Achieving Sustainability in Supply Chain during Disruption times: Role of Industry 4.0

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Abstract. The demand to digitalize the automotive sector, which entails linking manufacturers to a larger supply chain, is increasing. In the automobile industry, there is a higher requirement for sustainable growth due to rising supply disruption and frequent technology changes. Industry 4.0 can speed up manufacturing, increase customizability, and cut down on setup and lead times. It may result in innovation. The study focuses on establishing link between Industry 4.0 technologies and green supply chain practices, which will help in achieving sustainability during disruption times. It follows a qualitative survey approach to identify the prominent Industry 4.0 technologies and green supply chain practices using a fuzzy-set analytical hierarchy process. The other section uses interpretive structural modelling with a multi-level hierarchical structure to study the cause-and-effect relationship between the final selected Industry 4.0 technologies and GSC practices. The study identifies a strong linkage between Industry 4.0 technologies and green supply chain practices to achieve overall sustainability in the supply chain. The future automotive supply chain should focus on driving Industry 4.0 technologies for effective implementation of green supply chain practices. Also in the Indian automotive sector, government regulation and policies and top management commitment are two key factors for driving sustainability in the Indian automotive supply chain.

Keywords: Industry 4.0, Green supply chain, Fuzzy set Analytic Hierarchy Process

1 Introduction

Over the past decade, organizations have been working continuously towards achieving a sustainable and resilient supply chain. Assuring a balance between economic, social, and environmental growth, sustainability is described as meeting the needs of the present without compromising those of future generations. However, with COVID-19 and issues like semiconductor shortages, sea container shortages, the Russia-Ukraine war, and natural disasters such as earthquakes and tsunamis, the automobile industry is currently facing many new challenges in managing their supply chain operations. Such supply chain disruptions result in shortages of critical components, resulting in a loss of production.

The supply chain in the automobile industry in India is under considerable pressure from the government of India and society to pursue a more sustainable model of growth. The automobile industry in India is going through tough times. The growth has slowed down due to a liquidity crunch in the market. COVID-19 has worsened the situation in the first half of the financial year 2020–21. The supply chain in automobiles is playing a crucial role and withstanding the pressure of changing regulatory norms of the government and political dynamics of India, especially with its neighboring countries [1].

The structure schema of the paper is as follows: First, an introduction highlights the need for going towards sustainability practices and efforts in the supply chains specially in the disruption times. Second, a literature review is presented on Industry 4.0 and green supply chain practices. The third section describes the methodology, including a qualitative survey, a fuzzy set analytic hierarchy process, and interpretive structural modelling. The fourth section discusses the results and cause-and-effect relationship between these technologies and practices. Finally, conclusions, limitations, and future research are explained.

2 Literature Review

Several research articles on “Sustainable Supply chain” and “Industry 4.0” from relevant web, academic and research sources are presented below.

2.1 Industry 4.0

Industry 4.0 technologies are considered as the disruptive ones, such as the Internet of Things (IOT), 3D printing/additive manufacturing, cloud computing, block chain, etc. come under the purview of Industry 4.0, which has a huge potential to bring drastic change in the way current manufacturing is done in India. Let us investigate these technologies in detail in a subsequent section.

Additive Manufacturing also known as 3D printing, meets all essential requirements for bringing the Industry 4.0 revolution to the manufacturing sector. As the word "additive" suggests, it is the addition of material over its one layer to another in contrast to conventional manufacturing processes where material is chipped off to obtain required dimensions [2, 3, 4].

Internet of things (IOT) is the connection between physical objects or machines and the Internet. It enables the implementation of smart connected products or embedded sensors, resulting in machine-to-machine connectivity through the Internet [5, 6, 7, 8].

Blockchain is a type of distributed ledger technology with blocks of records that are linked securely through cryptography. The major benefit of Blockchain technology is that it ensures secure data storage and transactions to happen in a transparent and secured manner, preventing any unauthorized interaction during whole process [9, 10, 11].

Big Data Analytics (BDA) is characterized by a large volume of data with a wide variety, which requires specific analytical methods to transform it into valuable data.

