International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 31 No. 4 Jan. 2021, pp. 820-828

http://www.ijias.issr-journals.org/

The relation between Industry 4.0 and Supply Chain 4.0 and the impact of their implementation on companies' performance: State of the Art

Abdellah Sassi[1], Mohamed Ben Ali[2], Mohammed Hadini[2], Hassan Ifassiouen[2], and Said Rifai[2]

[1]Industrial Engineering, ENSEM School of Engineering, University Hassan II, Casablanca, Morocco

[2]LMPGI Research Laboratory, ESTC High school of Technology, University Hassan II, Casablanca, Morocco

ABSTRACT: Globalization has led to greater income, due to the rapid digital transformation that started to seem so important under the current circumstances because of the Covid-19 virus. To handle the performance issues the supply chains has to become smarter and all the researchers argued on the necessity of having smart SCs.
The automotive industry plays a significant role in the advancement of technology development and its application, despite that, the research field lack of articles that deal with SCM 4.0 in this industry.
The aim of this paper is to present a literature review of Supply Chain 4.0 and Industry 4.0 in the companies also to study the relationship between all these parties, to give us a ground to continue our works consisting the study of the impact of the implementation of SC4.0 on the industrial performance of automotive companies in a developing country such as Morocco.

KEYWORDS: Supply Chain 4.0; Smart Logistics; Industry 4.0; automotive industry; Morocco.

1 INTRODUCTION

All major industries are pushed to explore new ways to digitize their operations due to the current situation in the world because of the pandemic of the covid-19 virus; this digital transformation is considered as a strategic weapon, Industry 4.0 and Smart Factory are the terms that are being used for digital transformation [1].

The automotive industry plays a significant role in the advancement of technology development and its application, despite that, the research field lack of literature, only limited researches and writings that deal with SC 4.0 in this industry [2]. Industry 4.0 is the source of these new technologies, it includes additive manufacturing, advance robotics and cobots, artificial intelligence, augmented reality, human-machine interfaces, machine-to-machine communication, blockchain, internet of thing, cloud stored data, internet of services, digital transformation, autonomous vehicles, drones, etc [3].

Real benefits are given to the plants where the industry 4.0 technologies are implemented, such as performance, improvement, costs and delay reductions, most of these technologies could be implemented in the automotive factories and affect all of the processes within this type of industry such as engineering, production logistics, management etc [3].

According to Zekhnini, (2020) [2] the researches on SCM 4.0 is more Europe-centric at the moment, in fact, this concept is researched in developed rather than emerging countries, the author concluded that the countries which are aware of the importance of the digital transformation are the most likely to conduct and publish studies about this concept, at the same time many underdeveloped and developing countries has a lack of interest in it.

This paper focused only on the state of art of the relation between Industry 4.0 and Supply Chain 4.0 and the impact of their implementation on companies' performance

The remainder of this paper is structured as follows. Section 2 a literature review. Additionally, section 3 Conclusion and perspectives.

Corresponding Author: Abdellah Sassi

2 LITERATURE REVIEW

2.1 INDUSTRY 4.0

Industry 4.0 appeared, thanks to a German effort, for the first time in 2011 before that, the world has experienced four industrial revolutions shown in fig. 1, the term 'Industry 4.0' evokes a fourth industrial revolution and combine a set of technologies and concepts related to the reorganization of the value chain [4].

