performance on sustainability goals, but triple bottom line (TBL), which refers to social, economic and environmental performance [21], is perceived as a very important and effective one [22,23]. Reporting on the measures of TBL, a problem can be posed [24] as its measures are dynamic in nature, which requires the organization to be flexible and innovative [25]. Therefore, it is noticed that agility in the era of Industry 4.0 can provide organizations with dynamic capability, flexibility and innovation to successfully plan, organize and manage their corporate sustainability goals from social, economic and environmental perspectives [26,27]. Therefore, the purpose of the current research is to systematically review past research which has studied the relationship and context of organizational agility within the Industry 4.0 and its ecosystem.

Previous researchers have systematically reviewed the literature on both Industry 4.0 and organizational agility, separately. Most of the systematic studies in the context of Industry 4.0 address issues and current states of Industry 4.0 technologies, innovation and development [28–31], and the context of drivers, transition and application of Industry 4.0 technologies [32]. The researchers have also investigated the issues of Industry 4.0 along with lean management and manufacturing [33], digitization and automation of manufacturing, supply chain and other technologies [34]. Although, agility has been reviewed systematically with Industry 4.0, but under the framework named lean, agile, resilient and green (LARG) [35]. Therefore, a gap in the current literature exists which calls for developing a holistic view of organizational agility in the era of Industry 4.0. Thus, the current research shall try to answer questions such as, Q1: What is the current state of knowledge on organizational agility in Industry 4.0? Q2: What is the role of Industry 4.0 technologies in organizational agility? Q3: What is the future research direction in the scope of the agility of organizations in the context of Industry 4.0?

The adoption of Industry 4.0 ecosystem presents a change management challenge to the organization. The adoption of Industry 4.0 ecosystem will significantly change the culture, work system and operation of organizations. Therefore, in the literature, it is argued that, to cope with such change with adoption of technologies, organizations need to have a degree of flexibility and agility [10]. Thus, the objective of the current research is to review how the existing dynamic capability of agility is helping organizations to adopt and cope with such changes. Secondly, it is also argued and suggested in the literature that by adopting the Industry 4.0 ecosystem, organizations can also significantly enhance their

dynamic capability of agility [15]. Furthermore, it is argued that by adopting the Industry 4.0 ecosystem, aspects of agility will also change [9]. Therefore, the current research reviews the literature and identifies different aspects of Industry 4.0 in terms of dimension, enabler group and capability, and also reviews how each technology of Industry 4.0 is contributing to each aspect of organizational agility.

The paper is organized as follows: Section 2 focuses on the description of the research methodology. Section 3 illustrates descriptive statistics referring to year-wise publication, highly contributing papers, authors, journals, publishers, databases, countries and network analysis. Finally, Section 4 presents a discussion and Section 5 concludes the paper.

## 2. Materials and Methods

The review of literature is considered to be a basic building block of any research work [36]. It is the review of literature which helps a researcher to frame a question and develop a logical answer [37]. The undertaking of a review of the literature needs to be such that it helps to identify the critical gaps and questions which exist in the field of study [38], and answers to such research questions can help to contribute to the evolution of the field of research and particular theory [39]. Therefore, it is necessary that a methodology through which a review of the literature is undertaken and analyzed addresses the matter of contribution to the field of study and relevant theory and constructs [40]. Thus, many researchers, such as [41,42], have provided an effective guideline on developing a methodology of reviewing literature that helps to fulfil this purpose. It is also observed that such methodology of reviewing literature is being followed by others [43,44]. The current systematic review of the literature follows guidelines established within the literature. The following elements best describe our methodology, such as justification of the choice of keywords and search strings, limitation criteria and quality assessment.

### 2.1. Selection of Databases

In the current research, for the purpose of the identification of relevant literature to be systematically reviewed, we have selected the research databases Web of Science, Scopus and Google Scholar, as widely suggested [45]. These databases are considered to be imminent as they have indexing of peer-reviewed journals in our field. The research articles are published by recognized publishing houses, such as Emerald Insight, Springer, MDPI, Sage and Taylor and Francis, among others.

### 2.2. Identification of Keywords and Search Strings

The variety of relevant keywords were first identified and listed, and secondly, search strings were developed from identified keywords, which have been used to search and track down the literature from these databases. For the identification of keywords, the previous literature review papers on both Industry 4.0 and agility have been referred to [28,46], and such papers provided positive direction in this regard. Table 1 provides a brief overview of the keywords and search strings used.

**Table 1.** Keywords and search strings.

No	Agility	Industry 4.0
1.	Agility	Industry 4.0
2.	Organizational agility	Fourth industrial revolution
3.	Customer agility	Industrial revolution 4.0
4.	Supplier agility	I 4.0
5.	Manufacturing agility	Industry revolution 4.0
6.	Distribution agility	

### 2.3. Results of Search

The results of running keywords and search strings into the databases yielded 359 results, which included journal papers, conference papers and proceedings and book chap-

ters. It was made certain that the maximum amount of relevant literature needed to be extracted using different keywords and search strings was reached, which are mentioned in Table 1. Other kinds of publications, such as editorial notes, white papers and commentaries, were excluded to ensure that only relevant and academic literature was searched and considered for the current systematic review.

#### 2.4. Inclusion and Exclusion Criteria

The results of searching the databases were checked against the inclusion and exclusion criteria. The inclusion criteria included whether any of the keywords of agility and Industry 4.0 mentioned in Table 1 above were used in the topic line, abstract or keywords of particular papers. The total number of articles resulting from the original search was 381, and after applying the inclusion and exclusion criteria and removing the duplicates, 95 articles were included for the review and analysis.

#### 2.5. Quality Assessment

There were 21 articles about which there had been some considerable doubts as to whether these articles were (ir)relevant and could be included in the current systematic literature review. Therefore, to ensure inclusion and exclusion of such articles, qualities of these articles were assessed by reading their introduction and conclusion sections. The articles that clearly stated that they studied the phenomena of Industry 4.0 along with agility were included in the current review. The result of the quality assessment showed that 14 articles out of 21 were deemed relevant and 7 articles were completely irrelevant. Therefore, the total number of articles included in the systematic literature review was 109.

