

ROLE OF DIGITAL SUPPLY CHAIN TECHNOLOGIES (E.G., IOT, BLOCKCHAIN) IN ENHANCING ORGANIZATIONAL SUSTAINABILITY

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ABSTRACT

The demand for sustainable efficiency in supply chains in the emerging economies has a two-fold challenge in the age of swift digitalization. The paper examines the importance of digital supply chain technology, especially the Internet of Things (IoT) and blockchain, in improving organizational sustainability among companies in Karachi, Pakistan. The addressed problem is the lack of empirical support regarding the role of these technologies on the environmental, economic, and social performance of the local industries. The first research question is how exactly the adoption of digital technology influences sustainable organizational performance.

It was a formal quantitative research study, administered through a survey questionnaire sent to 350 professionals in supply chains across both manufacturing and service industries. Reliability was assessed using Cronbach's alpha (>0.80), and regression analysis was conducted in SPSS. The findings evidence that the moderate assumption that the adoption of digital supply chain technologies is positively related to sustainability performance is statistically significant ($R^2 = 0.47$, $p < 0.01$).

Among the most notable findings is that blockchain enhances traceability and accountability, while IoT facilitates real-time tracking and minimizes waste. The research provides guidelines for new projects to be built that incorporate digital infrastructure and education, as well as government incentives and investments, to foster the development of technology in supply networks. The results have significant implications for business executives and policymakers who seek to integrate sustainability objectives into their supply operations.

Keywords: Digital Supply Chain, Organizational Sustainability, Internet of Things (IoT), Blockchain Technology, Regression Analysis

INTRODUCTION

In today's global competitive landscape, institutions must face the pressure of improving their operational efficiency while ensuring the sustainability of their products. The integration of the latest digital technologies into the supply chain work process, including the Internet of Things (IoT), blockchain,

artificial intelligence (AI), and big data analytics, has led to a shift in its capabilities, enabling sustainable growth in organizational development. Such technologies automate processes and enhance visibility, but they also enable the optimization of resources, reduction of waste, and a decrease in

carbon footprints (Bag et al., 2021). The concept of the digital supply chain has therefore emerged as a strategic tool helping entities to balance the objectives of their operations with environmental and social concerns.

Organizational sustainability encompasses the economic, environmental, and social aspects of sustainability. Organizations are becoming increasingly concerned about sustainability, viewing it as more than just a compliance topic, as they adopt more advanced technological solutions to shape it into a means of innovation and long-term growth (Dubey et al., 2022). The implementation of a digital supply chain facilitates improvements in traceability, transparency, and responsiveness, allowing firms to curb potential risks and undertake data-driven decisions that underpin sustainable results.

In developing economies like Pakistan, the digital transformation of supply chains is still in its early phase, particularly in urban areas such as Karachi. Although most companies have begun deploying digital technologies, there is a scarcity of empirical studies that evaluate the outcomes of such interventions on organizational sustainability. This paper aims to bridge the gap by investigating the association between the use of digital supply chain technology and sustainable organizational development within the context of Karachi-based companies.

Problem Statement

Although the increasing attention to digital technology in the field of supply chains highlights the strategic value of digital technologies in supply chains, a gap still exists in empirical evidence that analyzes the role of digital technologies in achieving sustainable organizational results, especially in the developing world. Although various industries in Pakistan have begun deploying digital tools that incorporate the use of IoT and blockchain, the direct impact on an organization's sustainability remains unestablished. Most of the firms do not have a defined system or knowledge on how the digital transformation of the supply chain can contribute to long-term sustainable growth. Therefore, a lack of localized, evidence-based information hinders the formulation of policies and strategic decision-making. Thus, the research aims to examine the impact of deploying digital supply chain technology

on sustainable organizational development within enterprises established in Karachi.

Research Objectives

1. To investigate the degree of digital supply chain technology, the use of (e.g., IoT, blockchain) within organizations in Karachi.
2. To assess the effect of the digital supply chain technologies on the environmental, social, and economic aspects of organizational sustainability.
3. To determine challenges and facilitators of digital supply chain transformation towards sustainable organization growth.