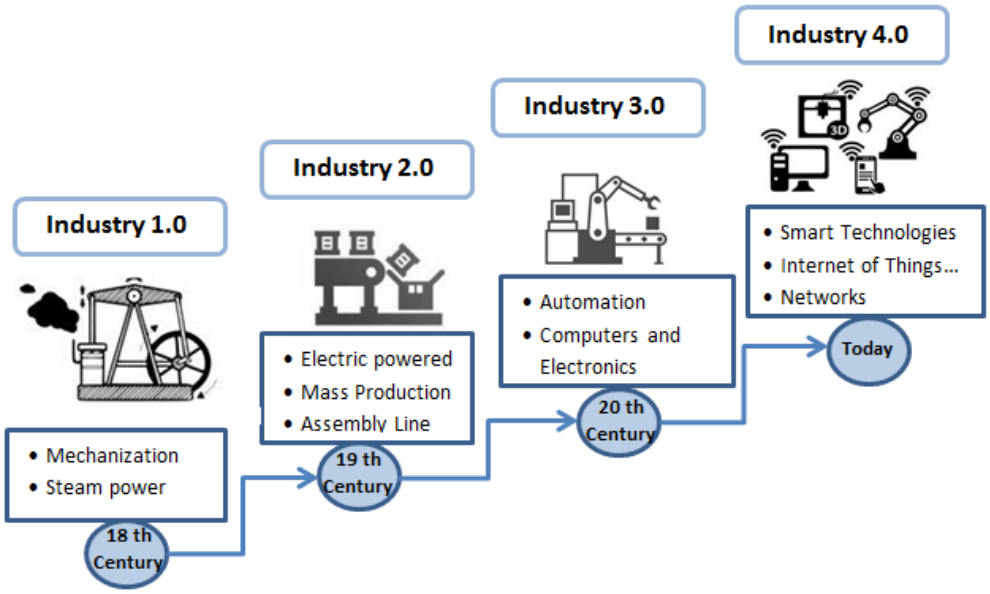

Fig. 1. Industrial revolution

Sources: b.telligent, Cademix.

The following table provides different definitions for industry 4.0 in different scholarly articles.

	Definition	Author/s
1	"Industry 4.0 is the vision of smart components and machines which are integrated into a common digital network based on the well proven internet standards." [5]	Kolberg, D. 2017
2	"Industry 4.0 shall be defined as the embedding of smart products into digital and physical processes. Digital and physical processes interact with each other and cross geographical and organizational borders." [6]	Shmid, R. 2015
3	"The term Industry 4.0 comprises a variety of technologies to enable the development of a digital and automated manufacturing environment as well as the digitization of the value chain." [7]	Oesterreich, T. D. and Teuteberg, F. 2016
4	"Industry 4.0 is the sum of all disruptive innovations derived and implemented in a value chain to address the trends of digitalization, transparency, mobility, modularization, and network-collaboration and socializing of products and processes." [8]	Pfohl H. C. 2015
5	"The convergence of industrial production and information and communication technologies, called Industry 4.0"; "In this publication, the authors name three key components of Industry 4.0: the IoT, Cyber- Physical Systems (CPS), and Smart Factories." [9]	Hermann, M. 2016
6	"Industry 4.0 will involve the technical integration of CPS into manufacturing and logistics and the use of the Internet of Things and Services in industrial processes. This will have implications for value creation, business models, downstream services and work organization." [10]	Kagermann, H. 2013

2.1.1 MAIN INDUSTRY 4.0 TECHNOLOGIES

Table 1. The definition of some enabling technologies

Enabling Technology	Definition	Author/s
Cyber – physical systems (CPSs)	"CPSs achieve the integration of physical and cybernetic networks through the use of multiple sensors, actuators, processing and control units and communication devices." [4]	Douaioui, K. 2018
Internet of things (IoT)	"The Internet of Things is defined by ISO / IEC 30141 as an interconnection infrastructure for physical entities, systems, information sources and intelligent services capable of processing information from the physical and the virtual world, " [4]	Douaioui, K. 2018
Big data analytics (BDA)	"big data refers to the enhanced decision making capabilities, due to the collection and analysis of large data sets" [11]	Astill, J. 2020
Cyber Security	"Emergence of data analysis and sharing technologies have forced users and manufacturers to secure their information" [12]	Holtwert, P. 2013
Cobotif	"Active cooperation with human operators during all industrial Activities" [13]	El-kaime, H. 2020
Painting 3D	"Manufacture of objects from a 3D model through a process in which the layers of materials are laid under precise computer control" [13]	EL-Kaime, H. 2020
Virtual Reality	"Improvement of the real environment of a human being thanks to a virtual environment"	-

We conclude that the industry 4.0 is the use of a variety of technologies, which are integrated into a common digital network, to improve industry by addressing digitalization, transparency, mobility, modularization and socializing of products and processes, so as to deal with the new global challenges such as sustainability, environment, the constantly changing customer demand and the complex and vulnerable business environment.