### 3. Descriptive Statistics

The extracted and sorted literature was applied with the indices of descriptive statistics for the purpose of describing the numerical properties of literature to be reviewed systematically. The descriptive statistics properties are helpful in understanding the ongoing academic and research work regarding the agility in the age of the fourth industrial revolution.

#### 3.1. Year-Wise Publication

The year-wise publication rate within the field of agility and Industry 4.0 showed a sharp increase from the year 2016 to 2018, and a drastic increase from 2018 to 2019, as shown in Figure 1.

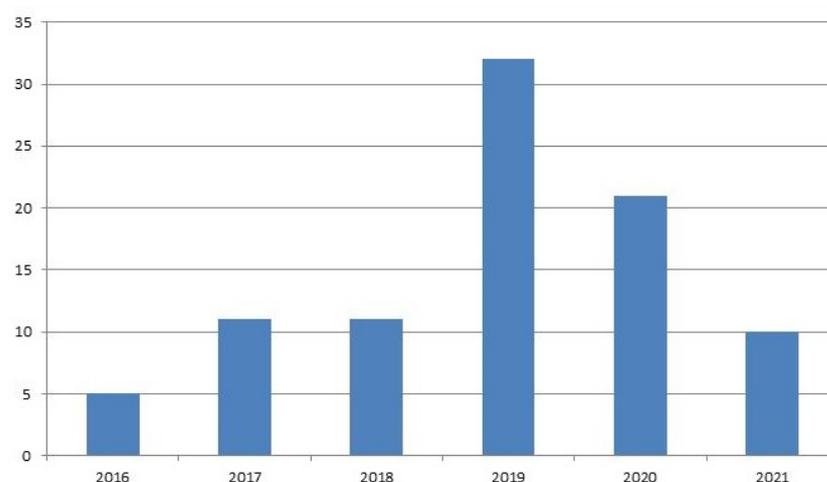


Figure 1. Year-wise publication trend.

The year 2019 reported more than 30 items articles in the single year. The year 2020 observed a decline in the number of publications as compared to 2019. However, this trend

seems to be on track to reverse again in 2021, as within four months, the year 2021 achieved a sharp increase in publications, accounting for up to more than 10 articles. Therefore, it can be predicted that by the end of the current year (2021), there will be a higher amount of publications within the field of agility in Industry 4.0.

### 3.2. Highly Contributing Papers and Authors

Table 2 shows a list of 10 research papers and authors whose academic work highly contributed in the area of agility and Industry 4.0, on the basis of the number of citations. As it can be noticed, the paper written by [47] in 2016 has received the highest amount, i.e., 295, of citations at the time of writing.

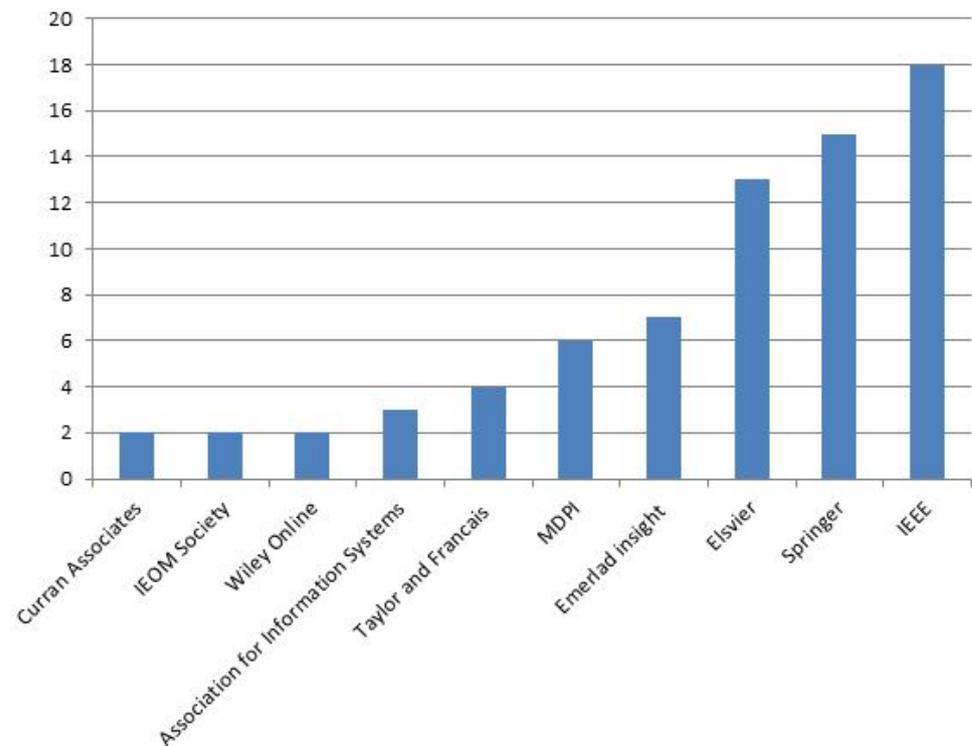
**Table 2.** Highest citations per paper.

Title of Article	Year	Authors	Citations
Software-Defined Cloud Manufacturing for Industry 4.0	2016	Thames, L., Schaefer, D.	295
Reconfigurable Smart Factory for Drug Packing in Healthcare Industry 4.0	2019	Wan, J. et al.	52
A big data-enabled load-balancing control for smart manufacturing of Industry 4.0	2017	Li, D. et al.	51
CASOA: An Architecture for Agent-Based Manufacturing System in the Context of Industry 4.0	2017	Tang, H. et al.	51
A bi-objective model in sustainable dynamic cell formation problem with skill-based worker assignment	2016	Niakan, F. et al.	48
Collaborative service-component integration in cloud manufacturing	2018	Moghaddam, M., Nof, S.Y.	46
Transformative sustainable business models in the light of the digital imperative—a global business economics perspective	2018	Brenner, B.	26
Working life within a hybrid world—How digital transformation and agile structures affect human functions and increase quality of work and business performance	2017	Bauer, W., Schlund, S., Vocke	23
Leadership 5.0 in Industry 4.0: Leadership in perspective of organizational agility	2019	Akkaya, B.	21
Incorporating social sensors, cyber-physical system nodes, and smart products for personalized production in a social manufacturing environment	2017	Ding, K., Jiang, P.	21

### 3.3. Contribution of Publishers

Figure 2 shows the contribution of various publishers in publishing the research and academic work in the area of agility and Industry 4.0.

