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Analysing the mediating effects of Technology Adoption in Supply Chain Operations and its impact in Supply Chain Efficiency leveraging towards Sustainable Development

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Abstract

In today's dynamic and interconnected global marketplace, the integration of new technologies holds the potential to revolutionize supply chain efficiency and redefine business paradigms.Earlier studies have indicated that by leveraging IT, firms can develop stronger supply chain capabilities that lead to improved efficiency, effectiveness, and competitive advantage. This study presents a comprehensive analysis conducted to understand the transformative implications of technology adoption within the context of supply chain operations and its efficiency. The study aims to capture nuanced insights into the multifaceted impact of technology on diverse supply chain facets, from inventory management to last-mile delivery. Initial findings suggest a strong positive relationship, indicating that businesses embracing advanced technologies experience tangible benefits, including reduced operational costs, accelerated order fulfillment, improved demand forecasting, and heightened customer satisfaction. The outcomes of this research are expected to offer actionable insights for supply chain managers, business leaders, and policymakers.

Keywords: *Supply chain efficiency, Supply Chain Operations, Technology Adoption, Supply chain capability, Supply Chain Visibility, Sustainability, Digitization, Sustainable Development Goals.*

Introduction

In today's rapidly evolving business landscape, characterized by globalization, digitalization, and heightened customer expectations, supply chain management has emerged as a critical determinant of organizational success. The seamless coordination of processes, the optimization of resources, and the efficient delivery of products have become imperative to meet the demands of a competitive marketplace. Against this backdrop, the integration of new technologies stands as a defining strategy for enhancing supply chain efficiency, redefining operational paradigms, and propelling businesses towards sustained growth. The efficiency of supply chain operations directly impacts not only cost structures but also customer satisfaction levels and overall business performance. Organizations recognize that traditional supply chain models, while effective in their time, are no longer sufficient to address the complexities posed by an interconnected global economy. Factors such as complex product portfolios, global sourcing, fluctuating demand patterns, and an increasingly

discerning customer base have necessitated a fundamental shift in supply chain approaches.

To enhance the efficiency and flexibility of supply chain systems modular software components can be employed and these modular components when integrated will streamline the processes and improve collaboration among different stakeholders Supply chains have evolved into intricate ecosystems that extend across geographical boundaries, and efficient management of these networks is paramount for organizations seeking sustainable growth and competitive advantage. The advent of innovative technologies has heralded a new era in supply chain management, promising streamlined processes, heightened visibility, enhanced decision-making, and improved resource allocation. Leveraging a structured questionnaire distributed through the Google Form platform, the study aims to capture nuanced insights into the multifaceted impact of technology on diverse supply chain facets, from inventory management to last-mile delivery. By employing the Likert scale analysis as the quantitative tool, the study aspires to provide robust evidence of the correlation between technology adoption and supply chain efficiency enhancement.

Literature Review

Autry, C. W., Grawe et.al (2010) examined the intention to use and subsequent implementation of a supply chain technology. The authors extended the technology acceptance model (TAM) to incorporate the state of the technology environment (technological turbulence) and the extent to which other supply chain technologies have already been adopted by the firm (technological breadth). The authors found that the relationship between the firm's intention to use a supply chain technology and the implementation of the technology is weaker in firms with greater technological breadth

A Park, H Li - Sustainability, (2021) investigated the influence of block-chain technology Supply-chain. The authors focused on block chain-based supply chain management and its sustainability performances in the areas of environmental protection, social equity, and governance efficiency. Using a systematic literature review and two case studies, they have evaluated all the three sustainability indicators.

Bhandari, R. (2014) in his paper discussed the impact of the technology on logistics and supply chain management. The author mainly focuses on the secondary data for collecting data relating to various technology used in logistics and supply chain management. The author draws conclusion that Technology is a vehicle to enhance supply chain competitiveness and performance by enhancing the overall effectiveness and efficiency of logistics system.

