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Research Article

The Impact of Industry 5.0 on Supply Chain Management for a Sustainable Future

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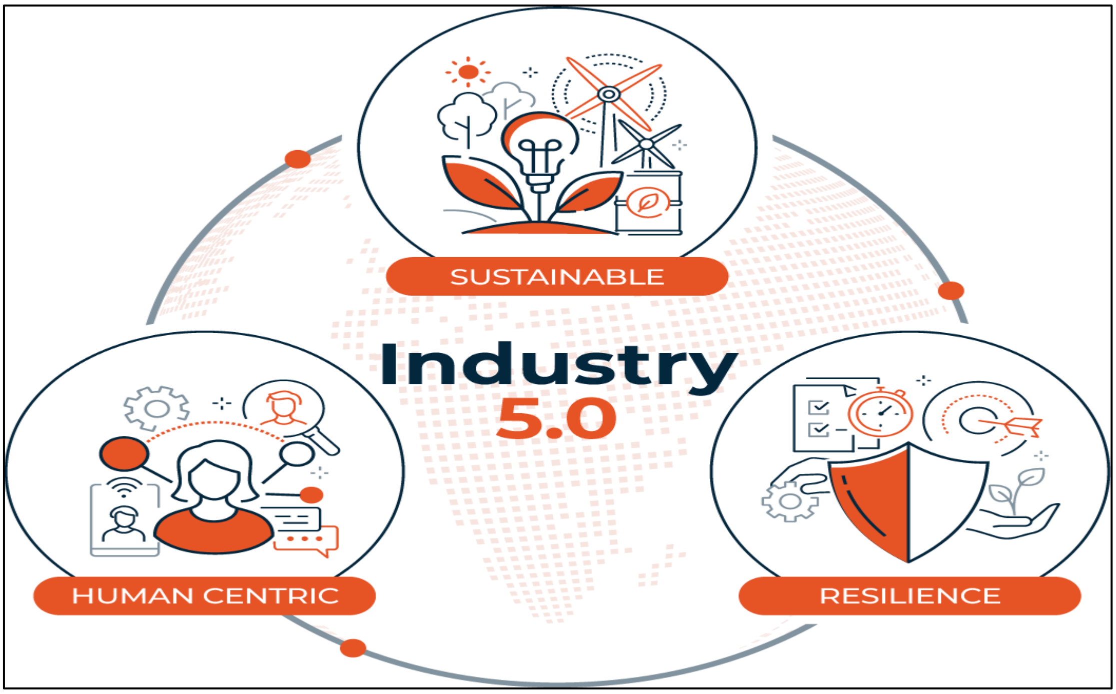
ARTICLE INFO **ABSTRACT**

Industry 5.0, the most recent version of the Industrial Revolution, has the potential to change the landscape of Supply Chain Management. constructing on the advancement in Industry 4.0, Industry 5.0 combines human creativity and innovation with cutting-edge digital technologies to create a more personalized, sustainable, and robust Supply chain. The implementation of Industry 5.0 technologies such as artificial intelligence, machine learning, and the Internet of Things is expected to improve Supply Chain visibility, agility, and adaptability. This paper discusses the impact of implementing Industry 5.0 in Supply Chain management so, that these advancements can bring a more holistic approach that emphasizes humanmachine collaboration, risk management, and sustainability. This research proves that Industry 5.0 technologies will have a positive impact on Supply Chain efficiency. Companies can substantially enhance the environmental and social responsibility of their Supply Chain management practices.

Keywords: Industry 5.0, Supply Chain Management, Human-Machine Collaboration, Customization, Sustainability.