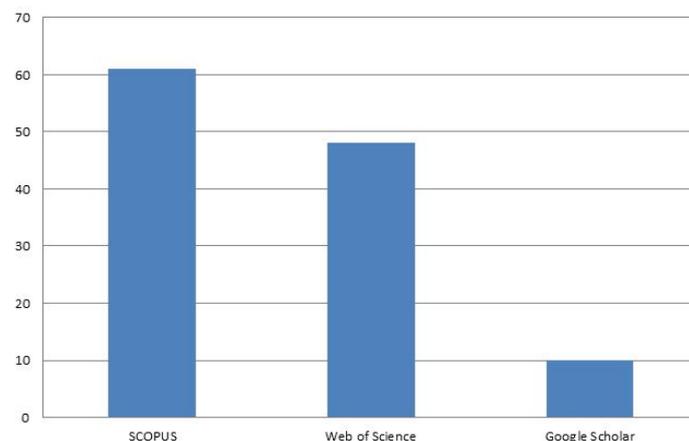
The descriptive statistics show that the top five publishers in the area of agility and Industry 4.0 include: IEEE, Springer, Elsevier, Emerald Insight and Multidisciplinary Digital Publishing Institute (MDPI). They published 59 papers, which constitutes more than 50% of all analyzed papers.



**Figure 2.** Contribution of publishers.

### 3.4. Contribution of Databases

Figure 3 shows the contributions of different databases in collecting and maintaining the data regarding the research and academic work in the area of agility and Industry 4.0.

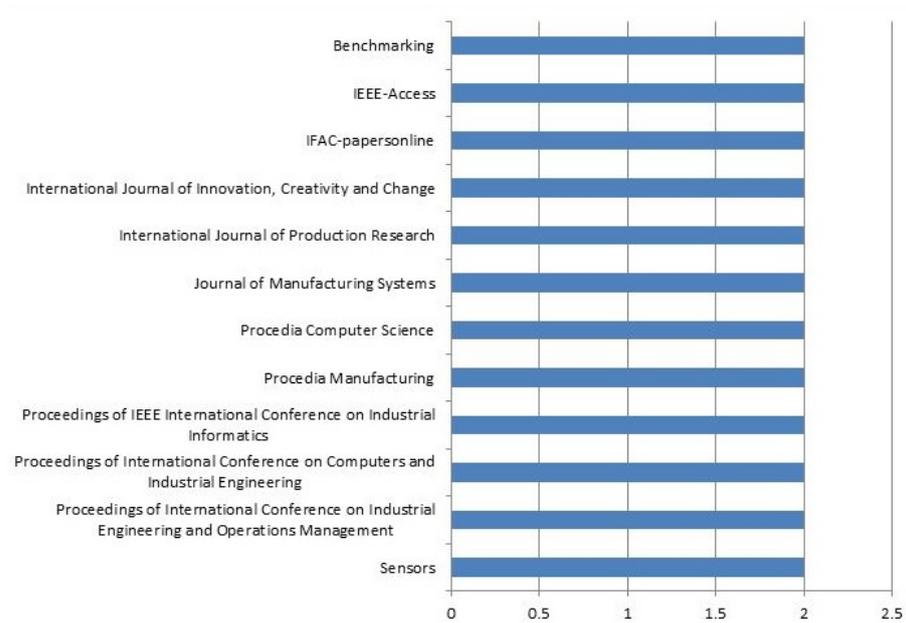


**Figure 3.** Contribution of databases.

The current research employed the databases Web of Science, Scopus and Google Scholar. According to the descriptive statistics, Scopus takes a lead in publishing the most research in the area of agility and Industry 4.0. It should be noted that Google Scholar referred to in the case of information on papers from Scopus and Web of Science is incomplete, inadequate or ambiguous.

### 3.5. Contribution of Journals

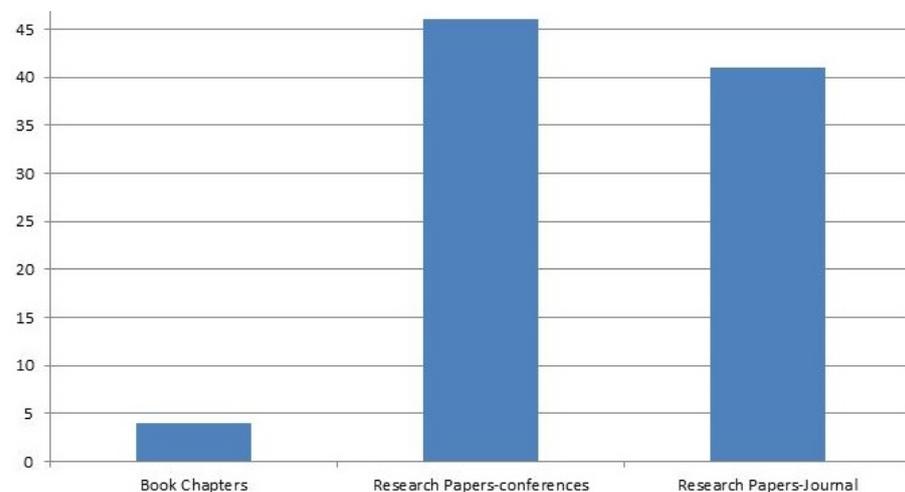
The research on agility in Industry 4.0 is scattered across different journals, conferences and book chapters. Figure 4 shows journals and conferences reporting more than 1 contribution.



**Figure 4.** Contribution of journals and conferences.

### 3.6. Type of Publication

The literature extracted from the previously mentioned research sources contains different types of publications in the area of agility and Industry 4.0, such as journal papers, conference papers and book chapters (Figure 5).

