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The Use of Industry 4.0 Tools in the SCM Context

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Abstract-
Industry 4.0 (I4.0) or the fourth industrial revolution is summarized in the fair to move towards a connected universe that is characterized by the digitalization of tools and materials. This change has had an extreme impact on the industrial world. Companies have adopted several new concepts such as IoT, Big Data, Cloud computing and CPS named 4.0 tools. The study's purpose is to examine and evaluate the impact of industry 4.0 on SC (supply chain) sector, affecting its management and way of design. It's proposed that the impact of I4.0 on SCM (Supply chain Management) is huge, promising profits and revolution. The Industry 4.0 Tools are used more by many companies worldwide-enjoying their benefits: improved efficiency and productivity, reduced cost, highly competitive advantages and predict behavior patterns and needs of consumers better than ever.

Keywords: Industry 4.0, IoT, Internet of things, cloud computing, CPS, industry 4.0 tools, SCM

I. Introduction

In our day, supply chain m anagement has become a very important part in the world of the industry. It allows a good follow-up of the production flow from the raw material until the finished product (Rao SK et al , 2021). The development and improvement of companies is related to the development of SCM (supply chain Management) as a whole. Industry 4.0 technologies have played a very important role in the improvement of companies to keep their competitiveness and competition in order to deliver good products to the right customer in the shortest time while meeting the requirements of customers (C.S. Tang et al, 2019). Several industry tools have been used in SCM in order to increase the level of management and competitiveness by betting on the convergence between the physical and virtual world cyber physical system CPS (Gu, J et al , 2019).The purpose of this study is to find out which I4.0 tools are most used by companies in the SCM field to achieve better results than their competitors**,** and to know how smart SCM can increase the industrial trends and challenges and their consequences on the economic aspects of the companies.
The following is the current study research question:
• RQ1 What are Industry 4.0 tools being used in the Supply chain?
• RQ2 What are the tools of Industry 4.0 capable of ensuring the success of businesses by increasing mobility and flexibility?

II. Industry 4.0 tools in SCM

The high level of competition in the industry forces companies to improve their supply chain towards a smart chain. This allows them to make their systems more efficient, more agile, and faster to adapt to the rapidly changing global market (Zhong, Z et al; 2016). Industry 4.0 technologies allow companies to achieve sustainable goals by reducing production time through the organization of the supply chain (Tommaso Gallo et al,2021). The objective is to have a great flexibility to manufacture personalized products of high quality while respecting the customer requirements (Kamble S et al ,2018). There are many Industry 4.0 tools used in supply chain management, in the following section we will mention the most used:

1. **Internet of things (IoT):** The concept of IoT is to connect several devices via an internet connection in order to collect, monitor and interact within the different areas of a company or between a company and its supply chain (B. mehl et al,2018) (Rejeb A et al ,2020). The objective is to track and share information to facilitate real-time planning and control between supply chain processes (M. Ben-Daya et al, 2019).
2. **Radio frequency Identification (RFID):** The technology of identification by radio frequency (RFID) is a system which allows making a follow-up of the intelligent labels by the integration of the sensors with the aim of detection and treatment of the information (Donno et al., 2014). This system allows us to connect a network in order to transmit identification information. The smart labels can replace or complement the wireless sensor network because of their size and their very cost-effective identification system. (Arif, J et al, 2019).
3. **Artificial Intelligence AI:** Defined as the ability of the machines to communicate with humans (R. Toorajipour et al. 2021). Consists in implementing a certain number of techniques aimed at allowing machines to imitate a real form of intelligence. AI describes the set of systems that mimic the cognitive functions generally associated with humans such as learning, responsiveness and problem solving (Russell and Norvig 2016). AI is also defined by the ability to interpret and learn independently from external data in order to obtain specific results through flexible adaptation (Kaplan and Haenlein 2019).