Introduction

Industry 4.0 is now a top priority for the World Economic Forum and many governments. The Industry 4.0 strategy has a direct impact on the global competitive market and creates significant value. Industry 4.0 introduced a number of technologies that had a significant impact on Supply Chain management, including the Internet of Things (IoT), big data analytics, artificial intelligence (AI), and advanced robotics. But the consumers are becoming more informed and concerned about the origins and processes associated with the products they purchase.Building on the achievements of Industry 4.0, Industry 5.0 combines human creativity and innovation with advanced digital technologies to create a more personalised, sustainable, and resilient Supply chain. The concept of Industry 5.0 has received a lot of attention in recent years, with the potential to transform how businesses operate and interact with their Supply chains. The implications of Industry 5.0 for SupplyChain management are multifaceted. By incorporating human expertise into decisionmaking processes alongside AI-driven analytics, it is possible to improve forecasting, risk management, and more adaptive responses to disruptions. Industry 5.0 also emphasizes the importance of customization and personalization, leading to more adaptable manufacturing processes and agile Supply networks capable of meeting individual customer demands.



Industry 5.0 aims to correct this imbalance by incorporating concepts such as cognitive computing, cyberphysical systems, and artificial intelligence to ensure that humans play a role in the ongoing digital transformation.

Industry 5.0 will demand a stronger emphasis on sustainability and social responsibility in operational planning. This will include optimising manufacturing processes to mitigate waste, lower environmental impact, and encourage social well-being. It will also necessitate a greater emphasis on transparency and ethical behaviour across the Supply chain. Furthermore, Industry 5.0 will necessitate an increased emphasis on creativity and innovation in SupplyChain planning. SupplyChain planners must be able to think outside the box and generate new ideas and approaches to improve manufacturing and SupplyChain processes.

Literature Review

(Varriale et al., 2023) This article explores the relationship between digital technologies and sustainable supply chain management practices. The article uses a systematic literature review to identify which technologies promote sustainable emerging practices from a triple bottom line (3BL) perspective. The following 11 technologies were analysed: 3D printing, artificial intelligence, blockchain, computing, digital applications, geospatial technologies, Internet of Things, immersive environments, open and crowd-based platforms, proximity technologies, and robotics. Sustainable emerging practices were assessed using four indices measuring environmental, social, economic, and total 3BL sustainability. This study may be useful to both academics and practitioners. For the former, it provides a comprehensive understanding of the application of digital technologies in sustainable practices for supply chain management.

(Wicaksono & Illés, 2022) aims of the study is to enhance food supply chain resilience through a quality function deployment approach that considers customer needs and logistical risks. Empirical studies were conducted to assess the impact of customer needs, food supply chain risks, and actions to enhance the resilience of SMEs in the agri-food industry. This study proposes a new approach to supply chain resilience in the agri-food industry that considers customer needs when mitigating risks to customer satisfaction. It also highlights the lack of skill and coordination in agri-food supply chains.

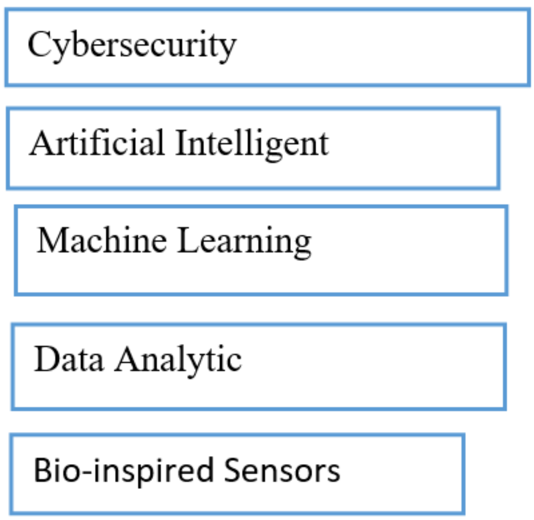
(Hoshimov et al., 2021) Industry 4.0 and its associated digital technologies enable real-time information sharing and data access. Such a capability should be investigated in Supply Chain Management (SCM) to study the combined effects of digital technologies on changing SC members' behaviour. Cloud Computing, Internet of Things, and Big Data Analytics were chosen for this paper because of their impact on real-time information sharing across multiple SC echelons rather than within a single echelon. Furthermore, implementing these technologies in real SC requires significant investment. Furthermore, due to the increased complexity of the SC after applying these technologies, their effects on SC behaviour and performance must be precisely determined. This paper proposes simulation as a cost-effective and comprehensive method for studying how digital technologies affect SC performance. A three-tier manufacturing supply chain was simulated using System Dynamics (SD) modelling under various scenarios in both traditional and digital SCM. The results show that digital SCs perform significantly better than traditional SCs in terms of inventory level, cost, and order fulfilment ratio.