Many organizations are spending a lot of money on training their employees to manage big data using BDA tools. It helps in taking decisions in a structured manner with reliable and real-time analysis [12, 13].

Cloud Computing (CC) refers to the idea that data can be stored, collected, and accessed from specialized shared data centers all over the world. Many organizations are now shifting to cloud-based data storage services such as Office 365, large database solutions, etc. [8].

2.2 Green Supply Chain practices

Traditionally the idea of incorporating sustainable supply chain operations is referred to as "sustainable" or "green supply chain" (GSC).

Green Purchasing (GP) is defined as purchasing the product or selecting a supplier that has a lesser effect on the environment or human health as compared to products serving the same purpose. It is also known as "environmentally preferable purchasing." This includes sourcing recyclable products, reusable raw materials, and products that do not harm the environment [14].

Green Design. Achieving sustainability through a green design approach is better, as under this practice, at the product design stage itself, the design is optimized, taking into consideration the energy and material requirements for manufacturing the design into the final product [15].

Reverse Logistics (RL). It is a type of supply chain management in which the flow of goods occurs from the customer back to the seller or manufacturer. The purpose is to retrieve maximum value from products and material disposed.

Supplier and Customer Collaboration. Sustainability is not a one-time process; it is an act of continual improvement where an organization needs to work together with all its vendor partners to achieve overall excellence [15].

Government regulation & policies. Regardless of their form, regulations and policies are the primary drivers for companies to plan and execute sustainable practices of supply chain in their organizations [16].

Top Management Commitment. It is very essential that the top management of an organization be strongly committed to achieving sustainability. This should also be clearly visible in the company’s vision and mission statements [16].

3 Research Methodology

The paper uses two-stages of data collection through expert opinions and analysis. In the first stage, key Industry 4.0 technologies and Green Supply Chain practices are identified, which are ranked through Fuzzy- Analytic Hierarchy Process (FAHP). Thereafter, the last ranked Industry 4.0 technology and GSC practices is removed, and balance factors are taken for further analysis. In the second stage, Interpretive Structural Modelling (ISM) is used to identify different hierarchical levels. Later, a cross impact matrix multiplication analysis (MICMAC) is done to find respective power of variables

in two categories, namely dependence and driving. Finally, the cause-and-effect analysis is done on the structure obtained through ISM.

3.1 Expert's profile and Data Collection

For creating contextual links between the variables in the interpretive structural modelling, the expert opinions are used. The selected experts have extensive experience in the automobile and manufacturing domains in India. They are automobile supply chain professionals and have good industry exposure related to the practical application of Industry 4.0 (I4.0) technologies and sustainable practices in supply chains. The experts' profile is highlighted in Table 1 below:

Table 1. Experts' profile

S. No	Expert	Experience	Industry	Domain	Designation
1	Expert 1	15	Automobile Industry	Research & Development	Deputy General Manager
2	Expert 2	16	Automobile Industry	Supply Chain professional	Assistant General Manager
3	Expert 3	23	Automobile Industry	Supply Chain professional	Vice President
4	Expert 4	21	Automobile Industry	Product Development	Assistant General Manager
5	Expert 5	14	Manufacturing Domain	Research & Development	Senior Manager

4 Results and Analysis

Table 2 suggests a list of alternative technologies and GSC practices as per the literature review.

Table 2. Set of Alternative I4.0 technologies and GSC practices

	Alternative I4.0 technologies		Alternative GSC Practices
IOT	Internet of Things	GP	Green Purchasing
3D	3D printing	SCC	Supplier/Customer Collaboration
BC	Blockchain	GD	Green Design
BDA	Big Data Analytics	RL	Reverse Logistics
CC	Cloud Computing	GRP	Govt Regulation & Policies
		TMC	Top Management Commitment

Initially, the AHP matrix is constructed by taking inputs from various experts with large experience in the automotive industry in India. For selecting options among five experts' opinions, the average of all expert opinions is calculated, which is further rounded to the closest integer in the relative importance scale (1 to 7) to obtain the final AHP matrix. Table 3 to Table 6 are showing various steps involved in Fuzzy- Analytic Hierarchy Process (AHP).