4. **Machine learning:** Machine learning applications in the supply chain are showing how retailers and suppliers work. This branch of artificial intelligence uses data to form an informatics model to adapt to working conditions without the need to program it to do a task. This technology allows the device to self-train over time to have more precision in its algorithms. The process of using machine learning is to improve decision making and reduce defects throughout the manufacturing process (Shahbazi, Z. , Byun, YC. 2021).
5. **CPS:** Cyber-physical systems (CPS) are systems of collaborative computer entities that are connected to the physical world through simultaneous access to data available on the Internet (Monostori, L. 2018). CPSs are characterized as "physical and technical systems whose operations are monitored, controlled, coordinated, and integrated by a computing and communication core" (Rajkumar et al. 2010).
6. **Cloud computing:** Cloud computing is a distribution of tasks in a large number of computer resources**.** The special cloud computing refers to the manufacturers by distributing the computer and the virtualization technique. The purpose of cloud computing is to build a data center to provide data storage, analysis and scientific calculation services by renting methods free of charge or on demand of the client companies (Chen Jun; Ma Yan Wei 2011). The cloud computing system uses several technologies virtualization technology, data management technology, platform management technology in supply chain information collaboration

III. *The integration between I4.0 tools and supply chains:*

As many fields, SCs are taking a big step toward digitization, automation and agility (Monahan & Hu, 2015). , and these could be achieved through the use of Industry 4.0 technologies , The impact of I4.0 can be seen at all stages of the CS processes, as well as in the SCM framework; for example, increased supplier performance through the real-time information exchange and harmonization with suppliers, and smart logistics and vehicle routing platforms, more accurate procurement through continuous flow and higher transparency of products and materials, (Hofmann and Rüsch, 2017; Ghobakhloo, 2018). The growing relevance of stakeholder engagement and increased connection across SC partners require examining the impact of Industry 4.0 enabled technologies on the SC network perimeter. (Tjahjono et al., 2017). Smart Supply Chain is defined by Frank et al. (2019) as an Industry 4.0 aspect that combines digital platforms with providers, distributors, consumer, and stakeholders. Expanding information sharing and synchronization of processes between SC members helps to lowering total expenses costs and improving the overall flexibility and reliability of SCs (Frank et al., 2019; Ghobakhloo and Fathi, 2019). The Increased confidence and deeper relationships between SC partners result from enhanced transparency and coordination within the SC ecosystem (Mussomeli et al., 2016), The adoption of Industry 4.0 technologies lead to end-to-end visibility and real-time asset monitoring to improve overall value chain effectiveness and decrease risks, equipment and SC variables help to enhance the overall global value chain performance and minimize risks (Luthra and Mangla, 2018). Thus, studies that work on this topic from a literature review perspective is needed to support enterprises in creating effective and resilient Industry 4.0-adapted supply chains and rapidly responding to quickly changing technologies and markets (Buer et al., 2018).

IV. Research methodology:

As the primary goal of this study is to evaluate the current knowledge structure of industry 4.0 tools in SCM, we employed a Mayring's method (2004). This method will allow us to make a deep analysis of the collected materials through structural dimensions by theme and analytical categories.