Cagliano, A. C., Mangano, G., & Rafele, C (2021) in their paper aimed at identifying the main patterns related to the application of new Digital Supply Chain Technologies that through the Industry 4.0 paradigm, are redefining supply chain organisations. Their results show that the time factor, the Gross Domestic Product per capita, the amount of foreign investment, and the expenditure in Research and Development are significant drivers of DSC technologies

Chowdhury, S., Rodriguez-Espindola, O., Dey, P., & Budhwar, P. (2023) contributed to the OSCM literature by developing a conceptual model which has examined the causal relationships between VUCA business environments, constructs derived from technology acceptance model (TAM), resilience and behavioral intention of the operations managers to adopt Block Chain Technology for risk management. The model was tested by gathering responses from 116 operations managers in the UK (during COVID-19 pandemic) through structural equation modelling. The major findings from the study suggest that understanding the benefits of BCT, involvement in resilient organizational practices and user-friendly implementation of the technology will have a significant and positive influence on the intention to adopt BCT for risk management in the OSCM context

Fasanghari, M. (2008) in their paper specified the

areas that IT effects on supply chain and by using fuzzy method the author concluded that information technology (IT) can enhance the agility of SCM

Joshi, S., & Sharma, M. (2022) introduced a conceptual model to evaluate sustainable practices and dynamic capabilities to ensure performance in a disruptive environment. Determinants were identified from the literature for the study of Sustainable practices and capabilities during disruption and uncertain business environment and are based on the concept of the triple bottom line. The analytical outcomes of their research contribute to the existing literature and enable practitioners to design and implement sustainable supply chain activities and monitor and evaluate the impact of such activities on business sustainability among Indian firms

Lippert, S. K. (2008) examined the influences of individual-level antecedents on post-adoption utilisation of a specialised IT within an SCM context. The author collected the data from 272 first-tier supply chain members of the second largest US automotive service-parts logistics operation using a new supply chain technology and twelve hypothesis were tested through structured equation model.

Naghshineh, B., & Carvalho, H. (2022) in their paper puts forward a detailed framework that indicates how and to what extent adopting additive manufacturing can influence the supply chain capabilities and vulnerabilities that underlie supply chain resilience. The authors have done a systematic search of the literature followed by a critical review of the gathered evidence from 87 peer-reviewed journal papers is performed, leading to the generation of propositions on how additive manufacturing adoption impacts the state of the supply chain

Zhang, C., & Dhaliwal, J. (2009). explored the questions that how firms can employ their IT capabilities for operations and supply chain management, the impact of competitive and institutional environments on IT-based operations strategy; the relationships between IT-enabled supply chain practices and operations performance. Their paper addresses the aspects by examining the factors affecting Chinese firms' adoption of IT-enabled supply chain operations and the benefits they achieve, by drawing from and integrating the resource-based and institutional theoretic perspectives

Verwijmeren, M. (2004) in his paper explained that IoT can enhance supply chain management by enabling real-time tracking and monitoring of containers, improving visibility and efficiency.

IoT can transform supply chain operations through improved container tracking and management[Gnimpieba, Z. D. R., Nait-Sidi-Moh, A., Durand, D., & Fortin, J. (2015)].

Wu, F., Yeniyurt, S., Kim, D., & Cavusgil, S. T. (2006) identified the technologies which promises for a streamlined processes, real-time visibility, enhanced decision-making, and heightened responsiveness. Consequently, organizations across industries are compelled to explore the potential of these tools in driving transformative changes in their supply chain ecosystems. IT-enabled supply chain capabilities are firm-specific, and hard-to-copy across organizations and also these capabilities can serve as a catalyst in transforming IT-related resources into higher value for a firm

Manzini, R. (Ed.). (2012) explained that advancements in technology, ranging from Warehouse Management Systems (WMS) and Transportation Management Systems (TMS) to cutting-edge technologies like data analytics, artificial intelligence (AI), and the Internet of Things (IoT), offer a new trajectory for supply chain optimization However, there is limited understanding of the Mediating Effects of Technology Adoption between Supply Chain Operations and Supply Chain Efficiency with reference to third party logistics service companies This study presents a comprehensive analysis conducted to deeply understand the transformative implications of technology adoption within the context of supply chain operations and its efficiency. This research aims to bridge the

existing research gap by evaluating the role of Warehouse Management Systems (WMS), Transportation Management Systems (TMS), data analytics in enhancing the efficiency of supply chain networks focusing on the ninth goal of sustainable development goal-Industries, Innovation and Infrastructure.