Literature Review

Digital Technologies in Supply Chain Management

Advances in electronic technologies have transformed the traditional supply chain management process by allowing real-time data gathering, high-level analysis, and decision-making. The Internet of Things (IoT), blockchain, cloud computing, and artificial intelligence (AI) provide an end-to-end perspective on the supply chain, enabling companies to respond to changes and eliminate inefficiencies promptly (Queiroz et al., 2022). Responsiveness and transparency are achieved through the tracking and control of inventories and equipment health, as well as logistics processes, made possible by IoT-enabled solutions (Choi et al., 2022). Blockchain eliminates the possibility of data mutability and ensures the safe transfer of data across the supply chain, making the risk of fraud very limited and traceability high.

Sustainable Organizational Growth

According to the definition, sustainable growth is the capacity of an organization to sustain its long-term profitability with minimal or no significant negative effects on the environment and society. It involves striking a balance between economic considerations, environmental protection, and social justice (Bag et al., 2021). In that regard, technologies in digital supply chains could facilitate a balance between operational convenience and sustainability. Research has indicated that the incorporation of online technologies has the potential to minimise waste, carbon emissions, and enhance resource utilization—thus making the environment sustainable (Jabbour et al., 2020).

Digital Supply Chains and Environmental Performance

Some of them have also inspired the supportive connection between digital transformation and environmental performance. An example is provided by Manavalan and Jayakrishna (2019), who concluded that digitally integrated supply chains significantly contribute to energy efficiency and waste management. The possibilities of tracking resource use and emissions within the supply chain to ensure sustainability reporting and adherence to environmental laws are enhanced by the presence of blockchain and IoT.

Digitalization and Social Responsibility

Besides sustainability advantages, digital technologies also contribute to social responsibility by improving working conditions, facilitating the ethical sourcing process, and increasing supply chain transparency. As an illustration, Dubey et al. (2022) noted that blockchain technology can be utilized to trace the origin of raw materials and ensure that suppliers adhere to labor and human rights standards. Such an ability not only reduces social risks but also enhances brand image and stakeholder confidence.

Barriers to Adoption in Developing Economies

Nonetheless, the deployment of digital supply chain technologies in Renaissance countries is associated with several constraints, such as the high costs of implementation, the digital infrastructure shortage, and the inadequate level of technical skills (Kache & Seuring, 2020). In the case of Pakistan, the digital preparedness is still in progress, especially with SMEs. Such constraints are counterproductive to community organizations that can only fully utilize digital tools to support long-term growth and therefore require capacity building, investment, and policy assistance.

Research Gap

As we see, international literature on digital supply chains and sustainability is growing; however, empirical evidence on developing economies such as Pakistan is limited. The connection between the adoption of digital technologies and sustainable organizational performance has not been studied thoroughly, especially within the industrialized urban centers like Karachi. This study aims to address this

gap by examining the quantitative evidence of how digital technologies affect sustainability dimensions within the supply chain scenario.

Theoretical Framework

The paper has been built on the Resource-Based View (RBV) and the Technology-Organization-Environment (TOE) construct to look at the importance of engaging digital supply chain technologies in increasing the sustainability of an organization.

Resource-Based View (RBV)

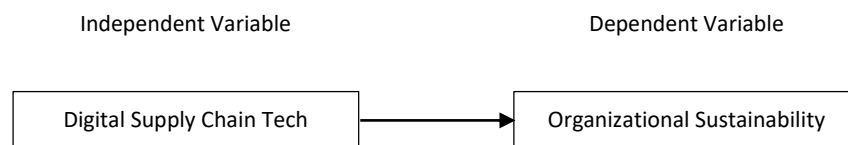
Resource-Based View (Barney, 1991) suggests that organizations can maintain sustainable competitive advantage through obtaining valuable, rare, inimitable, and non-substitutable (VRIN) resources and utilizing them competently. In its terms, IoT, blockchain, and big data analytics are digital supply chain technologies that fit the description of strategic resources in the current study. Once duly intertwined with the supply chain activities, these technologies guarantee the augmentation of the organizational potential in terms of the optimization of processes, transparency, and risk prevention, being the requisite for sustainability. According to the RBV, companies that take advantage of such distinctive features of digital capabilities are more likely to apply environmentally and socially responsible strategies, thereby realizing long-term growth (Agyabeng-Mensah et al., 2020).