Table 3. Initial I4.0 technologies Matrix (CR=.09<0.1)

I4.0 Technologies		IOT	3D	BC	BDA	CC
Internet of Things	IOT	1.00	3.00	5.00	1.00	3.00

3D printing	3D	0.33	1.00	4.00	1.00	3.00
Blockchain	BC	0.20	0.25	1.00	0.20	0.20
Big Data Analytics	BDA	1.00	1.00	5.00	1.00	5.00
Cloud Computing	CC	0.33	0.33	5.00	0.20	1.00

Table 4. Initial GSC Practices Matrix (CR=.094<0.1)

		GP	SCC	GD	RL	GRP	TMC
Green Purchasing	GP	1.00	0.33	0.50	2.00	2.00	2.00
Supplier/Customer Collaboration	SCC	3.03	1.00	3.00	4.00	4.00	3.00
Green Design	GD	2.00	0.33	1.00	2.00	2.00	1.00
Reverse Logistics	RL	0.50	0.25	0.50	1.00	0.50	0.17
Govt Regulation & Policies	GRP	0.50	0.25	0.50	2.00	1.00	2.00
Top Management Commitment	TMC	0.50	0.33	1.00	6.00	0.50	1.00

Table 5. I4.0 Technologies weighted Fuzzy set matrix.

I4.0 Technologies		**IOT**	**3D**	**BC**	**BDA**	**CC**	**AHP Weights**	**Fuzzy AHP Weights**	**Ranking**
Internet of Things	IOT	(1,1,1)	(2,3,4)	(4,5,6)	(1,1,1)	(2,3,4)	34%	34%	I
3D printing	3D	(1/4,1/3,1/2)	(1,1,1)	(3,4,5)	(1,1,1)	(2,3,4)	21%	21%	III
Blockchain	BC	(1/6,1/5,1/4)	(1/5,1/4,1/3)	(1,1,1)	(1/6,1/5,1/4)	(1/6,1/5,1/4)	5%	5%	V
Big Data Analytics	BDA	(1,1,1)	(1,1,1)	(4,5,6)	(1,1,1)	(4,5,6)	30%	30%	II
Cloud Computing	CC	(1/4,1/3,1/2)	(1/4,1/3,1/2)	(4,5,6)	(1/6,1/5,1/4)	(1,1,1)	11%	11%	IV

Table 6. GSC Practices weighted Fuzzy set matrix

Practices		**GP**	**SCC**	**GD**	**RL**	**GRP**	**TMC**	**AHP Weights**	**Fuzzy AHP Weights**	**Ranking**
Green Purchasing	GP	(1,1,1)	(1/4,1/3,1/2)	(1/3,1/2,1)	(1,2,3)	(1,2,3)	(1,2,3)	15%	15%	III
Supplier/Customer Collaboration	SCC	(2,3,4)	(1,1,1)	(2,3,4)	(3,4,5)	(3,4,5)	(2,3,4)	37%	37%	I
Green Design	GD	(1,2,3)	(1/4,1/3,1/2)	(1,1,1)	(1,2,3)	(1,2,3)	(1,1,1)	16%	16%	II
Reverse Logistics	RL	(1/3,1/2,1)	(1/5,1/4,1/3)	(1/3,1/2,1)	(1,1,1)	(1/3,1/2,1)	(1/7,1/6,1/5)	6%	6%	VI
Govt Regulation & Policies	GRP	(1/3,1/2,1)	(1/5,1/4,1/3)	(1/3,1/2,1)	(1,2,3)	(1,1,1)	(1,2,3)	11%	12%	V
Top Management Commitment	TMC	(1/3,1/2,1)	(1/4,1/3,1/2)	(1,1,1)	(5,6,7)	(1/3,1/2,1)	(1,1,1)	14%	13%	IV

There is a negligible difference in weights calculated from the normal AHP method and the fuzzy AHP method in both I4.0 technologies and GSC practices. It can be seen

from Table 7 that the Internet of Things (IOT), 3D-printing and others are the best choices among the alternative technologies for attaining supply chain sustainability. Blockchain is the least preferred choice among I4.0 technologies for achieving sustainability. Also, it can be seen from Table 8 that effective collaboration between supplier and customer is the most preferred choice to achieve sustainable automotive supply chain. However, reverse logistics is the least preferred choice among green supply chain practices.