(Kenny Raj, n.d.) The research aims to identify barriers to implementing Industry 4.0 and demonstrate that it improves supply chain efficiency. This research utilised both primary and secondary data collection methods. After conducting a literature review, variables such as cost, productivity, and risk were selected for research purposes, and a questionnaire was developed accordingly. The analysis is based on responses from employees and experts from various Indian companies involved in the supply chain. This research uses regression and correlation analysis to demonstrate the impact of Industry 4.0 technologies on supply chain efficiency. This research shows that Industry 4.0 technologies improve supply chain efficiency. This study also demonstrates that IoT implementation and a robotic working environment will have a greater impact on supply chain efficiency than data integration through the CPS.

(Marchese and Tomarchio 2022) presented in their research paper the application of data analytics in agri-food supply chains, emphasizing its role in optimizing routes, predicting demand, and improving overall decision-making. Big data analytics, coupled with predictive modeling, is shown to empower supply chain managers to proactively address challenges and enhance operational efficiency. In contrast to traditional supply chains, which are based on centralised systems, we propose a fully distributed approach, based on blockchain technology, to define a supply chain management system capable of providing quality, integrity, and traceability throughout the supply chain process.

(J & M, 2019) This review focuses on the role of Big Data in acquiring relevant data from factors affecting agriculture such as weather, soil, diseases, remote sensing, and the prospects for agricultural data analysis towards smart farming. Incorporating modern technologies into farming practices results in continuous monitoring of the environment, which generates a large amount of data. As a result, advanced practical and systematic strategies are required to correlate the various factors driving agriculture in order to extract useful information. Big data can be a promising aspect for the future of food production and agriculture's sustainability.

List of some Industry 5.0 technology used in this research papers



Research Question

1. What is the impact of 5.0 technology on the SupplyChain Management.
2. What are the strategies for applying 5.0 technology in SupplyChain Management ?
3. What are the barriers for implementing technologies in existing industries and converting them to Industry 5.0 ?

Objective

1. To analyze the impact of 5.0 technology on the SupplyChain Management.
2. To determine the strategies for applying 5.0 technology in SupplyChain Management
3. To find the the barriers for implementing technologies in existing industries and converting them to Industry 5.0 .

Research Methodology

In this research, the research approach is stared from reviewing the literature from various research papers. After reviewing the literature, we find the gap that most of the researches are done in the field of applying Big data Iot, cold chainand many more technologies in supply chain management but no researcher includes 5.0 industry revolution in supply chain and didn't shows the impact of this latest technology in supply chain . In this research we adopted the empirical research approach. Based on that approach, the close –ended Questionnaire would be framed. The researchers approached 93 respondents and this primary data is used for the testing the hypotheses. A survey was conducted on these respondents and data was collected from these respondents. The data was collected from NCR region based companies . Random and convenience sampling methods was used and questionnaire was filled by the respondent on online method. Data analysis for the research study has been done with the help of MS Excel, SPSS

Formulation of Research Hypotheses

On the basis of research objective some hypotheses has been formulated. In this research paper the null hypotheses, which are as follows:

- **Ho:** There is no significant impact of Cybersecurity in SupplyChain Management.
- **Ho:** There is no significant impact of Artificial Intelligent inSupplyChain Management
- **Ho:** There is no significant impact ofMachine Learning on SupplyChain Management.
- **Ho:** There is no significant impact of Data Analytic on SupplyChain Management.
- **Ho:**There is no significant impact of Bio-inspired Sensors on SupplyChain Management.

Survey Findings and Testing of Hypotheses

In this part of research presents the findings of the survey which was conducted on the use of 5.0 technology on SupplyChain Management for future sustainability. And this part also covers the testing of the hypotheses of the data which the researcher has been collected. These are the findings which the researcher found in there survey.