Technology-Organization-Environment (TOE) Framework

The TOE framework (Tornatzky & Fleischer, 1990) describes the role of the technological, organizational, and environmental factors in the process of adoption of innovation in firms. The technological environment involves an evaluation of perceived utility and compatibility on digital devices such as IoT and blockchain. Organizational context comprises the size of the firm, top management support and technical preparation. The environmental scenario considers the competitive pressure, regulatory concerns, and industry standards. The use of the TOE framework in this research is useful in providing insight into the impact of both internal and external elements on the adoption of digital supply chain technologies and

their importance in the attainment of sustainability goals (Nguyen et al., 2022).

Collaboratively, RBV and TOE offer a robust theoretical framework to affirm how and why organizations apply digital technologies to their supply chains and how those may deliver a sustainable result within the organizations.



Study Hypothesis (H1):

The adoption of digital supply chain technologies such as IoT and blockchain is strongly positively correlated with the organizational sustainability of firms in Karachi.

Research Methodology

Research Design

This research paper utilised a quantitative, cross-sectional, and explanatory research design to examine how the adoption of digital supply chain technologies could affect organizational sustainability. Quantitative research enables the gathering of numerical figures that can be analyzed using statistics to determine the truth behind a certain hypothesis and the pattern that emerges (Creswell & Creswell, 2018). We selected a structured survey that allowed gathering data among professionals involved in supply chain jobs in various business areas in the city of Karachi, Pakistan.

Population and Sample

The intended audience was professionals in 1) supply chain management, 2) operations management, 3) information technology, and 4) senior management of manufacturing, logistics and retailer companies that operate in Karachi. 350 respondents were sampled using non-probability purposive sampling, as they had a minimum of 2 years in the implementation or management of digital supply chains.

The choice in the form of purposive sampling could be explained by the fact that the topic of the research was highly specialized, and thus required informed respondents (Etikan et al., 2016). Sample size was

Conceptual Framework

The conceptual framework of this study illustrates the hypothesized relationships between the adoption of digital supply chain technologies and organizational sustainability outcomes, supported by the RBV and TOE frameworks.

identified due to the similarity of these quantitative studies and the minimal number required for multiple regression analysis (Tabachnick & Fidell, 2019).

Instrument Development

Validated scales were identified in the past literature and used to make a structured questionnaire. This questionnaire had three sections:

- **Section A: Demographics** (gender, age, job title, industry, years of experience)

- **Section B: Digital Supply Chain Technology Adoption**

- Items adapted from Queiroz et al. (2022) and Choi et al. (2022) measured the extent of use of IoT, blockchain, and data analytics.

- **Section C: Organizational Sustainability**

- Items covering **economic, environmental, and social sustainability** were adopted from Bag et al. (2021) and Jabbour et al. (2020).

A **5-point Likert scale** ranging from 1 (strongly disagree) to 5 (strongly agree) was used to measure responses.

Reliability and Validity

To achieve reliability, Cronbach's alpha was computed on every construct. The internal consistency was present as all values were above 0.70, which is acceptable (Hair et al., 2020). In the case of construct validity, factor analysis (Principal Component Analysis using Varimax type rotation) was done to establish unidimensionality of the scales. A review of convergent and discriminant validity was

conducted based on average variance extracted (AVE) and inter-construct correlations, respectively.

Data Collection Procedure

The data was gathered online and through field administration of surveys in six weeks. Informed consent and confidentiality were assured through the cover letter, which described the purpose of the study. The research ethics committee of the institution approved this study. Of the 400 questionnaires distributed, 350 valid answers were analyzed, and the effective response rate was 87.5 percent.

Data Analysis Techniques

The collected data were analyzed using **IBM SPSS Statistics 26.0**. The following techniques were applied:

- **Reliability analysis (Cronbach's Alpha)** to measure internal consistency.
- **Linear regression** to evaluate the impact of digital technologies on sustainability outcomes. Statistical significance was assessed at $p < 0.05$. The assumptions of regression (normality, linearity, multicollinearity, and homoscedasticity) were evaluated to ensure the validity of results.