Further below set of I4.0 technologies and GSC practices are taken to study the cause-and-effect diagram for achieving sustainability.

Table 7. Final selected I4.0 technologies and GSC practices for ISM modelling

	Alternative I4.0 technologies		Alternative GSC Practices
IOT	Internet of Things	SCC	Supplier/Customer Collaboration
3D	3D printing	GD	Green Design
BDA	Big Data Analytics	GRP	Govt Regulation & Policies
CC	Cloud Computing	TMC	Top Management Commitment
GP	Green Purchasing		

4.1 Interpretive Structural Modelling (ISM) for I4.0 technologies and GSC practices

In ISM methodology, the use of expert opinions is recommended, as they give their response based on practical experience in the subject domain. For selecting options among five experts' opinions, options with a clear majority are taken, and any arbitration with an option without a clear majority is pursued with revisiting the experts. SSIM was created with input from experts in two prestigious domains: I4.0 and GSC, as below. Table 8 to Table 10 are showing various steps involved in ISM modelling.

Table 8. Structural Self Interaction matrix (SSIM)

Structural Self-Interaction Matrix	Factors	3D	BDA	IOT	CC	SCC	GP	GD	TMC	GRP
3D Printing	3D	-	A	A	A	X	X	X	A	A
Big Data Analytics	BDA		-	X	X	X	V	V	A	O
Internet of Things	IOT			-	X	X	V	V	A	O
Cloud Computing	CC				-	A	V	O	A	O
Supplier/Customer Collaboration	SCC					-	X	X	A	A
Green Purchasing	GP						-	X	A	A
Green Design	GD							-	A	A
Top Management Commitment	TMC								-	A
Govt Regulation & Policies	GRP									-

Table 9. Final Reachability matrix

Final Reachability Matrix		Factors	1 3D	2 BDA	3 IOT	4 CC	5 SCC	6 GP	7 GD	8 TMC	9 GRP	Driving Power
1	3D Printing	3D	1	1*	1*	1*	1	1	1	0	0	7
2	Big Data Analytics	BDA	1	1	1	1	1	1	1	0	0	7
3	Internet of Things	IOT	1	1	1	1	1	1	1	0	0	7
4	Cloud Computing	CC	1	1	1	1	1*	1	1*	0	0	7
5	Supplier/Customer Coll.	SCC	1	1	1	1	1	1	1	0	0	7
6	Green Purchasing	GP	1	0	0	0	1	1	1	0	0	4
7	Green Design	GD	1	0	0	0	1	1	1	0	0	4
8	Top Management Commitment	TMC	1	1	1	1	1	1	1	1	0	8
9	Govt Regulation & Policies	GRP	1	1*	1*	1*	1	1	1	1	1	9
		Dep. Power	9	7	7	7	9	9	9	2	1	

In order to determine the levels of partitions, each factor's reachability, antecedent, and intersection set are found from the final reachability matrix. Following 3 iterations levels are obtained from final reachability matrix as shown in below Table 10.

Table 10. Levels of Partitions

Factors	Reachability Set	Antecedent Set	Intersection Set	Level
3D Printing	1,2,3,4,5,6,7	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7	I
Big Data Analytics	1,2,3,4,5,6,7	1,2,3,4,5,8,9	1,2,3,4,5	II
Internet of Things	1,2,3,4,5,6,7	1,2,3,4,5,8,9	1,2,3,4,5	II
Cloud Computing	2,3,4,5,6,7	1,2,3,4,5,8,9	2,3,4,5	II
Supplier/Customer Collaboration	1,2,3,4,5,6,7	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7	I
Green Purchasing	1,5,6,7	1,2,3,4,5,6,7,8,9	1,5,6,7	I
Green Design	1,5,6,7	1,2,3,4,5,6,7,8,9	1,5,6,7	I
Top Management Commitment	1,2,3,4,5,6,7,8	8,9	8	III
Govt Regulation & Policies	1,2,3,4,5,6,7,8,9	9	9	III

The final reachability matrix and levels of partitions are used to develop the ISM model, which incorporates selected I4.0 technologies and GSC practices from fuzzy AHP technique to ensure sustainability in the automotive supply chain. as shown in below Figure 1.