2.2 SUPPLY CHAIN 4.0

To present the definitions of the supply chain it's necessary to define the concept of "logistics" first:

"Logistics is the setting up of products or raw materials to customers in the best conditions, and when we talk about the conditions, it's mean a minimum cost, a better time, quality and a good delivery" [14]

Table 2. Definitions of Supply Chain 4.0

	Definitions	Author/s
1	"Smart Logistics" is related to planning and control by tools, means and intelligent methods, and the degree of intelligence depends on the applications and methods used" [4]	-McFarlane, D. 2016. -Douaioui, K. 2020
2	"SC4.0 is an advanced framework with interconnected procedures that grows from detached applications to a wide relationship, coordinated and effective between phases of the SC" [2]	-Merlino and Sproge, 2017. -Zkhnini, K. 2020
3	"Supply Chain 4.0 is the re-organization of supply chains – design and planning, production, distribution, consumption, and reverse logistics – using technologies that are known as "Industry4.0". These technologies, which emerged in the 21st century, are largely implemented by firms in high-income countries" [15]	-Ferrantino, M, J. and Koten, E. E. 2016
4	"Smart logistics is based on the use of technology to obtain information on the flow of material then the treat for monitoring, control and other purposes" [4]	-Uckelmann, D. -Douaioui, K. 2020

We conclude that Supply Chain 4.0 is the deployment of the industry 4.0 technologies like the IoT (Internet of things), BDA (Big Data Analytics), CPSs (Cyber – physical systems), RFID (Radio-Frequency identification), etc. in the traditional Supply Chain which allow the reform from linear and static SCs model "Supplier, Production, Distribution and Consumer" to a more

integrated, dynamic model, both presented in figures 2 and 3, the purpose is to solve different problems, gain competitive advantage and enhance firms' performance.

Fig. 2. Traditional Supply Chain model [15].