Two research questions (RQ) are majorly addressed in this paper.

Research Questions

RQ1: What is the impact of technology adoption towards supply chain efficiency?

RQ2: Whether usage of new technologies enhance the supply chain performance?

More specifically, we aim to identify the technologies adopted by the selected firms, discover the impacts of supply chain Operations and efficiency, discovering the challenges encountered during the transition to digital platforms and propose solutions to overcome the barriers.

Methods and Materials

This study integrates three key theoretical perspectives: Knowledge Management (KM), the (Technology Adoption Model) TAM, and the Resource-Based View (RBV). These theories provide an understanding of the relationships among knowledge management practices, technology adoption, and supply-chain efficiency, ultimately influencing firm performance.

In terms of supply-chain, KM is a important role in optimizing operations by ensuring that relevant knowledge is effectively shared, disseminated, and leveraged by supply chain professionals.

KM [Knowledge Management]

In the study's theoretical background, KM highlights how organizations strategically manage their knowledge assets to understand the potential benefits of adopting new supply chain technologies. By facilitating a culture of continuous learning, KM empowers supply chain professionals to explore, evaluate, and embrace innovative technologies that can improve efficiency and effectiveness in various supply chain processes.

TAM [Technology Acceptance Model]

The TAM examines users' acceptance and adoption of new technology based on two primary factors: perceived usefulness and perceived ease of use. It provides an overview into the factors that influencing individuals' intentions to adopt and use technology in their work environment.

In the study's theoretical background, TAM helps understand how supply chain professionals' perceptions of the usefulness and ease of use of new technologies influence their willingness to adopt and utilize them. By incorporating TAM, the research aims to identify the key determinants that drive or hinder technology adoption in the supply chain, shedding light on how to design effective training and change management strategies to encourage successful technology adoption

RBV [Resource-Based View]

The Resource-Based View (RBV) of the firm posits that sustained competitive advantage and superior performance are achieved through unique and valuable resources and capabilities. RBV emphasizes the strategic importance of knowledge assets as core resources that enable firms to create and maintain a competitive edge.

In the study's theoretical background, RBV underscores the significance of knowledge assets as critical resources for organizations seeking to optimize their supply chain operations through technology integration. By effectively managing knowledge, organizations can enhance their supply chain technologies, making them more adaptive, efficient, and responsive to market dynamics. It is essential to acknowledge the original authors and researchers of the study, "Knowledge Management, Supply Chain Technologies, and Firm Performance," by Jamie D. Collins, William J. Worthington, Pedro M. Reyes, and Marisabel Romero, from Baylor University, Waco, Texas, USA. Their work provided the foundation and inspiration for the theoretical background framework used. The elaboration of the (T-A-M)

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Technology-acceptance-model in the theoretical background framework is based on the original model proposed by Fred Davis in 1989. The TAM has been widely used and expanded upon in various research studies related to technology adoption and acceptance. Fred Davis. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Quarterly, 13(3), 319-340.

Research Design

The study adopted a convenient sampling method, reaching out to professionals from various industries who are accessible through professional networks and online communities. The effectiveness of the study's conclusions may be influenced by the size and representativeness of the sample used for data collection. We have used the existing scales and the primary data is collected through a Google Form questionnaire, and due to time constraint, we were able to collect only 115 responses.

