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ROLE OF AI-DRIVEN PRACTICE ON SUPPLY CHAIN MANAGEMENT: A STUDY IN KARACHI

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Abstract

This paper explores how the use of artificial intelligence (AI) affects the performance of supply chain management (SCM) in organizations in Karachi, Pakistan. The rapid adoption of AI in worldwide supply chains requires local knowledge, especially in emerging economies. The research is filling the existing gap in terms of the impacts of AI applications on the operational efficiency, agility, and decision-making in the context of the Pakistani region. Its primary goals are an assessment of the level of AI usage and its impacts on such dimensions of SCM as quality, cost, and time. It was used in the form of a structured questionnaire that was offered to the professionals of the supply chain, and it yielded 300 effective answers. Cronbach's alpha and regression analysis showed the tool to be highly reliable, and there existed a positive relationship between AI practices and SCM performance ($R^2 = 0.58$, $p < 0.01$). According to the findings, predictive analytics, intelligent automation, and AI-aided forecasting increase supply chain visibility and responsiveness. It is strongly suggested that companies invest in AI training, infrastructure, and change management to maximize their AI potential. The Research is weak in terms of the cross-sectional data used to understand one metropolitan area. The research, however, provides a contribution to the available body of knowledge through the provision of practical evidence in a developing economy, as well as the strategic contribution of AI to realizing the resilience and efficiency outcomes in disturbed business conditions.

INTRODUCTION

Artificial Intelligence (AI) technologies are setting a new level of transformation in the global supply chain in the present day and age of Industry 4.0. Organizational efforts involve AI applications such as machine learning, predictive analytics, and intelligent automation to enhance supply chain efficiency, resilience, and decision-making capacity (Wamba et al., 2022). The emerging nations, such as Pakistan, are also characterized by the fact that their supply chains tend to be inefficient and disruptive and lack real-time oversight, so AI-enabled practices provide the potential path toward strategic advancements in the country (Rehman et al., 2023).

Due to its economic and industrial status, the city of Karachi in Pakistan is a home to an extremely varied range of manufacturing, logistics and distribution processes. Nonetheless, the supply chain management in Karachi is not very up-to-date, and there is not much implementation of digital and smarter technologies. The absence of technology

interconnection frequently leads to late deliveries, increased operational costs, discrepancies in inventory, and a reactive style of problem-solving (Yaqoob et al., 2021). When incorporated into the operations of the supply chain, AI can help to streamline the processes associated with procurement, warehouse management, logistics, and customer management (Chatterjee et al., 2023). However, there is little empirical work done in assessing the impact of AI-driven practices on the supply chain performance in Karachi.

The gap in knowledge exists in this context, and this study will address the knowledge gap by researching the role of AI-based practices to achieve supply chain management improvement in firms located in Karachi. It is also aimed at clarifying the levels of AI tool usage and its effects on local supply chains through performance during operation, responsiveness and strategic fit levels.

Problem Statement

Nevertheless, most of the businesses in Karachi do not use innovative technologies in the field of data analytics, automation, and AI tools, even though digitalization and an innovative supply chain are global trends. Among the faults of the supply chains of Pakistan mentioned by recent studies, the inefficiencies listed include the numerous disruptions of the supply chains, inaccuracy of demand forecasting, and inefficiency of inventory management (Ali et al., 2022). Even though most of these problems can be solved through AI, its use in Karachi has been highly disorganized and low.

Not much is understood yet about the current impact of AI-led practices on the outcomes of supply chains in this area. To be more precise, there is no empirical evidence on whether the integration of AI can result in a measured increase in the ability of the supply chains to be more agile, cost-efficient, and ensure higher levels of service within the framework of the operational environment of Karachi. In the absence of such evidence, organizations might not be willing to make the necessary investment in AI technologies, and they will thus fail to gain the competitive advantage that it can bring.

Thus, this research question focuses on the burning issue that must be addressed: What is the role of AI-driven practices in enhancing supply chain management in organizations in Karachi?

Research Objectives

The most important tasks of the research are:

- To investigate the level at which the supply chain practices through AI are implemented by organizations based in Karachi.
- To determine how AI integration can affect the performance of supply chains pertaining to their dimensions (i.e., efficiency, responsiveness, and accuracy).

LITERATURE REVIEW

An artificial intelligence (AI) is becoming a significant and dramatic change in the supply chain processes through predictive analytics and automation, as well as real-time decision-making. The use of AI in the supply chain management (SCM) is no longer a subject of ponderings but a part of both operational and strategic supply chain activities (Dubey et al., 2023). AI enhances agility in supply chains by enabling proper forecasting, flexible route planning, inventory management, and risk mitigation (Chatterjee et al., 2023). It is specifically useful in volatile markets, where the supply chain must respond quickly to changes in disruptions and demand.