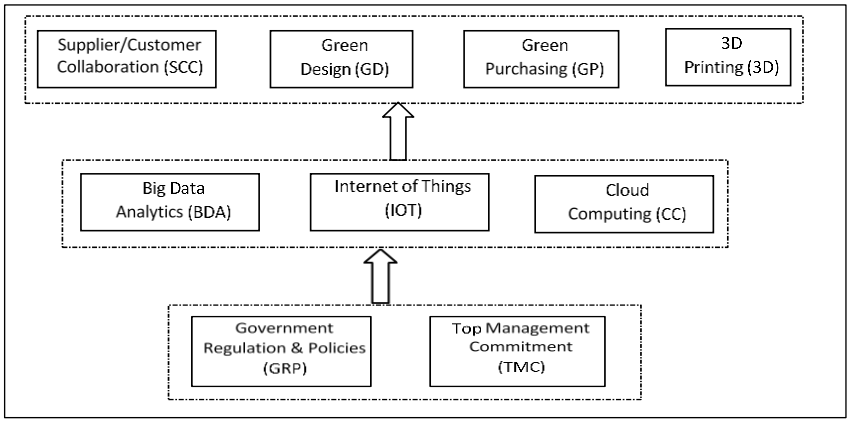

Fig. 1. ISM depicting levels of I4.0 technologies & GSC practices for achieving sustainability. (Source: Prepared by authors)

The above ISM model depicts that for achieving sustainability in the automotive supply chain in India, government regulation and policies and top management commitment towards sustainability are the most essential factors. It is followed by the Internet of Things, big data analytics, and cloud computing, which are directly or indirectly driving green supply chain practices to achieve overall sustainability. These factors are causing supplier and customer collaboration to be achieved in an effective manner.

4.2 Factor Classification using MICMAC Analysis

The driving power and dependence power of factors are further examined using a cross-impact matrix multiplication analysis (MICMAC). It is done to pinpoint the primary driving forces behind the system across different domains. There are four sorts of elements based on driving and dependence power.: autonomous factors (being less connected to the system and having weak driving & dependence power), linkage factors (having both strong driving & dependence power), dependent factors (having weak driving & strong dependence power) and driving factors (having strong driving power but weak dependence power). The results of the MICMAC analysis are shown in Figure 2 as below.