Analyses and Interpretations

Table 1: Demographic Profile of Respondents (N = 350)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	190	54.3%
	Female	160	45.7%
Age Group	21–30 years	120	34.3%
	31–40 years	150	42.9%
	41–50 years	60	17.1%
	51+ years	20	5.7%
Position	Executive	110	31.4%
	Managerial	140	40.0%
	Senior Manager	60	17.1%
	Director/Owner	40	11.4%
Sector	Manufacturing	160	45.7%
	Retail	100	28.6%
	Logistics	90	25.7%

This table presents the demographic characteristics of the 350 respondents involved in the study. Among them, 190 (54.3%) were male and 160 (45.7%) were female, showing a balanced gender distribution. In terms of age, the majority were aged between 31 and 40 years (42.9%), followed by 21 and 30 years (34.3%), while fewer respondents were aged 41 to 50 years (17.1%) and 51 years or older

(5.7%). Regarding professional position, most respondents held managerial roles (40.0%) or were executives (31.4%), with a smaller proportion identified as senior managers (17.1%) or directors/owners (11.4%). The respondents represented various sectors, including manufacturing (45.7%), retail (28.6%), and logistics (25.7%), reflecting diverse industry participation in Karachi.

Table 2: Reliability Statistics (Cronbach's Alpha)

Scale	Number of Items	Cronbach's Alpha
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Digital Supply Chain Technologies	5	0.874
Organizational Sustainability	6	0.891

This table shows the internal consistency of the measurement scales used for the two primary constructs. The Cronbach's Alpha for "Digital Supply Chain Technologies" was 0.874, and for

"Organizational Sustainability," it was 0.891. Both values exceed the acceptable threshold of 0.70, indicating strong reliability of the measurement instruments used in the survey.

Table 3: Model Summary (Regression Analysis)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.712	0.507	0.504	0.582

The regression model summary indicates that the use of digital supply chain technologies explains 50.7% ($R^2 = 0.507$) of the variance in organizational sustainability. The adjusted R^2 value of 0.504 confirms the model's explanatory power remains

strong even when adjusted for the number of predictors. The R value of 0.712 suggests a high degree of correlation between the independent and dependent variables.

Table 4: ANOVA (Analysis of Variance)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	102.647	1	102.647	303.478	0.000
Residual	99.543	348	0.286		
Total	202.190	349			

$p < 0.01$ indicates the model is statistically significant.

This table evaluates the statistical significance of the regression model. The F-value of 303.478 is highly significant ($p = 0.000$), confirming that the model

significantly predicts organizational sustainability based on the use of digital supply chain technologies. The results support the hypothesis that digital technologies play a meaningful role in sustainability outcomes.

Table 5: Coefficients

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	
(Constant)	1.783	0.152	—	11.726
DSC Tech Use	0.694	0.040	0.712	17.426

This table provides the coefficients from the regression equation. The unstandardized coefficient (B) for the use of digital supply chain technologies is 0.694 with a standard error of 0.040, and the standardized beta coefficient is 0.712, indicating a strong positive influence on organizational sustainability. The t-value of 17.426 and significance level ($p < 0.01$) further confirm the robustness of this relationship.

Discussion

This study aimed to understand how digital supply chain technologies, namely IoT, blockchain, and big data analytics, affect the sustainability of organizations. Findings of regression analysis indicated that there is a positive and statistically significant correlation between the adoption of digital supply chain technologies and sustainability outcomes ($R^2 = 0.507$, $p < 0.01$). This shows that the adoption of digital supply chain tools had the potential of explaining more than 50 per cent of the

variance in organizational sustainability. Such results tally well with the theoretical predictions by the Resource-Based View (RBV) as well as the Technology-Organization-Environment (TOE) framework.

The significant positive relationship shown by the positive regression coefficient (0.694, $p < 0.01$) implies that companies that adopt advanced digital instruments are in a better position to realize long-term sustainability objectives. Such technologies increase visibility, operational efficiency, and responsiveness, which are vital in lessening waste, maximizing resources, and being in line with standards, regulatory and environmental (Bag et al., 2021; Dubey et al., 2022).