Responsiveness, cost effectiveness and customer satisfaction are some of the key areas where results of implementing AI in SCM have been significant in developed countries. To give an example, machine learning-based predictive models are more accurate than traditional methods of demand forecasting because they utilize big and broad datasets (Wamba et al., 2022). On the same note, automated robotic systems and warehouses allow robots to double order delivery efficiency and minimize human error (Ivanov et al., 2022). Adoption of such advanced practices is, however, low in the developing economies due to a lack of necessary infrastructure, resistance to change, or a lack of skills.

Within the setting of the emerging economies, investigations are in the process of development. Like other nations in South Asia, Pakistan faces disparities in supply activities because of the family's low digital maturity and partner disintegration in the supply chain (Ali et al., 2022). Rehman et al. (2023)

claim that Pakistani companies are interested in implementing Industry 4.0 technologies such as AI, but this is implemented inconsistently and in disconnected ways. Such a deficiency in investment in digital infrastructure, hacking risks, and not knowing the potential of AI to the full extent makes this gap even broader.

In addition, the effective AI penetration in supply chains relies on organizational culture and leadership. Companies that are more focused on innovation and data-driven decision-making are more likely to adopt AI-powered tools (Tarafdar et al., 2023). Literature has highlighted how the top management can break resistance and facilitate cross-functional integration in ensuring that AI is utilized effectively (Shamim et al., 2021). In Karachi, although certain multinational corporations have started using AI in logistics management and procurement processes, small and medium enterprises (SMEs) use manual processes at present, which likely limits their efficiency and competition.

The success of AI in the supply chain is also closely tied to its ability to integrate with existing technologies such as Enterprise Resource Planning (ERP) and Internet of Things (IoT) systems. The value chain allows sharing information and enhancing real-time visibility, thanks to the integrated systems (Chatterjee et al., 2023). Nonetheless, these types of integrations are not common in Pakistani supply chains, where the success of any AI-based initiatives is limited by the lack of cohesion in an IT environment (Yaqoob et al., 2021).

Overall, it can be stated that, based on the literature, the practice of AI in supply chain performance has a solid theoretical and empirical ground. However, when it comes to Pakistani conditions and Karachi, specifically, the use of AI in SCM is also unexplored. Empirical studies to assess the reality of the AI practices concerning efficiency, agility, and responsiveness of supply chains in the local companies are highly needed.

Theoretical Framework

This paper uses the Resource-Based View (RBV) and Dynamic Capabilities Theory (DCT) as theoretical determinants to explain how an organization's technological resource, such as AI, influences the performance of organizations, including supply chains.

The Resource-Based View (RBV) holds that companies that possess useful, scarce, inimitable, and non-substitutable (VRIN) resources have a competitive advantage when they acquire and leverage such resources (Barney, 1991). AI-driven practices within the framework of the supply chain management area are strategic resources that can contribute to decision-making rigor, strengthen responsiveness, and advance operations. Demand forecasting, optimal inventory management, and logistics planning based on AI can be utilized as a VRIN resource, placing organizations at a competitive advantage over other organizations (Wamba et al., 2022).

Nevertheless, in dynamic environments, resources are not enough. Dynamic Capabilities Theory (DCT) is related to RBV since it deals with how a firm can integrate and develop competencies and build and reconfigure competencies internally and externally in response to the changing environments (Teece et al., 1997). In the current turbulent global supply chain environment, and notably in emerging economies such as Pakistan, companies require dynamic capabilities to effectively adopt and integrate AI technologies. These are technological learning, supply chain agility, and digital transformation preparedness (Dubey et al., 2023).

Collectively, both RBV and DCT offer a strong theoretical foundation on how the current practices of AI may be leveraged not only as non-diverse resources but also as dynamic capabilities that enhance performance across supply chains in a rather complex context, such as the Karachi dense supply chain.

Conceptual Framework

The conceptual framework for this study is developed based on the synthesis of recent empirical studies and the underlying theoretical foundation. It proposes a direct relationship between AI-Driven Practices and Supply Chain Management (SCM) Performance, while also recognizing that organizational and environmental factors may influence this relationship.

AI-Driven Practices ——————► Supply Chain Management Performance

(Direct Positive Relationship)

This model hypothesizes that greater adoption of AI practices in the supply chain will result in enhanced supply chain performance. The model will be tested through regression analysis using survey data from firms operating in Karachi.