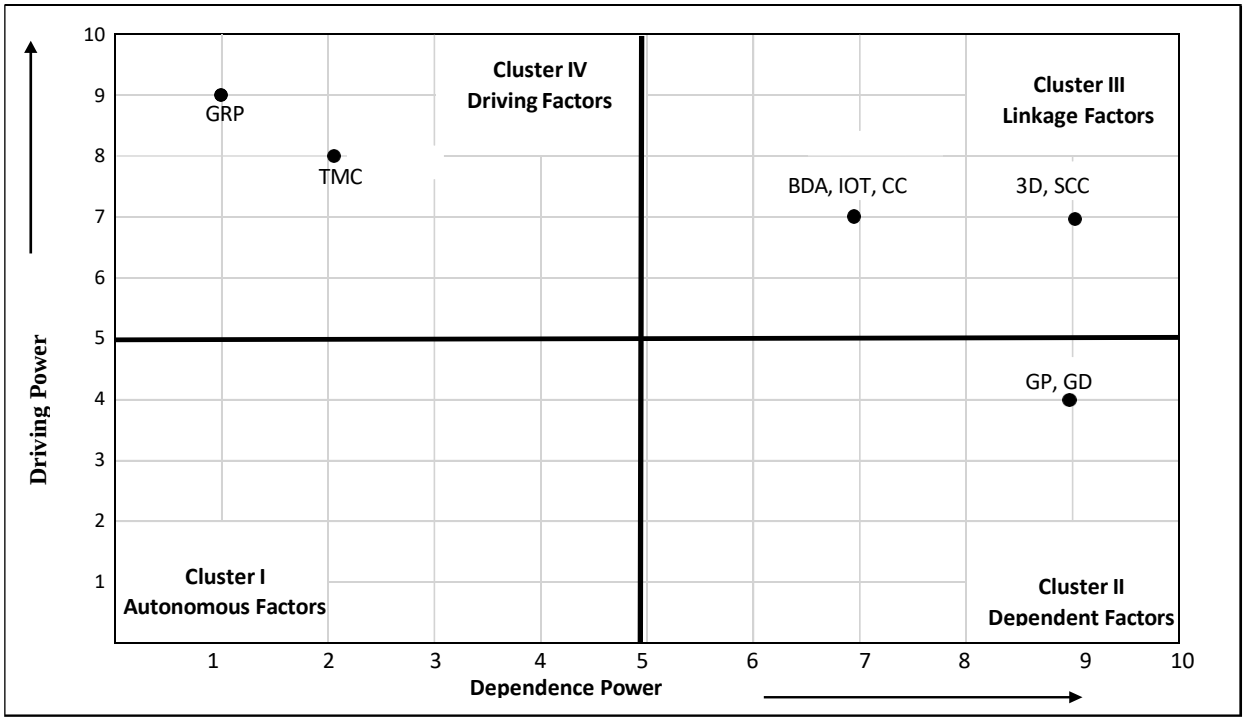

Fig. 2. Factor classification in MICMAC analysis (Source: Prepared by authors)

There are no autonomous factors present in the MICMAC analysis, as shown in Figure 2, hence all the Industry 4.0 technologies, considered and green supply chain practices are important. Top management commitment and government regulation and policies are driving factors that affect sustainability's performance because they are the driving dependent factors. Among them, government regulation and policies are key factors with highest driving power.

Big data analytics, the Internet of Things, cloud computing, and supplier/customer collaboration are linkage factors. They may have an impact on other system components for achieving sustainability in the supply chain. These factors holds both strong driving and dependent power. Dependent factors include green design and green purchasing, which have high dependence power. Thus, it can be interpreted from the analysis that industry technologies are essential to implementing GSC practices in the automotive supply chain.

5 Conclusion

There is a greater need to digitalize the automobile industry, which involves integrating manufacturers with extended and broad supply chain. The research aims to achieve the linkage between I4.0 technologies and green supply chain practices to achieve sustainability in the automotive supply chain. The study found that I4.0 technologies have a direct or indirect linkage with green supply chain practices.

The study uses a two-stage process wherein, in the first stage, prominent I4.0 technologies and green supply chain practices are selected using a fuzzy-set analytical hierarchy process. The expert opinions are validated using the AHP method consistency ratio, which is obtained within the range of 0 to 10%. The uncertainty in the expert's value preferences is further eliminated using a hesitant fuzzy AHP method to find the final set of I4.0 technologies and GSC practices for further cause-and-effect study. Thereafter, in stage 2, through interpretive structural modelling, the interrelationship between I4.0 technologies and GSC practices is studied for cause-and-effect analysis. The three-level hierarchical structure depicts that government regulation and policies, and top management commitment are two essential factors for driving sustainability in the automotive supply chain in India. Further MICMAC analysis supports the driving and dependence power matrix with no autonomous factors in selected variables. Also, it states that major I4.0 technologies such as the Internet of Things, big data analytics, cloud computing, etc. are linkage factors that could have an impact on other factors of the system to achieve supply chain sustainability. Thus, it can be interpreted from the analysis that in the automotive supply chain, I4.0 technologies are essential to strengthening GSC practices.

Further investigation can explore the specific challenges and barriers faced in implementing I4.0 technologies and green supply chain practices in the automotive sector. The study focuses on the Indian automotive supply chain, to examine the applicability of the findings in different geographical contexts. The paper highlights the importance of government regulations and top management commitment, but future research can

delve deeper into the specific policies and strategies that can drive sustainability in the supply chain.