The findings of this research are consistent with previous findings in developed and emerging economies. As an example, Choi et al. (2022) concluded that the use of digital technologies in the supply chain enhances decision-making processes and the level of traceability and reduces transaction costs, which contributes to sustainability. On the same note, Queiroz et al. (2022) have pointed out that blockchain and IoT not only automate the logistics part but also make the sourcing and inventory management more accountable, which is also socially and environmentally responsible.

The findings also verify those made by Jabbour et al. (2020), who observed that organizations that invested in Industry 4.0 technologies showed an improved level of environmental performance due to enhanced monitoring and control over emissions and energy consumption. When it comes to Karachi, which is home to one of the biggest industrial centers in Pakistan, the technologies currently being discussed have been effectively deployed by several companies, especially those operating in the manufacturing and logistics industries, to increase the level of sustainability.

Moreover, findings also reinforce the value of technological capability as a strategic resource as implied by RBV. There is also a competitive advantage in the digital transformation of the supply chains, resulting in increased agility and cost reduction, which also serves the mandate of corporate social responsibility (Barney, 1991; Agyabeng-Mensah et al., 2020).

Although such results are positive, differences were also detected between sectors. Although large

organizations were associated with greater digital adoption and sustainable results, small and medium enterprises (SMEs) are behind in adopting technology, especially due to insufficient resources and infrastructure, which was also noticed by Kache and Seuring (2020). It implies that special policies and incentives are required to promote SME digitalization in Pakistan.

Overall, the paper has contributed to the emerging body of studies on sustainable supply chain management by offering empirical evidence on the developing country-level perspectives. It highlights the idea that digital technologies are not only tools of operation but are also strategic capabilities and thus, they promote the sustainable value creation in economic, environmental, and social dimensions.

CONCLUSION

The paper investigated how digital supply chain technologies, namely the IoT and blockchain, can influence the sustainable development of organizations in Karachi. The results of the regression analysis, which included a sample of 350 respondents, indicated that there is a positive and statistically significant relation between the use of digital supply chain technologies and organizational sustainability. Such technologies not only improve the efficiency of operations, but they also lead to higher environmental, economic, and social performance. Those organizations that successfully incorporate these technologies achieve a higher rate of transparency, traceability, and waste prevention, which are the most vital measurements of sustainability (Bag et al., 2021). This paper confirms the possibility of digital transformation of supply chains being a strategic driver of sustainability in such emerging markets as Pakistan.

RECOMMENDATIONS

Digital Infrastructure Investment Strategy

The companies are advised to invest in IoT sensors, blockchain-based platforms, and real-time data analytics to enhance supply chain efficiency in a complex environment (Dubey et al., 2022).

Training and Skill Learning

Development of human capital is of the essence. Technical training should be given to the workers to operate the digital supply chain system in the firms.

Government Policy and Incentives

Policy makers should create tax advantages and rewards to the companies investing in digital technologies based on sustainability objectives (Sial et al., 2021).

Collaborative Ecosystems

Promote partnerships among technology providers, supply chain members, and research institutions to enhance innovation and environmental sustainability in the industries.

LIMITATIONS

The research work involved only the firms located in Karachi, and this does not provide a full representation of the rest of the industrial sector in Pakistan. Also, it is subject to response bias when structured questionnaires are used to collect self-reported data, which can distort the results. It has expanded on only two technologies (IoT and blockchain) and excludes other technologies, which also determine sustainability, including AI and big data analytics.

SIGNIFICANCE OF THE STUDY

The study gives realistic evidence of the influence of digital supply chain technologies in facilitating organizational sustainability. It adds to the current body of knowledge by addressing a knowledge gap in a regional context, specifically in the case of Pakistan, and it has practical implications to guide business leaders and policymakers on integrating the sustainability objectives into business practice. Furthermore, the paper supports theoretical assumptions like the Resource-Based View and the Technology-Organization-Environment that prove the mutual impact of the combination of internal capability (readiness) and external readiness on sustainable results.

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