Data Analysis through Statistical Techniques

To analysis the data the fowling statically techniques has been used through SPSS software.

- Mean
- Standard Deviation
- One-way ANOVA

Results and Findings

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.891	.894	16

The above data shows that the Cronbach's alpha value for this test or survey is 0.891, indicating a high level of internal consistency. The Cronbach's alpha for standardized items is 0.894, which supports the items' internal consistency. With 16 items, the test or survey shows a high level of reliability in measuring the intended construct.

Descriptive Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Cybersecurity threats can be resolved by 5.0 technology in my current SupplyChain operations.	93	3.57	1.087	.113
The current cybersecurity measures in my SupplyChain operations are effective.	93	3.58	.876	.091
I am concerned about the potential impact of cybersecurity breaches on my SupplyChain operations.	93	3.59	.846	.111
I believe that ai-powered tools can improve SupplyChain visibility, forecasting, and decision-making.	93	3.67	.886	.097
I am familiar with ai-powered chatbots and their potential applications in SupplyChain communication.	93	3.69	.884	.092
Ai can improve SupplyChain optimization, predictive maintenance, and quality control.	93	3.48	.892	.093
I am concerned about the potential impact of ai on job security in my SupplyChain operations.	93	3.59	.969	.101
Machine learning algorithms can improve SupplyChain forecasting and demand planning.	93	4.03	.667	.069
Machine learning-powered predictive analytics and their potential applications helps in SupplyChain optimization	93	3.47	1.069	.111
Machine learning can improve SupplyChain visibility and real-time monitoring.	93	3.66	.984	.102
Data analytics can improve SupplyChain visibility, forecasting, and decision-making.	93	3.75	.654	.068
Data visualization tools and their potential applications helps in SupplyChain operations.	93	3.75	.717	.074
Data analytics can improve SupplyChain optimization, predictive maintenance, and quality control	93	3.84	.798	.083
Bio-inspired sensors can improve SupplyChain monitoring, tracking, and quality control.	93	3.84	.741	.077
Bio-inspired sensors and their potential applications helps in SupplyChain operations.	93	3.59	.797	.083
Bio-inspired sensors can improve SupplyChain resilience and adaptability.	93	3.73	.754	.078

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Cybersecurity threats can be resolved by 5.0 technology in my current SupplyChain operations.	Between Groups	12.422	3	4.141	13.824	.013
	Within Groups	96.374	89	1.083		
	Total	108.796	92			
The current cybersecurity measures in my SupplyChain operations are effective.	Between Groups	9.807	3	3.269	14.681	.004
	Within Groups	62.150	89	.698		
	Total	71.957	92			
I am concerned about the potential impact of cybersecurity breaches on my SupplyChain operations.	Between Groups	10.141	3	3.380	14.973	.003
	Within Groups	60.504	89	.680		
	Total	70.645	92			
I believe that ai-powered tools can improve SupplyChain visibility, forecasting, and decision-making.	Between Groups	11.341	3	3.780	15.436	.002
	Within Groups	61.885	89	.695		
	Total	73.226	92			
I am familiar with ai-powered chatbots and their potential applications in SupplyChain communication.	Between Groups	16.702	3	5.567	17.101	.010
	Within Groups	69.772	89	.784		
	Total	86.473	92			
Ai can improve SupplyChain optimization, predictive maintenance, and quality control.	Between Groups	9.536	3	3.179	19.018	.020
	Within Groups	31.368	89	.352		
	Total	40.903	92			
I am concerned about the potential impact of ai on job security in my SupplyChain operations.	Between Groups	25.538	3	8.513	19.513	.001
	Within Groups	79.645	89	.895		
	Total	105.183	92			
Machine learning algorithms can improve SupplyChain forecasting and demand planning.	Between Groups	4.814	3	1.605	11.697	.023
	Within Groups	84.175	89	.946		
	Total	88.989	92			
Machine learning-powered predictive analytics and their potential applications helps in SupplyChain optimization	Between Groups	9.668	3	3.223	19.675	.000
	Within Groups	29.644	89	.333		
	Total	39.312	92			
Machine learning can improve SupplyChain visibility and real-time monitoring.	Between Groups	6.577	3	2.192	14.790	.004
	Within Groups	40.735	89	.458		
	Total	47.312	92			
Data analytics can improve SupplyChain visibility, forecasting, and decision-making.	Between Groups	10.635	3	3.545	16.580	.010
	Within Groups	47.946	89	.539		
	Total	58.581	92			
Data visualization tools and their potential applications helps in SupplyChain operations.	Between Groups	17.569	3	5.856	15.789	.000
	Within Groups	33.012	89	.371		
	Total	50.581	92			
Data analytics can improve SupplyChain optimization, predictive maintenance, and quality control	Between Groups	16.833	3	5.611	11.993	.010
	Within Groups	41.640	89	.468		
Bio-inspired sensors can improve SupplyChain monitoring, tracking, and quality control.	Total	58.473	92			
Bio-inspired sensors and their potential applications helps in SupplyChain operations.	Between Groups	52.280	3	17.427	15.993.	.010.
	Within Groups	.000	89	.000		
	Total	52.280	92			
Bio-inspired sensors can improve SupplyChain resilience and adaptability.	Between Groups	20.084	3	6.695	12.651	.001
	Within Groups	47.098	89	.529		
	Total	67.183	92			