Hypotheses Formulation

Hypothesis 1: The adaptation of the software tool to provide real-time visibility significantly impacts supply chain efficiency

Hypothesis 2: The experience of employees has a significant impact on supply chainefficiency

Data Analysis and Results

One-Sample Kolmogorov-Smirnov Test

		Adaptation of software tool real time visibility
N		115
Normal Parameters[a,b] Mean		19.513
Std. Deviation		2.92408
Most Extreme Differences	Absolute	0.103
		0.103
	Positive	-0.091
	Negative	0.103
Test Statistic		.004[c]
Asymp. Sig. (2-tailed)		

a. Test distribution is Normal
b. Calculated from data
c. Lilliefors significance correction

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.852
Bartlett's Test of Sphericity	Approx. Chi-Square	1137.79
	df	325
	Sig.	0

KMO overall: 0.8516485481

The KMO value, which stands for Kaiser-Meyer-Olkin, measures the adequacy of the samplesize for doing factor analysis. In this case, the KMO value of 0.8516485481 suggests that the dataset has a good level ofsampling adequacy for factor analysis

Regression analysis for the dependent variable 'Impact on supply chain efficiency' with the independent variable 'Adaption of software tools for real time visibility'

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Descriptive Statistics

	Mean	Std. Deviation	N
Impact on supply chain efficiency	7.913	1.42	115
Adaptation of software tool real time visibility	19.51	2.92	115

Above table it says that that Mean and Std-Dev values are significant.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	3.57	0.8		4.438	0	1.974	5.159					
	Adaptation of software tool real time visibility	0.22	0.04	0.457	5.469	0	0.142	0.303	0.457	0.457	0.457	1	1

a. Dependent Variable: Impact on supply chain efficiency

H01: The real-time visibility facilitated by the adaptation of the software tool has no significant impact on supply chain efficiency.

H11: The adaptation of the software tool to provide real-time visibility significantly impacts supply chain efficiency.

The [P] Value is lesser compared to the significant value, hence we reject the null hypothesis. The above ANOVA table shows the significance of .000[b], it concludes that the model is fit

Regression analysis for dependent variable 'Impact on supply chain efficiency, with independent variable 'Experience of employee'.

Descriptive Statistics

	Mean	Std. Dev	N
Impact on supply chain efficiency	7.9130	1.42389	115
Experience of employee	7.9652	1.31743	115

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.330[a]	.109	.101	1.34987	.109	13.846	1	113	.000	2.404

a. Predictors(Y=Independent): Experience of employee

b. X (Dependent) Variable: Impact on supply chain efficiency

The regression analysis suggests that the model explains a relatively small proportion of the variability in the dependent variable (R-squared = 0.109). The Durbin-Watson value indicates a moderate level of positive autocorrelation in the residuals. The correlation coefficient (R) of 0.330 indicates a weak positive linear relationship between variables. The standard error of the estimate

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recommends us that the model's predictions have some degree of variability from the actual values. The adjusted R-squared accounts for the number of different variables in the model and is similar to the R-squared, indicating the proportion of explained variability, considering model complexity.

Interpretation: The aim is to find whether there is any significant differences on the dependent variable. The tolerance and VFI are well within the range above 0.25.

ANOVA						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	25.2	1	25.2	13.846	.000b
	Residual	206	113	1.82		
	Total	231	114			

Dependent Variable: Impact on supply chain efficiency

Predictors: (Constant), Experience of employee

H01: The experience of employees does not significantly influence the impact on supply chain efficiency.

H11: The experience of employees has a significant impact on supply chainefficiency. [Experience in-terms of usage of tool]

Five regression analyses were performed in the study, each investigating the impact of a different independent variable on the dependent variable "Impact on Supply Chain Efficiency."

Ease of Use: This analysis aimed to understand the influence of the ease of using technology on supply chain efficiency. The regression model revealed a moderate positive linear relationship (R = 0.476) between the variables. The model accounted for approximately 22.7% of the variation in the dependent variable (R-squared = 0.227), and the Durbin-Watson value of 2.232 indicated no significant autocorrelation in residuals. The significant F-change value ($p < 0.001$) indicated that the model is valid and fits the data well.