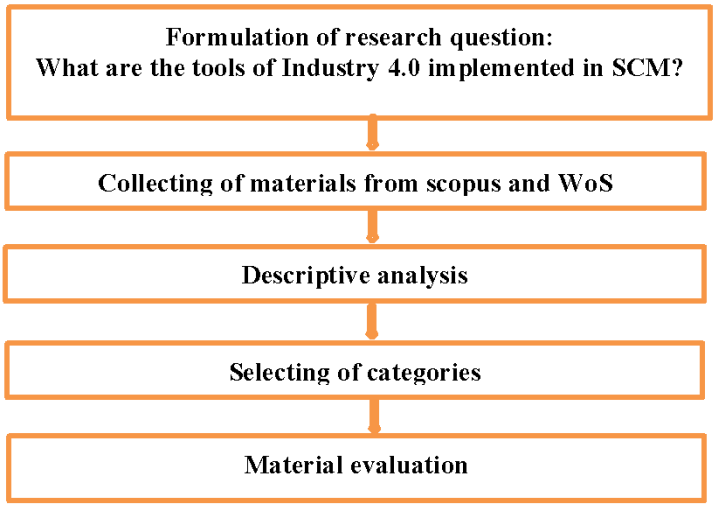

Fig 1: Methodology of SLR. Source: Authors elaboration

V. Collecting of Materials:

Our collection of materials was based on two main databases namely Web of Science (WoS) and Scopus. On WoS the search was started using the subject, on Scopus using "Title, Keywords and abstract". The keywords used on this search are Industry 4.0 and SCM. On scopus, we found 1289 articles related to these keywords, and on WoS 116. This will push us to deepen our research by using the following keywords " Industry 4.0 tools " AND "SCM".
After using our new filter, we found 29 articles on Scopus and only one article on WoS as indicated by the fig 1.

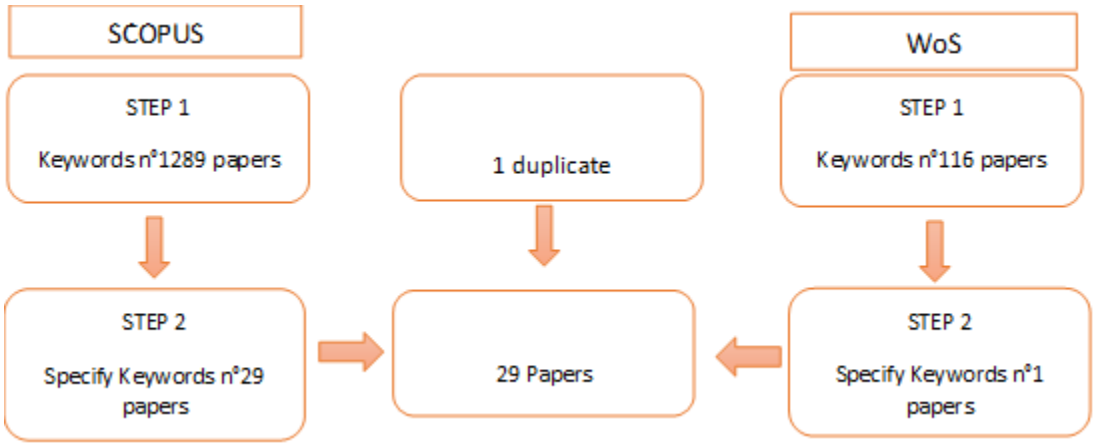

Fig 2: Identification of appropriate articles process. Source: Authors elaboration

VI. Selecting Materials:

In this section, we will show the types used to analyze the selected articles. Some types required a partial analysis, while others required a very deep analysis.
The Table 1 shows, for every types and structural aspect, the envisaged approach.

Table 1: Structural Aspect and analytical Types. Source: Authors elaboration

Structural Aspect	Analytical Types
Number of publications for Years	-2021 -2020 -2019 -2018
Publications for Journal	-Procedia Manufacturing -Journal of Cleaner production -Resources, Conservation and Recycling -Procedia Computer Science -Procedia CIRP
Research methodologies	-Review -Case Study -Focus Group -Others
Country of first Author	-Italy -South Africa -Germany -India -Greece -Taiwan -Iran -Turkey -USA -UK -France -Nederland -Colombia -Ireland -Finland

VII. Results:

After analyzing the date of publication of the selected articles, we notice that the study on Industry 4.0 tools and SCM increase, it has reached its peak in 2021 with 10 publications as shows in the Fig 2.

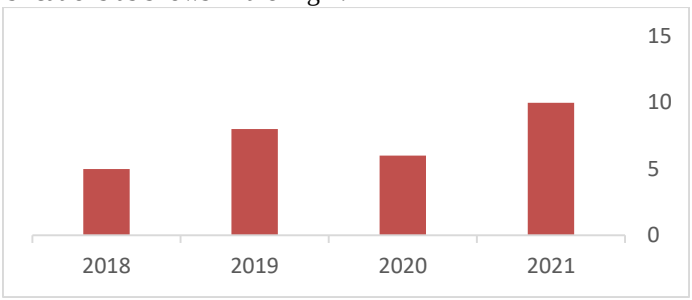

Fig 3: Numbers of publications for years. Source: Authors elaboration

In addition, "Procedia Manufacturing" is the journal with the most publications related to the keywords used in our search, followed by "Journal of Cleaner production"; "Resources, conservation and recycling"; "Procedia computer science" and "Procedia CIRP". For the rest of the journals, we found one article per journal. As observed in the Fig 3.