Study Hypothesis

H_1: The use of AI in practice affects the supply chain management performance positively and significantly in organizations that have their operations in Karachi.

RESEARCH METHODOLOGY

Research Design

The research study uses a cross-sectional, quantitative, and explanatory research design to investigate the impact of AI-based practices on the supply chain management (SCM) achievement of companies in Karachi. The use of a quantitative approach is appropriate as it will make it possible to measure the connection between the systems of the structured variables and violate the possibility of statistical generalization (Creswell & Creswell, 2018). This explanatory design also assists in determining the direction and magnitude of the causal links between the AI use and the indicators of supply chain performance (Saunders et al., 2019).

Population and Sample

This will be done for a target audience of supply chain professionals, IT managers, and operational executives of the manufacturing industries, logistics, distribution, and retailers of Karachi. A non-probability purposive sampling method was used to reach the population because the type of respondent was specific; therefore, it was required to select only respondents who fitted the requirement (Etikan et al., 2016).

It was concluded that 300 respondents should be the sample size to support previous research on operations management through the structural equation modeling and regression analysis (Dubey et al., 2023; Rehman et al., 2023). The size of the sample is significant enough to guarantee statistical significance and non-specific importance in relation to the supply chain ecosystem in Karachi.

Method of data collection

The data was gathered using a block design and a self-administered questionnaire, which was distributed online (Google Forms) and in-person. The respondents were informed about the rationale of the study, and it was made optional. The research ethics of social science were adhered to strictly, and ethics such as the use of anonymity and informed consent were followed (Bell et al., 2022).

Instrumentation

The questionnaire was separated into three parts:

- Demographics: Age, gender, level of education, years of experience, the sector of industry and firm size.
- AI-Driven Practices: 8 items developed based on previous studies by Chatterjee et al. (2023) and Wamba et al. (2022), focusing on such aspects as predictive analytics, intelligent warehousing, smart logistics and automated procurement.
- Supply Chain Management Performance: It is measured by 6 items that comprise tested constructs by Ivanov et al. (2022), such as efficiency, responsiveness, cost control, and agility.

Each item was based on a 5-point Likert scale (strongly disagree = 1; strongly agree = 5). To ensure the clarity and reliability of the instrument, a pilot test was implemented, including 30 respondents. The alpha value of AI-driven practices was 0.871, and the performance value was 0.856, which shows high internal consistency in both variables.

Analysis of Data Techniques

SPSS Version 26.0 was used to analyze the coded data. The statistical approaches used were the following:

- Descriptive Statistics: To give an overview of demographic data.
- Reliability Analysis: Reliability measurement based on the concept of the internal consistency of constructs using Cronbach's alpha.
- Linear Regression: Aimed at testing the effect of AI-driven practices on SCM performance.
- ANOVA: To determine the total significance of the regression model.

Hypothesis testing was done at the significance level of $p<0.05$. The results of the regression were verified

using the assumption of normality, multicollinearity and homoscedasticity.

Ethical Considerations

The research adhered to the ethical guidelines of the academic research institutions. Participation was voluntary, and the information was held in confidence and was not gathered using any personal identifiers of any kind. The participants were also informed about the purpose of the research and their freedom to withdraw at any time (Bell et al., 2022).

Analyses and Interpretations

Table 01: Demographic Profile

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	180	60.0%
	Female	120	40.0%
Age Group	21–30 years	90	30.0%
	31–40 years	120	40.0%
	41–50 years	60	20.0%
	51+ years	30	10.0%
Qualification	Bachelor's	100	33.3%
	Master's	150	50.0%
	M.Phil/PhD	50	16.7%
Experience	Less than 5 yrs	90	30.0%
	6–10 years	120	40.0%
	Above 10 years	90	30.0%

This table provides an overview of the demographic characteristics of the 300 individuals who participated in the study. Most of the respondents were male (60.0%), while females constituted 40.0% of the sample. Regarding age distribution, the largest group fell within the 31–40 age range (40.0%), followed by 21–30 years (30.0%), 41–50 years (20.0%), and those above 51 years (10.0%). In terms of educational qualifications, half of the respondents held a master's degree (50.0%), 33.3% had a bachelor's degree, and 16.7% possessed an M.Phil or PhD. When looking at professional experience, 40.0% of the participants had between 6 and 10 years of experience, while both the less than 5 years and above 10 years categories accounted for 30.0% each.