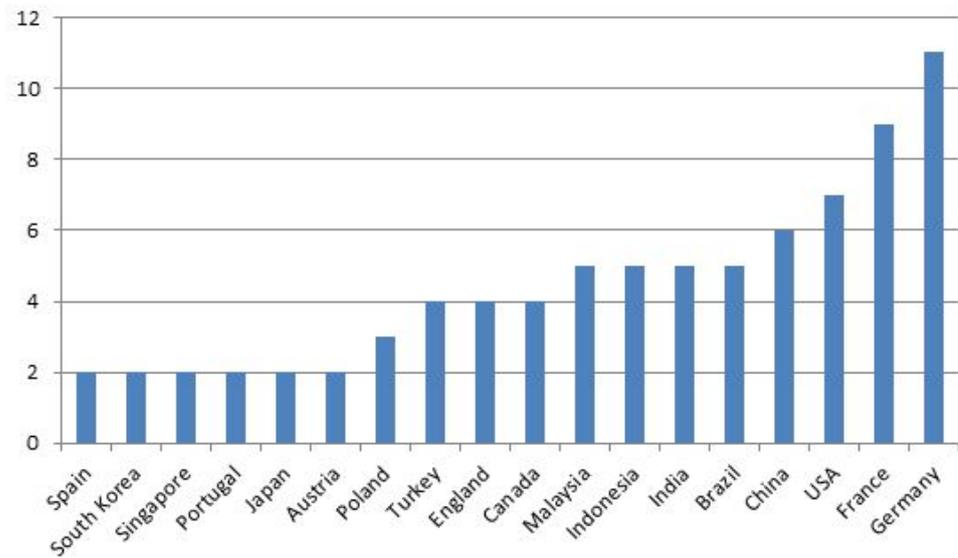


**Figure 5.** Types of publication

As it can be seen in the figure, the conference papers take a lead by publishing 46 full papers, whereas there are 41 journal papers. Only 4 publications were published as chapters in books.

### 3.7. Contribution by Country

The authors' affiliation to research published on agility in Industry 4.0 (Figure 6) shows that most of the authors came from Germany (11 articles), followed by France (9), the United States of America (7) and China (6 articles).



**Figure 6.** Contribution by country.

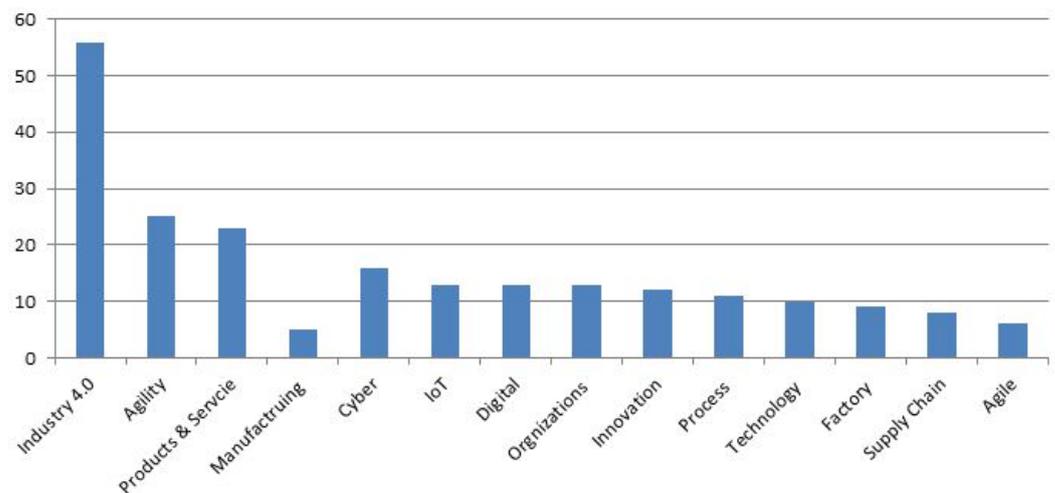
The contribution of the authors from Brazil, India, Indonesia and Malaysia is 5 papers per each country. Moreover, there were also some authors from Canada, Turkey and England who contributed to this field by writing 4 papers, followed by Poland with 3 papers and various other countries who contributed 2 articles. Figure 7 illustrates the research publication distribution on a map. Its results clearly show that Europe is the top research area of Industry 4.0 and agility.



**Figure 7.** Map of contribution by country.

### 3.8. Keyword Statistics

The keyword lists used in each paper provided by the databases were extracted from all of the papers for further analysis. For this aim, IBM-SPSS was used to generate the keywords statistics. In these statistics, the keywords which were repeatedly used or used more than once were included. Figure 8 shows the final results.