References

1. Tseng, M. L., Tan, R. R., Chiu, A. S. F., Chien, C. F., & Kuo, T. C. (2018). Circular economy meets industry 4.0: Can big data drive industrial symbiosis? Resources, Conservation and Recycling, 131, 146–147. https://doi.org/10.1016/j.resconrec.2017.12.028
2. Frazier, W. E. (2014). Metal additive manufacturing: A review. Journal of Materials Engineering and Performance, 23(6), 1917–1928. https://doi.org/10.1007/s11665-014-0958-z
3. Chang, C.-Y., Pan, W., & Howard, R. (2017). Impact of Building Information Modeling Implementation on the Acceptance of Integrated Delivery Systems: Structural Equation Modeling Analysis. Journal of Construction Engineering and Management, 143(8), 4017044. https://doi.org/10.1061/(asce)co.1943-7862.0001335
4. Holmström, J., Liotta, G., & Chaudhuri, A. (2017). Sustainability outcomes through direct digital manufacturing-based operational practices: A design theory approach. Journal of Cleaner Production, 167, 951–961. https://doi.org/10.1016/j.jclepro.2017.03.092
5. Mastos, T. D., Nizamis, A., Vafeiadis, T., Alexopoulos, N., Ntinas, C., Gkortzis, D., Tzovaras, D. (2020). Industry 4.0 sustainable supply chains: An application of an IoT enabled scrap metal management solution. Journal of Cleaner Production, 269, 122, 377. https://doi.org/10.1016/j.jclepro.2020.122377
6. Rebelo, R. M. L., Pereira, S. C. F., & Queiroz, M. M. (2022). The interplay between the Internet of things and supply chain management: challenges and opportunities based on a systematic literature review. Benchmarking, 29(2), 683–711. https://doi.org/10.1108/BIJ-02-2021-0085
7. De Vass, T., Shee, H., & Miah, S. J. (2021). IoT in Supply Chain Management: Opportunities and Challenges for Businesses in Early Industry 4.0 Context. Operations and Supply Chain Management: An International Journal, 14(2), 148–161. https://doi.org/10.31387/oscm0450293
8. Huang, F., Chen, J., Sun, L., Zhang, Y., & Yao, S. (2020). Value-based contract for smart operation and maintenance service based on equitable entropy. International Journal of Production Research, 58(4), 1271–1284. https://doi.org/10.1080/00207543.2019.1617450
9. Agrawal, P., & Narain, R. (2023). Analysis of enablers for the digitalization of supply chain using an interpretive structural modelling approach. International Journal of Productivity and Performance Management, 72(2), 410–439. https://doi.org/10.1108/IJPPM-09-2020-0481
10. Esmaeilian, B., Sarkis, J., Lewis, K., & Behdad, S. (2020). Blockchain for the future of sustainable supply chain management in Industry 4.0. Resources, Conservation and Recycling, 163, 64, 105. https://doi.org/10.1016/j.resconrec.2020.105064
11. Jabbar, S., Lloyd, H., Hammoudeh, M., Adebisi, B., & Raza, U. (2021). Blockchain-enabled supply chain: analysis, challenges, and future directions. Multimedia Systems, 27(4), 787–806. https://doi.org/10.1007/s00530-020-00687-0
12. Kache, F., & Seuring, S. (2017). Challenges and opportunities of digital information at the intersection of Big Data Analytics and supply chain management. International Journal of Operations and Production Management, 37(1), 10–36. https://doi.org/10.1108/IJOPM-02-2015-0078

13. Gravili, G., Benvenuto, M., Avram, A., & Viola, C. (2018). The influence of the Digital Divide on Big Data generation within supply chain management. International Journal of Logistics Management, 29(2), 592–628. https://doi.org/10.1108/IJLM-06-2017-0175
14. Min, H., & Galle, W. P. (2001). Green purchasing practices of US firms. International Journal of Operations and Production Management, 21(9), 1222–1238. https://doi.org/10.1108/EUM0000000005923.
15. Vachon, S., & Klassen, R. D. (2008). Environmental management and manufacturing performance: The role of collaboration in the supply chain. International Journal of Production Economics, 111(2), 299–315. https://doi.org/10.1016/j.ijpe.2006.11.030
16. Centobelli, P., Cerchione, R., Chiaroni, D., Del Vecchio, P., & Urbinati, A. (2020). Designing business models in circular economy: A systematic literature review and research agenda. Business Strategy and the Environment, 29(4), 1734–1749. https://doi.org/10.1002/bse.2466

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