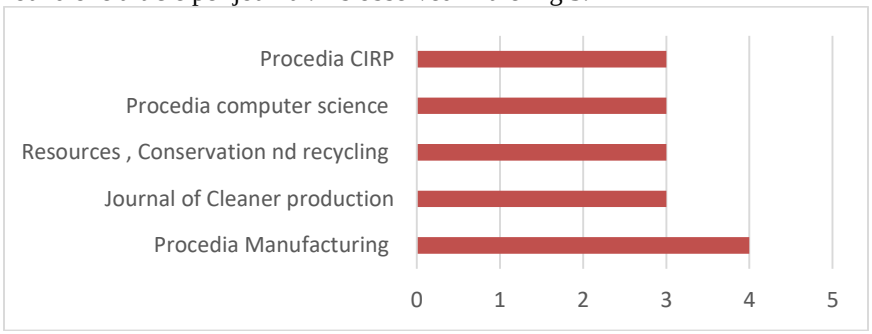

Fig 4: Publications for Journal. Source: Authors elaborations

The 29 articles were divided into four main categories based on research methodologies as shown in the Fig 4 The most used are case studies (56%) and reviews (27%).

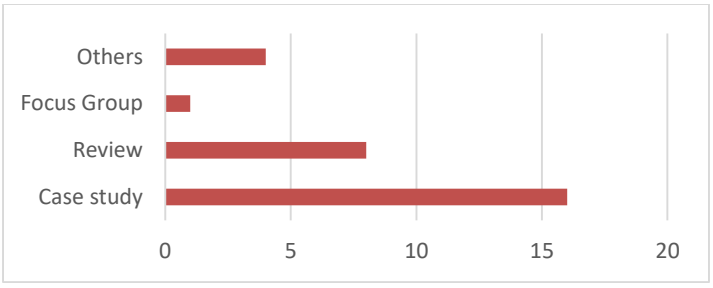

Fig 5: Research methodologies employed. Source: Authors elaborations

The table 2 shows that most articles are with 4 authors with a percentage of 28%.

Table 2: Numbers of authors per publications. Source: Authors elaborations

Authors	1	2	3	4	5	≥ 6	Tot
n	2	4	5	8	6	4	29
%	7%	14%	17%	28%	20%	14%	100%

The figure 6 demonstrates that the geographical origin of the first author, in its majority from Italy with a percentage of 28% followed by south Africa 14%.

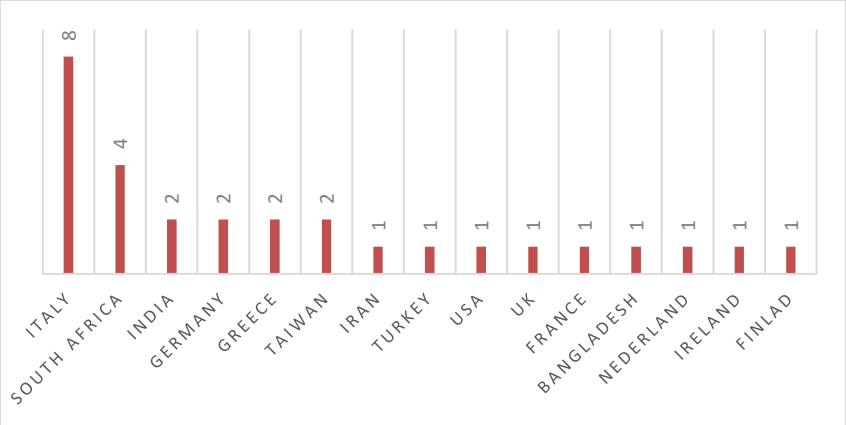

Fig 6: Number of papers per county of the first author. Source: Authors elaborations

Lastly, the table 3 shows the Industry 4.0 tools used in each article and is what they mentioned SCM in their analysis.