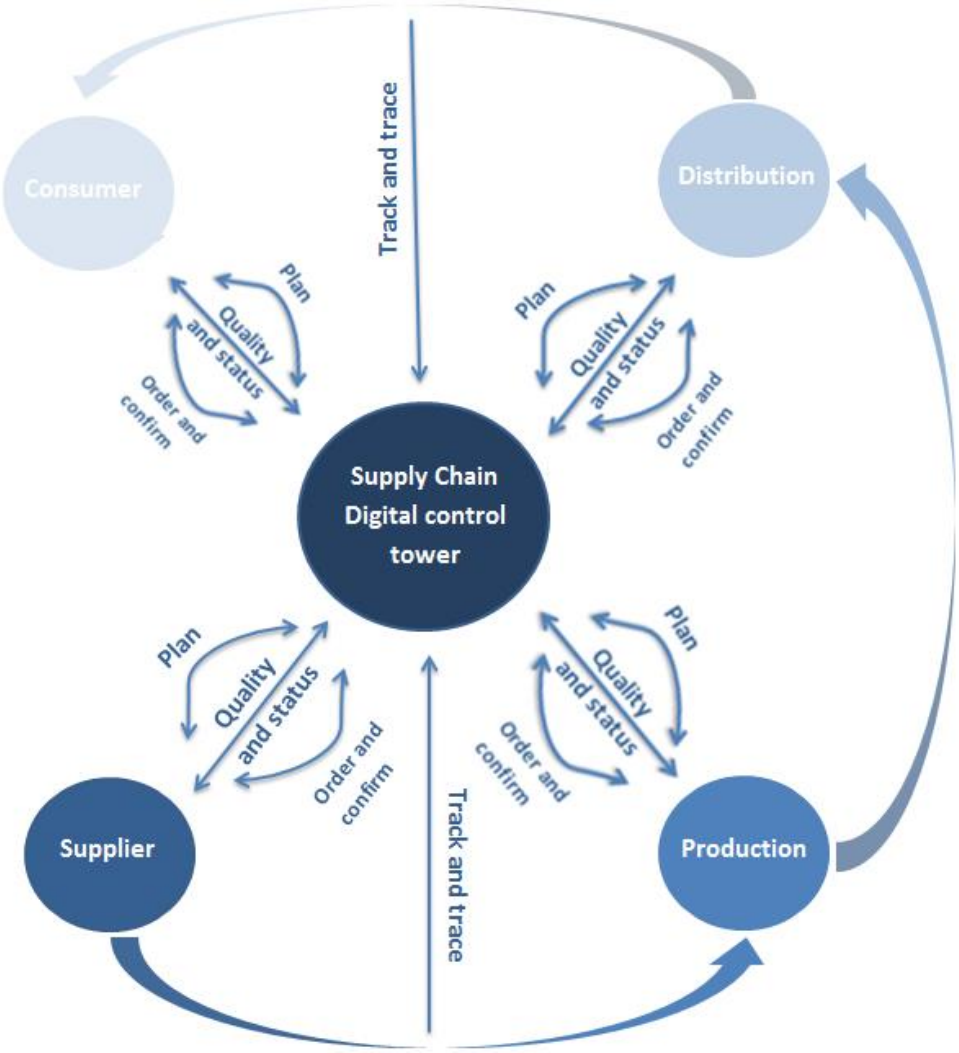

Fig. 3. Integrated supply chain model [15]

2.3 IMPACTS OF INDUSTRY 4.0 WITHIN THE SC 4.0

The opportunities surrounding the rapid digitization of industry (industry 4.0) is trending in supply chain management, these opportunities have allow for supply chains to access, store and process a large amount of data both from within a firm and externally, which allows firms to obtain individualized customer data to personalize the sales process, product design and service [16].

In his study, Tjahjono, B. 2017, [17] presented a preliminary analysis of the impact of industry 4.0 on SCM and provided a thought towards Supply Chain 4.0, the study includes only four functions within a supply chain, i.e. Procurement, Warehouse, Transport Logistics and order fulfillment. The results showed that the order fulfillment will be the most affected area by

introducing the technologies of industry 4.0, 53.84% of the impact will be opportunities, the reminders could be opportunities or threats, moving to transport logistics that has 61.54% of impact as opportunities, 6.69% threats and the reminders can be both. About Warehouse, 66.6 % can be opportunities and the rest can be both. Finally, the procurement function, 71.43% are opportunities and 28.57% being opportunities or threats.

On other studies cited by Fatorachian, H. and Kazemi, H. 2020, [18], the potential impact of industry 4.0 technologies and key enablers on supply chain performance is shown in and also the impact on each of the four key supply chain processes performance, i.e., Production, procurement, logistics and retailing, has been revealed in

Table 3. The potential impact of industry 4.0 enabling technologies on supply chain performance [18]

Key enablers	The potential impact on supply chain performance
CPSs	• Improved responsiveness. • Enhanced collaboration and cooperation. • Seamless and flexible operations. • A better understanding of the requirements of different parties. • Enhanced decision making
IoT	• Flexibility at the process level. • Improved responsiveness and proactivity. • Improved decision making. • Monitoring and communication real-time performance. • Improved productivity, efficiency and; quality controls.
BDA	• Developing operational frameworks and predictive models. • Improved forecasting and planning. • Real-time problem solving. • Developing superior qualities. • Enhanced decision making and planning.
Cloud computing technologies	• Enhanced integration. • Enhanced collaboration and coordination. • Improved decision making and planning. • Quick and independent access to data form any part of the supply chain.