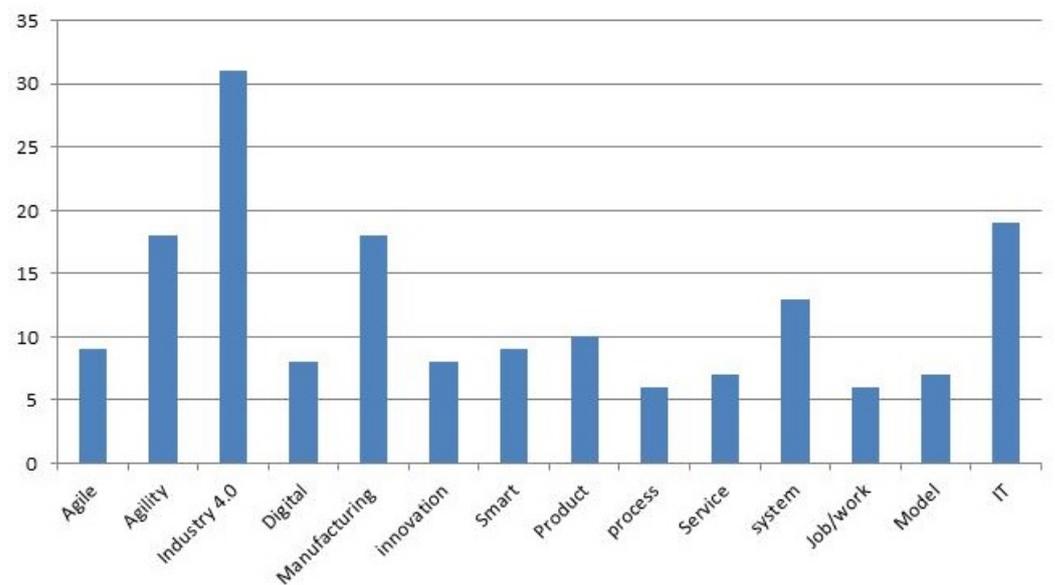


**Figure 8.** Keyword statistics.

The “Industry 4.0” remains the most popular keyword, followed by “Agility”. The other keywords, which were repeatedly used along with Industry 4.0 and Agility, included: “Product and Services”, “Manufacturing”, “IoT”, “Cyber and Physical system”, “Digital”, “Innovation” and others.

### 3.9. Title Keyword Statistics

The title keyword lists used in each paper were extracted from the papers manually. We used IBM-SPSS to generate the title keyword statistics. Figure 9 shows the results of such descriptive statistics.

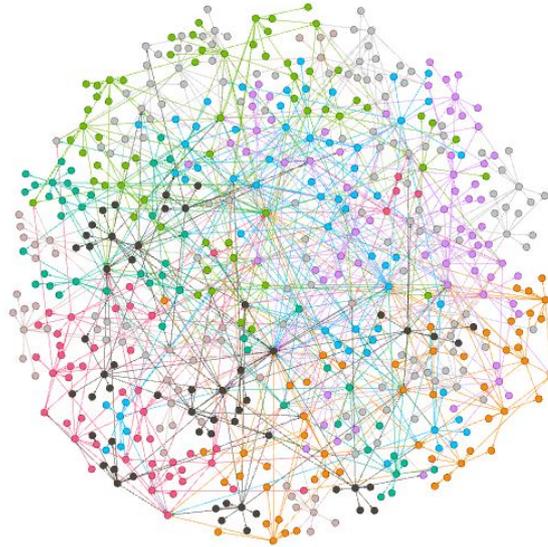


**Figure 9.** Title keyword statistics.

The “Industry 4.0” remains the most popular keyword, followed by “Agility”, in the titles of the papers. The other keywords which were used together with Industry 4.0 and Agility were: “Manufacturing”, “IT”, “System”, “Digital”, “Product”, “Agile”, “Smart”, “Innovation”, “Digital” and “Model”. It was also possible to identify such words as “telecommunication 4.0” and “leadership 4.0”.

### 3.10. Network Analysis

The current research led to perform a co-citation analysis and generate the map of co-citation shown in Figure 10.



**Figure 10.** Co-citation map.

In order to achieve the map, we applied a Gephi tool. The obtained co-citation map shows that the nodes with overlapping networks are papers which contain the most co-citations in the extracted literature. Therefore, the current map shows that nodes in the middle of the map are the papers with the most overlapping networks. Thus, it can be said that these are papers which report the most co-citations in the systematic review of the literature.

## 4. Review Discussion

### 4.1. Industry 4.0 and Agility

The literature reviewed on Industry 4.0 shows that the authors from across different areas of research tend to define Industry 4.0 in diverse ways [48]. Thus, in the current study, we follow the definition of the Industry 4.0 concept as an industrial infrastructure which tends to embed different technologies, such as machine, electrical, operational and information technology, with the purpose to create efficient, effective and sustainable products and services. The key technologies, which create such an infrastructure, are discussed in the proceeding sections.

The literature shows that agility is an important element in I4.0 infrastructure. Some studies argued that organizational agility is a consequence of implementation of I4.0 technologies [49]. However, other studies showed that implementing the I4.0 technologies is all about bringing important changes in the organization, culture and work setting. Thus, agility is a necessary requirement to successfully implement I4.0 technologies and integrate the organization with the fourth industrial revolution environment [50]. Therefore, it is concluded here that agility is an important aspect of I4.0 industrial infrastructure. For organization to successfully integrate with the I4.0 environment, implementing agility and technologies will go hand in hand [51].

### 4.2. Agility in Organization

The (organizational) agility is defined as the capacity, ability and flexibility of an organization to adopt quickly to a changing external environment and landscape [11]. The Industry 4.0 ecosystem, referred to as implementation and adoption of I4.0 technologies to leverage a competitive advantage, presents significant external challenges faced by organizations [52]. Agility is often referred to as an organization's (dynamic) capability to

gain and leverage the competitive advantage by adopting and implementing I4.0 technologies [11]. Further, it is argued that I4.0 technologies are themselves agile in nature. The organizations will significantly achieve agility in terms of supply chain, manufacturing and workforce, etc. [9,49,53]. Other researchers claim that organizations which are agile in nature, and quickly and easily adapt to external changes, are going to be the first to adopt and implement I4.0 technologies and leverage the competitive advantages provided by Industry 4.0 ecosystem. These studies point out that Industry 4.0 ecosystem is highly sophisticated as it requires significant reconfiguration in terms of organizational culture, facilities and management. Therefore, implementing Industry 4.0 ecosystem would present a challenge for the organization in terms of reconfiguration of culture, management and facility. The organization with agility as a (dynamic) capability will be able to quickly reconfigure and pave a smooth way for adopting and implementing I4.0 technologies [54–56]. Thus, a debate exists in the literature as to whether agility is a driver in the implementation of I4.0 or a consequence of it.

#### 4.2.1. Agility as a Consequence

The findings of the current review show that agility is being considered by some authors as a consequence and a result of implementation of I4.0 technologies [57,58]. The researchers who theorize agility as a consequence of I4.0 technologies' implementation conclude that technologies such as industrial internet of things, cloud computing, machine to machine communication, Cyber-physical system and big data increase an organization's ability and flexibility to manage uncertainty in consumer demand and supply chain [59,60]. This review allowed us to find that due to implementation of I4.0 technologies, organizations achieve agility in the shop floor, organizational facility, workforce and management [61,62].