Table 3: Authors who talked about Industry 4.0 tools and / Or SCM. Source: Authors elaborations

Authors	I4.0 tools	SCM
Tommaso Galloa et Al (2021)	Big Data, CPS, IoT, Cloud computing.	×
Theofilos D. Mastos et Al (2021)	IoT, Big Data	×
Rafael Diaza et Al (2021)	CPS	×
Devashish Nagar et Al (2021)	Cloud computing, Big Data, Machine learning , CPS, Artificial Intelligence	×
Theofilos D. Mastos et Al (2020)	IoT, CPS, Big Data, IMS, Cyber security	×
E. Manavalan et Al (2019)	CPS, IoT, ERP, Artificial Intelligence	×
Yasmine Sabri et Al (2018)	IoT	×
John Sakwe Bake et Al (2018)	IPS2, IoT, Cyber physical Interaction,	×
Ming-Lang Tseng et Al (2019)	Artificial Intelligence	×
Sara Moghadaszadeh Bazaz et Al (2020)	ERP, CPS, WMS, MES, IoT, PLM, CRM , Big Data	×
Ming-Lang Tseng et Al (2018)	IoT, Big Data	×
Fernando Calvo et Al (2020)	Artificial Intelligence, Big Data, Machine Learning	×
Andrea Benešová et Al (2019)	Cps, Big Data, IoT, Horizontal and Vertical system integration, Cloud computing, Cybersecurity, Additive manufacturing , Augmented reality	×
Neil J.Rowan (2021)	Internet of Things, big data, blockchain, artificial intelligence, robotics, augmented and virtual reality, 3D printing	×
Masoud Shayganmehr et Al (2020)	IoT, BigData, Blockchain, Machine learning	×
Francesco Galati, Barbara Bigliardi (2019)	CPS, Radio Frequency Identification (RFID), Enterprise ResourcePlanning (ERP), Internet of Things (IoT), cloud-based manufacturing, and social product development	×
Arnesh Telukdarie et Al (2018)	IoT, CPS, Big Data	×
Surajit Bag et Al (2020)	IoT, CPS, Big Data, Cloud	×
Felix Schulze , Patrick Dallasega (2020)	Big Data and Analytics, Autonomous Robots, Simulation, Horizontal and Vertical System Integration, Industrial Internet of Things, Cybersecurity, the Cloud, Additive Manufacturing , Augmented Reality	×
Surajit Bag et Al(2020)	IoT, big data analytics, smart objects, RFID ,robotics , Cyber-physical systems, ,cloud computing	×

Surajit Bag et Al (2019)	IoT, artificial intelligence (AI)and machine learning (ML), big data analytics (BDA), blockchaintechnologies, , advanced manufacturing technologies	×
Fabio Fava et Al (2021)	Big data analytics	×
Sri Kolla et Al (2020)	Big data ,CPS , ICT, software, cloud computing, data analytics	×
Reza Vatankhah Barenji et Al (2019)	Internet of Things (IoT), Artificial Intelligence (AI), and cloud computing , CPS	×
Khaled Medini et Al (2019)	CPS ,Big data , Cloud , IoT , Machine Learning , RMS	×
Md. Abdul Moktadir et Al (2018)	Big data analytics(BDA), robotics, simulation, industrial internet of things, cyber-security, cloud computing, additives manufacturing, augmented reality, machine learning	×
Marcello Mariani , Matteo Borghi (2019)	autonomous robots, simulation, horizontal and vertical integration systems, industrial IoTs, cybersecurity, cloud, additive manufacturing, augmented reality, big data, and analytics	×
Francesco Mariatti et Al (2021)	the Internet of Things (IoT), Cloud Manufacturing, Big Data, Cyber-Physical Systems (CPS), Additive Manufacturing	×

As mentioned in the table, all articles talk about at least one Industry 4.0 tool, the tools that are repeated in almost all publications are: IoT, CPS, Cloud Computing and Big Data.
Without forgetting the direct interaction between these tools and the supply chain management which explains the existence of this term in all articles without exception.
Finally, and according to the analysis of these 29 articles, we found that it is necessary to implement the tools of industry 4.0, if we want to progress our supply chain in accordance with the fourth revolution.