Table 4. The resulting performance improvements of Supply Chain processes due to the impact of Industry 4.0 [18]

Supply chain process	Performance improvements
Product development and production	• Improved production planning and control. • Improved product design/development and production process. • Enhanced production efficiency and productivity.
Fulfilment, procurement and logistics	• Improved planning and control. • Improved distribution. • Effective order fulfilment management. • Reduced bullwhip effect. • Improved procurement and supplier relationship management. • Effective purchasing.
Inventory management	• Improved product distribution and delivery. • Accurate inventory planning and control. • Increased operational efficiency.
Retailing	• Improved operational efficiency and productivity. • Enhanced forecasting and planning. • Improved responsiveness and revenue growth.

There are also some intimidating barriers according to multiple authors, cited by Zekhnini, K. 2020 [2]., for implementing industry 4.0 within the SC, such as the complexity of the Supply Chain, the lack of internal knowledge, the limited financial resources, high investment, technological immaturity, privacy and security data and the insufficient communication.

2.4 IMPACTS OF INDUSTRY 4.0 AND DIGITAL SUPPLY CHAIN FOR COMPANIES

Changes are rapidly taking place in all business environments and industries, which introduces incertitude for the future of companies, they could disappear or increase exponentially, for that it is crucial to introduce the industry 4.0 and supply chain 4.0 technologies to these companies by showing the impacts that they can brings with them.

Menon, S. and Shah, S. 2020 [19] summarized the impacts of industry 4.0 and digital supply chain according to multiple authors, the following table 5 [19] describes each impact.

Table 5. Impacts of Industry 4.0 & Digital SC for companies [19]

Impacts	Description
"Increased Efficiency"	"Technologies within Industry 4.0 generate variety of data with continuous analysis which enables to optimize the process. This data helps for self-correction, with seamless integration of people, processes and technology that results in a greater overall efficiency"
"Increased Quality"	"The technologies within Industry 4.0 foresee and detect defect within the quality of the product, or sustainability issues due to low quality that helps to optimize and improve the quality."
"Interconnected value chain"	"RFID technologies enables more visibility within supply chain, that provide it more traceable"
"Significant Cost Reduction"	"Analytic tools with advanced automation, flexible systems with shared information help the industry to increase forecast accuracy and decrease waste."
"Advanced analytical tools"	"Decision making is refined with data analysis that gain finer forecasting to interpret and meet demand"
"Reduced time to market"	"The technologies within industry 4.0 empower for cheaper and faster technology procedures like 3D printing and additive manufacturing that makes it an alternative to traditional methods."
"Flexibility"	"Production and service operations are altered to meet varying customer demands. Technology makes it effortless to reframe based on varying demands"
"Shared information"	"Digitalization allows sharing of information from sales, resources to production that makes the process work to meet the demand."
"Enhanced responsiveness"	"Analytics and data boost and respond to demand fluctuation and competitors & client technology switch"
"Predictive Maintenance"	"Predictive data analytics provide improved visibility that paves way for predictive maintenance of machinery avoiding the downtime"
"Improved Productivity"	"Real-time data helps the industry to optimize the resources and assist to ensure the process meet the demands without any downtime in the supply chain."
"Safety and Sustainability"	"Industry 4.0 improves operational efficiency by decreased human-machine interaction with automation."

As stated in [20], there is also some resisting forces, according to multiple authors, for implementing industry 4.0 and SC 4.0; they are classified under four dimensions: organizational nature, legal and ethical issues, strategic perspective and technological dimension [21]., the most common barriers are as followed: Financial constraints, lack of management support, resistance to change, lack of expertise, legal issues, lack of policies and support from the government, insufficient research and development practices, lack of infrastructure and lack of digital culture.

2.5 SWOT ANALYSIS

To summarize the previous sections, and based on [2], [18], [20], [22], [19] we adopted the SWOT tool to have a large and clear view of the multiple impacts of implementing the industry 4.0 and SC 4.0.