The novel I4.0 technologies increase the ability and flexibility of organizations to meet any uncertainty in the value and supply chain. These technologies will significantly improve organizations' decision-making regarding new product development and testing. Thus, I4.0 will help organizations to respond to competitive challenges quickly through new products' development and placement. Further, I4.0 technologies will make shop floors more lean, increase communication between different functional units and amass and analyze more data on market needs and wants. Therefore, organizational staff at the manufacturing and management levels will find it easier to respond to changes in the external environment by allocating necessary resources without disturbing current functions.

#### 4.2.2. Agility as a Driver

The current review also shows that an organization's existing agility is being considered by other authors as a driver for the companies to adopt I4.0 technologies [10,14]. In contrast to a driver, some researchers also define agility as just one prerequisite for companies to adopt I4.0 technologies [13,15]. The researchers who consider agility as a prerequisite or driver conclude in their findings that Industry 4.0 ecosystem will bring enormous changes into the organization with respect to the work-setting, management, culture and dealing with customers and suppliers. The existing or traditional structure of organizations will be obsolete and incompatible with the Industry 4.0 ecosystem [63–65]. Therefore, for smooth operation and working of I4.0 technologies, some necessary changes in work-setting, management and culture are required by the organization. The research reviewed in the current study theorizes that effective change management and orientation systems can bring about such changes in the organization with respect to work-setting, management and culture, which pave the way for successful implementation and adoption of I4.0 technologies. The effective change management structure is only possible for organizations which already have the (dynamic) capability of agility [66–68].

Considering the above, as it is shown in Figure 11, having agility as a prerequisite is necessary before implementing and adopting the I4.0 technologies because it helps organizations to smoothly transition towards Industry 4.0 ecosystem.

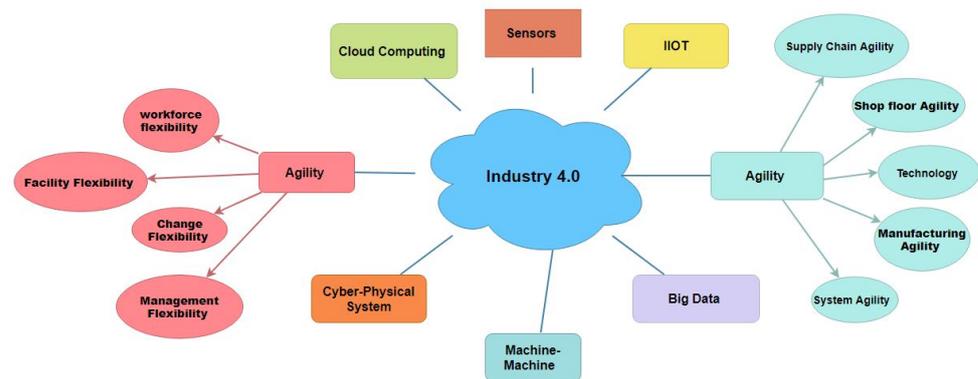


Figure 11. Agility as a consequence and a driver.

Further, the organizations which have achieved some level of agility in their operations are more energetic in adopting and implementing I4.0 technologies. It can be concluded that agility remains their core and competitive advantage [69]. By adopting I4.0 technologies, organizations want to enhance their agility further and sustain their competitive advantage.

#### 4.3. Key I4.0 Technologies of Agility

The current research briefly reviewed the technologies in the literature which are being used by the different companies throughout the different industries to increase and introduce agility within the organizations. Here, we provide in-depth reviews on both aspects and dimensions of agility and I4.0 technologies [11,28], as discussed in Sections 4.3.1–4.3.9.

##### 4.3.1. Smart Manufacturing

Smart manufacturing is a computer-aided and integrated manufacturing system which automates the stream of manufacturing activities [70]. The researchers discuss smart manufacturing technologies with respect to agility in the organizations [71,72] as they significantly enhance supply chain [73], workforce [47], process [74], information system [75], organizational flexibility [76], management [77], manufacturing [78] and technology [79] agility in the organizations. Moreover, they provide wide-ranging agility to the companies [80]. For example, the smart manufacturing through technology, supply chain, workforce, information system and manufacturing agility helps companies to meet uncertainty in the demands of consumers [81]. It is concluded that smart manufacturing technologies are also a useful tool to transition companies from traditional to agile manufacturing [82]. Finally, it is concluded that smart manufacturing technologies make facilities or the shop floor lean and agile through technology agility [83]. The management, information system and workforce become highly flexible in undertaking decisions to satisfy customer needs and supplier demands [84].

##### 4.3.2. Cyber-Physical System

The cyber-physical system (CPS) is an important I4.0 technology which controls the interconnection between the computer system and physical system and networking [85]. The CPS is also one of the most important I4.0 technologies which is being used by companies to fulfil their transition goals towards Industry 4.0 ecosystem [86] and increase the agility of company [87]. Our current review shows that CPS is highly effective in creating organizational agility [88]. The results of the literature review show that companies use or can use CPS to develop process [89], information system [90], facilities [91], flexibility [89], management [58], manufacturing [78] and technology [91] agility.

The literature argues that CPS connects and integrates the physical assets with computer programs. The connection and integration significantly enhances the agility of manufacturing and process. The CPS helps companies to automate and quickly shift their manufacturing resources to face any perspective uncertainty. The computation program

used in CPS for integration with physical assets also facilitates the ability of technology through self-learning or use of machine learning. Along with technological agility, CPS significantly adds to facility and information system agility. The automation and integration of machines with computers makes facility of factory more resilient, flexible and agile through leanness. Finally, CPS is a highly important technology of Industry 4.0 ecosystem. The CPS helps companies to increase their agility in a range of activities, which leads them to achieve a dynamic capability of facing any environmental uncertainty around organizations.