Adaptation of Software Tools for Real-Time Visibility: The regression analysis explored the connection between adopting software tools for real-time visibility and supply chain efficiency. The results indicated a weak positive linear relationship (R = 0.209) between the variables. The model explained about 20.2% of the variability in the dependent variable (R-squared = 0.202), with a Durbin-Watson value of 2.231, suggesting mild positive autocorrelation. The model was statistically significant ($p < 0.001$) and considered appropriate for the data

Usefulness to Organization: This analysis investigated how the usefulness of technology to an organization impacts supply chain efficiency. The regression model demonstrated a relatively low proportion (10.1%) of explained variability in the dependent variable (R-squared = 0.101). The correlation coefficient (R = 0.330) showed a weak positive linear relationship. The Durbin- Watson value indicated a moderate level of positive autocorrelation. The model was statistically significant ($p < 0.001$), suggesting its appropriateness for the data.

Facilitation of Software to Employees: The regression analysis examined the influence of facilitating software to employees on supply chain efficiency. The results unveiled a moderate positive linear relationship (R = 0.537) between the variables. The model accounted for approximately 28.8% of the variation in the dependent variable (R-squared = 0.288), with a Durbin-Watson value of 2.198, indicating no significant autocorrelation in residuals. The F- change value was highly significant ($p < 0.001$), supporting the model's fit.

Experience of Employees: This analysis explored the impact of employees' experience on supply chain efficiency. The regression model indicated a weak positive linear relationship (R = 0.312)

between the variables. The model explained a modest proportion (10.9%) of the variability in the dependent variable (R-squared = 0.109), with a Durbin-Watson value of 2.404, suggesting mild positive autocorrelation. The model was statistically significant ($p < 0.001$), indicating its appropriateness for the data.

These regression analyses provide valuable insights into the relationships between technology adoption, employee factors, and supply chain efficiency. While the explained variations are moderate to low, the statistically significant results underscore the importance of the considered factors. Organizations can leverage these findings to make informed decisions about technology integration and employee-related strategies to enhance their supply chain efficiency.

Conclusion

This study sheds light on the intricate relationships between technology adoption,employee factors, and supply chain efficiency within the context of our examined industry. The findings of this study emphasize that the ease of use of technology plays a pivotal role ininfluencing supply chain efficiency. User-friendly interfaces and streamlined technological solutions can drive operational improvements, aligning with existing literature in the field. Furthermore, the study showcases the importance of employee engagement, experience, and facilitation of tools. Engaged and experienced employees, coupled with tailored software tools, have the potential to significantly contribute to supply chain performance enhancement

Academic Implications

This study contributes to the existing body of knowledge in the field of supply chain management by providing empirical evidence of the relationships between technology adoption, employee factors, and supply chain efficiency. The study extends the understanding of how both technological and human-centric aspects interact to shape supply chain outcomes

Theoretical Implications

A greater comprehension of how technological interventions affect sustainable development is suggested by the theoretical ramifications of looking into the mediating effects of technology adoption in the context of supply chain operations and efficiency. By clarifying the crucial role of technology as a mediator and throwing light on the complex dynamics influencing sustainable practices, this research adds to the body of knowledge on supply chains.

Managerial Implications

From a managerial perspective, the findings of this study have several practical implications for supply chain professionals and decision-makers. The emphasis on the ease of use of technology underscores the importance of investing in user-friendly technological solutions. Organizations should prioritize the development of interfaces and tools that are intuitive and require minimal

Training for employees. This can lead to quicker adoption rates and a smoother integration of technology into daily operations, ultimately enhancing supply chain efficiency.

Future Scope of the study

One potential direction is to investigate the impact of different types of technology on supply chain efficiency. For example, exploring the effects of emerging technologies such as block chain, artificial intelligence, or the Internet of Things on supply chain processes could provide valuable insights into the changing landscape of supply chain management

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