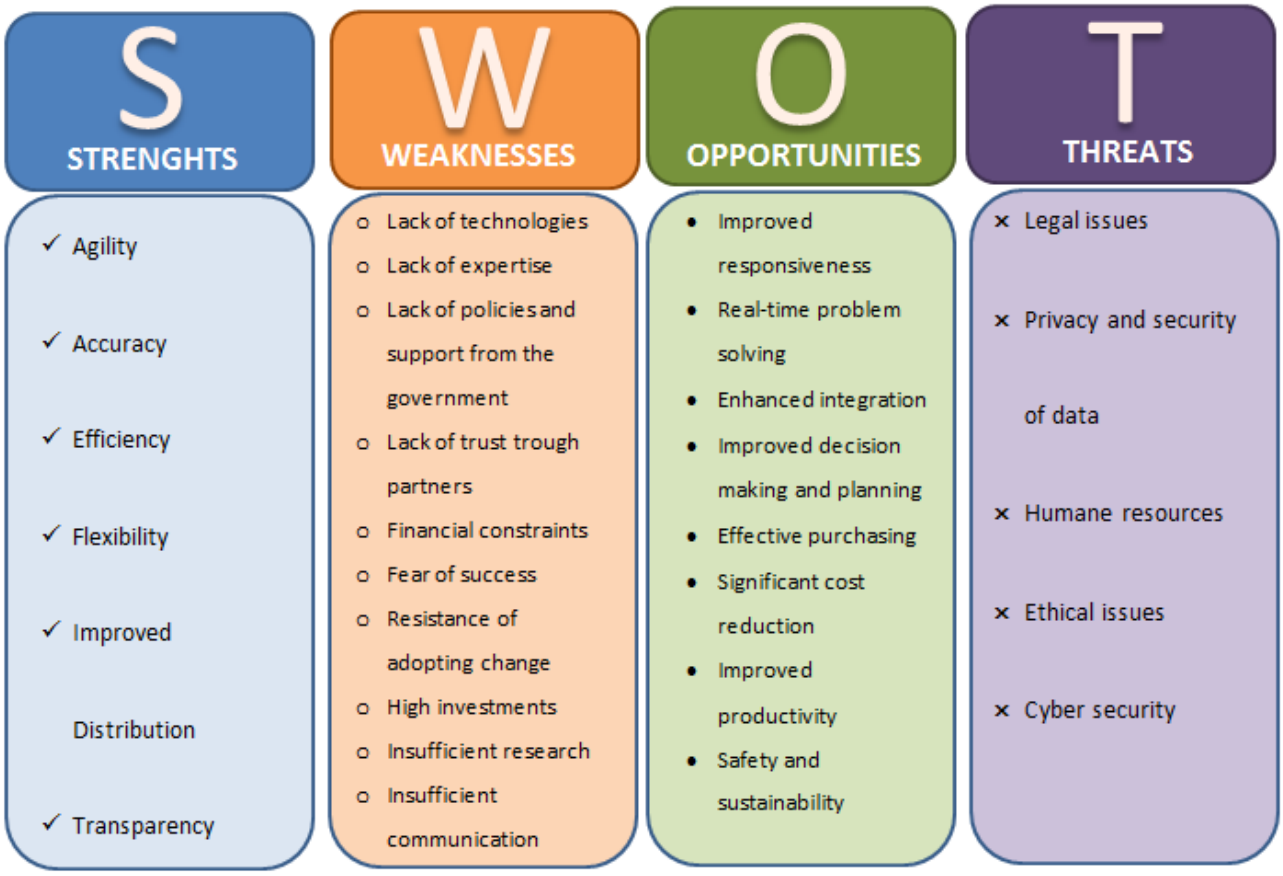

Fig. 4. SWOT analysis

2.6 AUTOMOTIVE INDUSTRY IN MOROCCO

The Moroccan automotive industry has grown; in terms of export this industry claim the first place presenting, in 2018, 26% of national exportations and plays an important role in job creation with 27%, in the African scale Morocco is in the first place of the producers of tourism cars and the 24th in the international scale, and due to the perspectives that expect the increase of the production capacity (700.000 units by 2023), it would allow the country to further boost its positioning in the automotive industry on a regional and international scale [23].