#### 4.3.3. Cloud Computing

The cloud computing is referred to as a system resourced with advanced data storage and user capability which does not require any direct human maintenance [92]. In manufacturing it integrates manufacturing resources and capabilities into services by allowing the manufacturing system to operate manufacturing resources and capabilities in an intelligent way [93]. It is referred to as a key technology of Industry 4.0 ecosystem, and especially within manufacturing it helps to transition the companies towards Industry 4.0 [94]. Moreover, it enables to create on-demand, cost-effective and high-quality manufacturing services which can help companies to gain competitive advantages [95]. Cloud computing is increasingly referred to with increasing agility in the organizations [96].

The literature clearly supports a relationship between agility and cloud computing technologies. Our systematic review concludes that cloud computing effectively enhances agility in process [89], information system [97], flexibility [98], manufacturing [66] and technology [79]. Cloud computing makes information systems more flexible and agile by increasing the power of the system and self-management with lower human input. It makes manufacturing more agile through servitization by integrating resources and capability, such as technology, thus making the technology of the company agile as well. Therefore, it is concluded that more and more companies adopt cloud computing technologies to increase agility within organizations [99], as the literature clearly supports the evidence of cloud computing and agility [100].

#### 4.3.4. Big Data and Analytics

The big data is referred to as data of higher volume generated with greater velocity and a higher amount of variety, often referred to in the literature as the 3V's [101,102]. The source of creating such data is due to technologies, i.e., IoT, cloud computing and social media [58]. In the last years, a shift has been observed in the concept, where big data is increasingly discussed along with analytics [103]. The analytics in big data offers companies to extract valuable insight from the data to support decision-making [104]. The studies found that one of the most important advantages the companies gain by using big data analytics is agility [105].

The big data and analytics are important contributors towards the Industry 4.0 ecosystem. Adopting the big data and analytics technologies significantly helps companies to transition towards Industry 4.0 [106]. They contribute to the organizational agility. Given the nature of Industry 4.0 ecosystem, companies rely more upon the data-driven approach of decision-making [107]. The big data supported by analytics brings accuracy in the predictive models of demand and supply [108]. Thus, the predictive accuracy in decision-making, more access to data about consumer and supply trends and internal resource reconfiguration develop a dynamic capability of organizations to increasingly face and address uncertainty in making themselves more agile [105].

#### 4.3.5. Augmented and Virtual Reality

The augmented and virtual realities are two different technologies of I4.0. The augmented reality (AR) refers to technology which further augments or supplements real-world objects using smart technologies such as 3D and other computer technologies [109]. The virtual reality (VR) refers to simulated re-creation of reality virtually, which can be both

similar and different to real-world experience of reality based upon the objective of the VR program [110]. The AR and VR technologies initially started in gaming, retailing and marketing [111], but now they are also used in manufacturing and increasingly considered to be part of Industry 4.0 ecosystem [54]. The AR and VR technologies can significantly enhance the organizational agility [112]. The AR and VR automate the manufacturing and supply chain activities and help a company to create more collaboration with other stakeholders [51]. Controlling activities through AR and VR eliminates a lot of waste, which makes the process leaner. Thus, it is concluded that AR and VR have the potential to make organizations more agile and lean. However, literature reviewed on the role of AR and VR in creating agile organizations is limited. Therefore, it is a future research recommendation to collect empirical data on the role of AR and VR in creating agility in organizations.

#### 4.3.6. Simulation

The technology of simulation refers to the imitation of process or system through the use of models which represent key elements of process or system which are supposed to be imitated [113]. The simulation is considered to be an important part of the Industry 4.0 ecosystem [114], especially in the additive and 3D-printing manufacturing ecosystem [115]. Simulation has important implications towards increasing agility in the organizations, and simulation as a research technique was used by different researchers [116,117]. However, current knowledge is very limited on the impact of simulation on agility. The simulation would make the supply and value chains more lean and agile [118]. Thus, it is necessary to measure the impact of the use of simulation in both the supply and value chains on the agility of the organizations.

#### 4.3.7. Internet of Things Platforms

The internet of things (IoT) is often referred to as the internet of everything or industrial internet of things, which is a technology platform which connects physical objects such as machines with the internet and its platform, including sensors, software and others [119]. The embedding of things with the internet stimulates the process of data collection and enhances the communication between physical objects through the exchange of data over the internet [120]. The IoT is one of the most important parts of Industry 4.0 ecosystem [121], and transitioning from traditional to Industry 4.0 environment requires the implementation of IoT and platforms [122]. Moreover, IoT platforms are also instruments used in enhancing the organizational agility [100] as they increase the agility of organizations with respect to the process [60], information system [91], facility [89], flexibility [71], management [117], manufacturing [61] and technology [79]. The embedding of (organizational) objects with the internet creates communication between them, and these objects start to exchange data among themselves [69], which results in the effective automation in the organization. The connection of objects over internet platforms, subsequent automation and leanness creates agility in the shop floor and process [60]. Furthermore, it makes information systems respond to changes quickly in any uncertainty of such changes in consumer demand [62]. The IoT also makes technology capability and manufacturing systems more agile through rapid communication and creation of more data through different touch points. Such data and subsequent analytics enhance the self-learning process, which makes machines respond to changes quickly [77].

#### 4.3.8. Machine-to-Machine Communication

The machine-to-machine communication (M-M-C) is a direct communication between different machines using any channel of communication, such as wired and wireless. The sensors and meters in M-M-C record and transmit information from one machine to another [123]. The M-M-C is considered to be an important technology of Industry 4.0 ecosystem [118]. Currently, it is used in supply chain and manufacturing with the help of radio-frequency identification (RFID) as a M-M-C tool, which helps to identify and

track tags attached to objects [124]. The automated guided vehicle identifies tags and transports them accordingly in manufacturing and supply chain activities [125]. The M-M-C technology can make the facilities more lean and agile as it increases efficiency, speed and remove hurdles [126]. However, the research on the relationship between M-M-C and agility is highly limited. There are only a few studies in our systematic review which have studied M-M-C in relation to agility. Thus, future research should empirically study such gap in the literature.