VIII. Discussion

Integrating Industry 4.0-tools to SCM would lead to substantial increased performance (Christopher, 2000), by creating a comprehensive approach to supply chain management as a consequence of global supply chain integration, information access, and efficiency across the supply chain (Wang, S et al, 2016). Furthermore, by encouraging process convergence, and introducing novel analytical capabilities (Laureti. T et al,2018), these technologies enable huge significant improvements across particular supply chain operations including such sourcing, manufacturing, inventory management, and sales (Bologa. R et al, 2017), While automation and assistance technologies are becoming more common in supply chain networks, (Patrick Neumann et al, 2020) believes that humans will continue to be a critical aspect in supply chains. As a result, it is developing a storytelling in which the human element is the key character for the integration of Industry 4.0 within industries through the use of various Industry 4.0 technologies (Wittenberg C, 2016).

The use of CPS technology, for example, requires a high level of staff training (Wittenberg, 2016). As a result, in order to increase business efficiency, the man must have a highly creative mindset (Scholer and Müller, 2017).

Without the human aspect, Industry 4.0 cannot be served by technological innovations (Ras et al, 2017). As a result, Industry 4.0 does not mean that the human element would be eliminated from businesses (BRICS Business Council, 2017). Rather, it is a golden opportunity for man to discover new ways of work within companies (Romero D, 2016). Since employees are the innovators, they must be able to match their expertise and attributes to emerging technology (Ansari F et al, 2018).

Table 3 shows that there are several tools (IoT, Big Data, blockchain, etc.) that can be used to implement Industry 4.0 within the supply chain. All the resources outlined in the previous section are designed to give an advantage over the rivals, boost the ability to serve customers and create stronger business partnerships, and open up new revenue streams (Figueiredo MJG et al ,2014). IoT and CPS are at the heart of Industry 4.0, without which no organization could even begin the fourth industrial revolution phase (Gattullo M et al ,2019). And those are the technologies that can be classified as Industry 4.0's “stone tools” (Tommaso G et al, 2021).

Finally, Studies suggest that an interconnected, digital supply chain can lower operational costs by more than 30 percent, reduce lost sales opportunities by more than 60 percent, and even reduce inventory requirements by more than 70 percent (Barreto et al,2017), all while making companies faster, more agile, accurate, and efficient (Kolberg D et al ,2017). Despite transforming to a computerized, digital, and completely integrated supply chain will take time and money (Chong S et al, 2018) the benefits will be enormous. Getting supply chains digital can assist businesses in reaching new levels of operating efficiency and achieving substantial cost savings (Chong S et al, 2018).

IX. Conclusion

The objective of this study is to give a global vision on the use of Industry 4.0 tools in the field of supply chain management SCM. In order to answer our research question, we conducted an analysis of literature related to industry tools and SCM extracted from the Scopus database and web of science. A total of 29 journal articles were selected for the final review. This document is a guide to get a clear idea of the implementation of industry 4.0 tools in SCM.There is still a lack of information on the real use of these tools in SCM in industrial companies. According to the analysis, the use of industry 4.0 tools in SCM has a positive impact on the companies in the countries of the world such as Italy, south Africa, India, Germany. IoT and CPS are the most used Industry 4.0 tools by companies in the SCM area to develop their performance and keep their competition. The results obtained show that the use of Industry 4.0 tools in SCM will allow the company to have good results in terms of productivity, flexibility and reduce total production time. The in-depth analysis of the articles shows that the human factor plays an important role in the integration of Industry 4.0 tools in SCM to have targeted results. In this article we have studied the use of industry 4.0 tools in the whole SCM. In the next research, it is necessary to study the tools used in each SCM component.

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