The table 6 below summarizes the development of the automotive sector from 1959 to 2017; the grown of the automotive industry is due to the presence of renowned international groups such as Renault, Sews, Delphi, Yazaki, and more recently PSA (Peugeot- Citroen) [24]

The following table shows the chronological development of automotive industry in Morocco [24].

Table 6. Development trends in the automotive sector in Morocco from 1959 to 2017 [24].

Year	Phases	Companies
1959	Start of the automobile assembly initiated by the promulgation of the Dahir (royal decree)	Creation of SOMACA
1995	Development of the automotive component manufacturing industry	Convention FIAT Auto S.P.A
1996		Two agreements with PSA and Renault
2003	Liberation of the sector market y the privatization of the SOMACA and the conclusion, in July 2003, of an agreement with Renault bearing the industrial project of assembly of the family car "Dacia Logan"	SOMACA and RENAULT
2012	Start of the activity of the Renault-Tangier industrial complex	Renault-Tangier
2014	Development of automotive ecosystems launched in October 2014	Industrial Acceleration Plan 2014-2020 (PAI)
2019	The PSA group confirmed the opening of the site for early 2019 with the target in 2014 of 200.000 vehicles and engines per year	PSA Group

3 CONCLUSION AND PERSPECTIVES

Industry 4.0 is a revolution that uses a variety of technologies such as Internet of things (IoT), Big Data Analytics (BDA), Cyber-Physical Systems (CPSs), RFID technologies etc. to improve the companies' performances, with this revolution, the SCs is affected also since the application of these technologies on the traditional SCs leads to transform it swiftly to a more integrated and dynamic one under the name of SC4.0 or Smart Supply Chain. Companies are looking beyond the boundaries of the SC and search to implement the new revolution, in the other hand the lack of researchers in this topic is steal an issue and especially for the automotive industry. This study contributes to this critical gap by discussing the relation between Industry 4.0 and Supply Chain 4.0 and the impact of their implementation on companies' performance, and provides a ground to know more about the automotive industry in Morocco to open the possibilities in the future works to study the implementation of these smart concepts on this very particular industry.

The perspective of our work is to measure the maturity level of SC4.0 in the Moroccan automotive companies based on the current literature study and a maturity model that to be presented in the next works, also to study the impact of the implementation of SC4.0 on the industrial performance of automotive companies in a developing country such as Morocco.

FUNDING

This work is funded by **CNRST** (Le Centre National de la Recherche Scientifique et Technologique / National Center for Scientific and Technological Research)

REFERENCES

[1] S. Xue-Feng, W. LIU, and Y. Liu, « Multistage implementation framework for smart supply chain management under industry 4.0 ». Technological Forecasting and Social Change, 2020, vol. 162, p. 120354.

[2] K. Zekhnini, A. Cherrafi, I. Bouhaddou, Y. Benghabrit, and J. A. Garza-Reyes, « Supply chain management 4.0: a literature review and research framework ». Benchmarking: An International Journal, 2020. (In press).

[3] K. Markov and P. Vitliemov, « Logistics 4.0 and supply chain 4.0 in the automotive industry ». In: IOP Conference Series: Materials Science and Engineering. IOP Publishing, 2020. p. 1-7.

[4] K. Douaioui, M. FRI, and C. Mabroukki, « The interaction between industry 4.0 and smart logistics: concepts and perspectives. ». In: 2018 international colloquiom on logistics and supply chain management (LOGSTIQUA). IEEE, 2018. p. 128-132.

[5] D. Kolberg, J. Knolbloch and D. Zühlke, « Towards a lean automation interface for workstations ». International journal of production research, 2017. vol. 55, no 10, p. 2845-2856.

[6] R. Schmid, M. Möhring, R. C. Härting, C. Reichstein, P. Neumaier, and P. Jozinović « Industry 4.0 - potentials for creating smart products: empirical research results ». In: International Conference on Business Information Systems. Springer, Cham, 2015. p. 16-27.

[7] T. D. Oesterreichet and F. Teuteberg, « Understanding the implications of digitisation and automation in the context of Industry 4.0: a triangulation approach and elements of a research agenda for the construction industry ». Computers in industry, 2016. vol. 83, p. 121-139.