#### 4.3.9. Sensors

A sensor is any device which is designed to detect changes and events in its surrounding environment, and which communicates such information to central data storage, typically a computer system [127]. The sensors are considered to be a key part of Industry 4.0 ecosystem [128] as they are used to automate the factory and manufacturing activities [129]. They facilitate to gain knowledge on the stage of production of a specific product and also help to communicate information regarding the state of machinery and equipment and update about the need of maintenance [130]. Although the sensors are an important part of Industry 4.0 ecosystem, their implication on agility of organizations is highly limited [62]. It may be due to fact that the sensors are new in Industry 4.0 [86], and thus less attention is given to the impact of sensors on agility. Therefore, the future research recommendation is to conduct empirical evidence supporting the association between agility and Industry 4.0.

#### 4.4. Aspect of Agility in Industry 4.0

The systematic literature revealed that agility is an advanced capability which allows different industries to gain competitive advantage and sustain their performance in the long term [12,131–134]. It is also confirmed that companies want to build their agility capability through adopting Industry 4.0 technologies [135–137]. However, the authors argued whether adopting the Industry 4.0 technologies increase agility in a dynamic way [138,139], or whether adopting the Industry 4.0 technologies presents a change management challenge [140]. Moreover, it is suggested that the change induced by adopting Industry 4.0 technologies is not ordinary but rather a radical change in culture, structure and operations of organizations [139,141–143]. Thus, only organizations which develop a nascent capability of agility will be better off by adopting Industry 4.0 technologies [107,144–146]. Therefore, it can be concluded that organizations that have agility will be able to adopt Industry 4.0 technologies, and once adopted, the capability of agility will become highly dynamic [144,147,148]. In the following section, the major aspects of agility are discussed with respect to Industry 4.0, as suggested by [147,149–151].

#### 4.5. Agility Dimensions

One of the most important aspects of agility is its dimensions [11]. It is possible to identify the following six dimensions, such as:

- Supply chain
- Workforce
- Processes
- Strategy
- Information system
- Facilities

All of the dimensions mentioned above facilitate to adopt the I4.0 technologies, such as smart manufacturing, cyber-physical system, cloud computing and internet of things.

#### 4.6. Agility Capabilities

According to Walter [11], there are different varieties of agility capabilities. However, in our systematic literature review, we refer only to the capabilities which refer to Industry 4.0, such as:

- Facilities agility
- Flexibility agility

The facilities agility is defined as the ‘ability of manufacturing facility or shop floor to accommodate any uncertain change in the product manufacturing preferences’. On the other hand, the flexibility agility refers to the organizational capability needed to undertake work on different objectives at the same time. In both capabilities, the technologies such as smart manufacturing, cyber-physical system, internet of things and big data analytics are used to increase the facilities and flexibility agility.

#### 4.7. Agility Enablers

The agility enabler groups refer to units of organization which are interested in bringing about an increase of the agility in the organization. The systematic review found the following enabler groups of agility which are studied along with the Industry 4.0:

- Management agility
- Manufacturing agility
- Technology

Management or manufacturing agility enablers are the most important drivers of adopting the Industry 4.0 technologies such as smart manufacturing, cyber-physical system, big data and analytics, internet of things and cloud computing. Moreover, these technologies also increase manufacturing agility further along with facility or shop floor agility. As far as technology is concerned, it is perceived as a unit of organization responsible for the development and adoption of technology and innovation. Thus, it is responsible for and a driver of adopting the Industry 4.0 technologies in the organization. Such adoption of Industry 4.0 technologies enhances the agility of organizational technology. The technology will be able and better positioned to face the uncertainty in the environment.

## 5. Conclusions

The purpose of the current systematic literature review was to study the underlying relationship between Industry 4.0 ecosystem and agility in organizations. For this aim, we considered 381 papers, but after applying inclusion and exclusion criteria, we finally analyzed 91 of them. The results of this investigation showed that the adoption of the technologies of Industry 4.0 can enhance the organizational agility. It would also result in significant changes in culture, operation, supply and value chain. Furthermore, only organizations which have agility as a (dynamic) capability can effectively cope with the changes and become key drivers for adopting such technologies. The results also showed that technologies such as smart manufacturing, cyber-physical system, big data and analytics, cloud computing and IoT help companies to enhance their agility in both value and supply chains. The technologies such as machine-to-machine communication, sensors, simulation and augmented and virtual reality are also critical in enhancing the agility of organizations, but at present, less research has been carried out in this area. Therefore, it is necessary to study the role of these technologies in the agility of organizations.

The current systematic literature review allowed to identify the categorization of agility into dimensions, capabilities and enablers in reference to Industry 4.0 ecosystem. The results show that dimensions of agility include workforce, supply chain, process and information system, whereas agility capabilities include facilities and flexibility, and agility enablers include management, manufacturing and technology. In all of these categories, the technologies such as smart manufacturing, cyber-physical system, big data and analytics, cloud computing and IoT play important roles. However, other categories such as strategy agility, speed agility, competitiveness agility and competency agility are less discussed in the literature. Thus, this gap in the literature also calls for studies on these types of agility, along with and in relation to the I4.0 technologies.

Regarding the organizational resilience, it can be noted that organizations across different industry branches look to develop the dynamic capability of resilience. The

present pandemic in the form of a novel coronavirus has taught organizations that Industry 4.0 technologies are a need of the time. These technologies can not only enhance the organizations' agility but can also boost their resilience to help them to bounce back from crises. Therefore, future research is needed to address the Industry 4.0 technologies from both agility and resilience perspectives.

Lastly, the current research attempted to provide an insight into the relationship of organization and agility and Industry 4.0 ecosystem from the perspective of corporate sustainability goals, especially from the triple bottom line perspective. The technologies of Industry 4.0 help companies to meet their corporate sustainability goals from social, economic and environmental perspectives. Various technologies are designed to address ecological sustainability, causing very low harm. The technologies are also efficient from an economic perspective as they make production processes more lean and agile, which helps companies to achieve their economic objectives such as low costs and higher profits. Furthermore, as organizations become more agile due to the adoption of Industry 4.0 technologies, new economic opportunities, jobs and goods and services are created that can serve the society. In conclusion, it can be stated that the agility of organizations in Industry 4.0 will be highly important to achieve corporate sustainability goals and enhance the ability to report effectively on the TBL perspective.

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