Inte rpre tation

- **Null Hypothes is (H0):** There is no sign ificant impact of Cyb erse curi ty in Sup plyC hain Ma nagement.
  The ANOVA results show that Cybersecurity can resolved threats(013), effective (004), and potential (003)of SupplyChain Management.
  It is interpreted that the null hypothesis is rejected.
  That show's there is an significant impact of Cybersecurity in Supply Chain Management.
- **Null Hypothesis (H0):** There is no significant impact of Artificial Intelligent inSupplyChain Management
  The ANOVA results show that Artificial Intelligent in Supply Chain management benefits from visibility, forecasting, and decision-making, ($p = .002$), potential($p = .010$), and optimization, predictive maintenance, and quality control ($p = 0.020$).
  It is interpreted that the null hypothesis is rejected.
  That show's there is an significant impact of Artificial Intelligent in Supply Chain Management

- **Null Hypothesis (H0):** There is no significant impact ofMachine Learning on SupplyChain Management.
  The ANOVA results show that Machine learning improves forecasting and demand planning. (p = .023) and potential(p = .000). visibility and real-time monitoring(p = .004).
  It is interpreted that the null hypothesis is rejected.
  That show's there is an significant impact of Machine Learning on Supply Chain Management.
- **Null Hypothesis (H0):** There is no significant impact of Data analytics on Supply Chain Management. The ANOVA results show that Data analytics on Supply Chain Management make a significant contribution to the visibility, forecasting, and decision-making. (p = .010) potential (p = 0.000) , optimization (p = .010) of Supply Chain Management.
  It is interpreted that the null hypothesis is rejected.
  That show's there is an significant impact of Data analytics on Supply Chain Management.
- **Null Hypothesis (H0):** There is no significant impact of Bio-inspired on optimizing Supply Chain Management.

The ANOVA results show that Bio-inspired improves potential (p = .010) and contributes to the monitoring, tracking, and quality control (p = 0.000) of Supply Chain Management. It is also critical for improving resilience and adaptability (p = .001) in Supply Chain Management. It is interpreted that the null hypothesis is rejected.

That show's there is an significant impact of Bio-inspired on Supply Chain Management.

Overall, the ANOVA results indicate that Cybersecurity, Artificial Intelligent, Data analytics, Machine Learning, Bio-inspired all play important roles in improving the efficiency and optimisation of SupplyChain Management.

Conclusion

The advent of Industry 5.0 is poised to significantly impact supply chain management, particularly in the context of sustainability. This new industrialrevolution emphasizes human-machine collaboration, customization, and sustainability, which will reshape the way companies approach supply chain management. The integration of technologies such as artificial intelligence (AI), data analytics, machine learning, and bio-inspired approaches will be crucial in achieving a sustainable future for supply chains

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