[8] H. C. Pfohl, B. Yahsi and T. Kurnaz « The Impact of Industry Supply Chain ». In: Innovations and Strategies for Logistics and Supply Chains. 2015. ISSN (online): 2635-5070.

[9] M. Hermann, T. Pentek, and B. Otto, « Design principles for industrie 4.0 scenarios ». In: 2016 49th Hawaii international conference on system sciences (HICSS). IEEE, 2016. p. 3928-3937.

[10] H. Kagermann, J. Helbig, A. Hellinger, and W. Wahlster, « Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Securing the future of German manufacturing industry ». final report of the Industrie 4.0 Working Group. Forschungsunion: Berlin, Germany, 2013.

[11] J. Astill, R. A. Dara, E. D. Fraser, B. Roberts, and S. Sharif, « Smart poultry management: Smart sensors, big data, and the internet of things", Computers and Electronics in Agriculture, 2020. vol. 170, p. 1-8.

[12] P. Holtwert, R. Wutzke, J. Seidelmann, and T. Bauernhansl, « Virtual fort knox federative, secure and cloud-based platform for manufacturing » Procedia CIRP, 2013, vol. 7, p. 527-532.

[13] H. El-kaime, and S. L. Lissane Elhaq, « Methodology for Implementation of Industry 4.0 Technologies in Supply Chain for SMEs ». In: International Conference on Artificial Intelligence & Industrial Applications. Springer, Cham, 2020. p. 59-76.

[14] I. Ait Lhassan and R. Daanoune, « Supply Chain Performance Measurement Tools: Case of Moroccan Companies ». In: International Journal of Science and Research (IJSR). 2019. ISSN: 2319-7064.

[15] M. J. Ferrantino et E. E. Koten, « Understanding Supply Chain 4.0 and its potential impact on global value chains ». GLOBAL VALUE CHAIN DEVELOPMENT REPORT 2019.

[16] D. G. Schniederjans, C. Curado, and M. Khalajhedayati, « Supply chain digitisation trends: An integration of knowledge management ». International Journal of Production Economics, 2020. vol. 220, p. 107439.

[17] B. Tjahjono, C. Esplugues, E. Ares, and G. Pelaez, « What does Industry 4.0 mean to Supply Chain?", Procedia Manufacturing, 2017. vol. 13, p. 1175-1182.

[18] H. Fatorachianet and H. Kazemi, « Impact of Industry 4.0 on supply chain performance ». Production Planning & Control, 2020. vol. 32, n°1, pp. 63-81.

[19] S. Menon and S. Shah, « Are SMEs Ready for Industry 4.0 Technologies: An Exploratory Study of I 4.0 Technological Impacts ». In: 2020 International Conference on Computation, Automation and Knowledge Management (ICCAKM). IEEE, 2020. p. 203-208.

[20] A. Ghadge, M. E. Kara, H. Horadlou, and M. Goswarni, « The impact of Industry 4.0 implementation on supply chains ». Journal of Manufacturing Technology Management, 2020. Vol. 31 No. 4, pp. 669-686.

[21] S. Luthraet and S. K. Mangla, « Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies ». Process Safety and Environmental Protection, 2018. vol. 117, p. 168-179.

[22] M. Sharma, S. Kamble, M. Venkatesh, R. Sehrawat, A. Belhadi, and V. Sharma « Industry 4.0 adoption for sustainability in multi-tier manufacturing supply chain in emerging economies ». Journal of Cleaner Production, 125013. 2020.

[23] A. Hakam, « L'industrie automobile au Maroc : Vers de nouveaux gisements de croissance ». 2020, [Online]. Available: http://www.depf.finances.gov.ma. Consulted, December 8, 2020.

[24] S. Yahyaoui, F. Fedouaki, and A. Mouchtachi « A Supply Chain Maturity Model for automotive SMEs: a case study", IFAC-Papers OnLine, 2019. vol. 52, no 13, p. 2044-2049.