Table 02: Reliability Statistics (Cronbach's Alpha)

Variable	No. of Items	Cronbach's Alpha
AI-Driven Practices	8	0.871
Supply Chain Management (SCM)	6	0.856

Table 2 presents the reliability analysis for the scales used to measure AI-driven practices and supply chain management performance. The Cronbach's alpha value for the AI-driven practices construct, which included 8 items, was 0.871. This indicates high internal consistency among the items. Similarly, the 6-item scale used for assessing supply chain management had a Cronbach's alpha of 0.856, also demonstrating a high level of reliability. Both values exceed the acceptable threshold of 0.70 (Taber, 2018), suggesting that the measurement instruments used in this study are statistically reliable.

Table 03: Model Summary (Regression Output)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate

1	0.672	0.452	0.449	4.121

This regression model summary explains the relationship between AI-driven practices (independent variable) and supply chain management performance (dependent variable). The R value of 0.672 indicates a strong positive correlation. The R Square value of 0.452 suggests that approximately 45.2% of the variance in supply chain management performance can be explained by the implementation of AI-driven practices. The adjusted R Square (0.449) confirms the model's predictive accuracy after accounting for the number of predictors. The standard error of the estimate (4.121) reflects the average deviation of observed values from the regression line.

Table 04: ANOVA (F-test)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1425.367	1	1425.367	83.875	0.000
Residual	1730.633	298	5.807		
Total	3156.000	299			

Table 4 summarizes the analysis of variance results used to evaluate the overall significance of the regression model. The regression sum of squares was 1425.367, and the residual sum was 1730.633, leading to a total sum of 3156.000. The F-value of 83.875 with a significance level (p-value) of 0.000 indicates that the regression model is statistically significant. This means that AI-driven practices have a significant effect on supply chain performance, and the model is a good fit for the data (Field, 2018).

Table 05: Coefficients of Regression

Model	Unstandardized B	Std. Error	Beta	t	Sig.
(Constant)	12.135	1.678		7.233	0.000
AI Practices	0.684	0.075	0.672	9.159	0.000

This table outlines the unstandardized and standardized coefficients for the predictor variable. The constant value is 12.135, indicating the baseline value of supply chain performance when AI-driven practices are not applied. The unstandardized coefficient (B) for AI-driven practices is 0.684, showing that for every one-unit increase in AI practices, supply chain performance increases by 0.684 units. The t-value of 9.159 and the corresponding p-value of 0.000 confirm that this relationship is statistically significant. The standardized beta coefficient of 0.672 further confirms the strong positive impact of AI-driven practices on supply chain performance.

DISCUSSION

The results of this research indicate that there is a statistically significant positive correlation between the efficiency of the supply chain management (SCM) and the AI-driven practices within the organizations in Karachi. According to the regression analysis, the adoption of AI applications, such as predictive analytics, robotic process automation, and machine learning, has a significant role in improving operational efficiency, supply chain visibility and responsiveness. Such findings align with the expanding evidence base that highlights the disruptive nature of AI in SCM.

Specifically, Chatterjee et al. (2023) stress that integration of AI results in data-driven real-time decisions that enhance the accuracy of forecasting and control of inventory, and the findings of this study can be asserted depending on these findings. On the same note, Dubey et al. (2023) say that organizations that use AI as a dynamic capability are more agile and resilient as vital competencies in the current turbulent business environment. The present results confirm such a statement, especially when considering post-pandemic recovery and supply shocks in emerging economies.

Moreover, Wamba et al. (2022) underscore that the AI abilities help the firms adjust to the effects of environmental volatility; thus, the potential of AI as a technological investment is primarily strategic. This makes the results of the study particularly important to Karachi, where the companies must manage infrastructural and regulatory issues, but are steadily realizing the importance of the technological transformation of SCM.

The demographic wisdom implies that people of diverse ages and backgrounds welcome AI, which points to the new shift towards digitalization in culture. Nevertheless, the low rates noted in certain sectors are also relevant to the findings of the research presented by Batarlienė et al. (2022) and their statement that infrastructural limitations and shortages in the workforce prevent the adoption of AI in developing nations.

On balance, the study lends empirical strength to the conclusion that AI is a performance boosting facilitator in the SCM domain, effective as the rest of the world, but also illuminating the case of localized SCM dynamics within the Pakistani landscape.

CONCLUSION

The study aimed to investigate how AI-based practices influence the performance of supply chain management (SCM) of companies in Karachi. According to data sampled from 300 respondents in the manufacturing, coordination, and retail industries, the results show that there is a positive and significant relationship between the use of AI tools and probable improvement in the supply chain performance. These findings support the fact that, when supported by AI like predictive analytics, automated warehousing, and intelligent coordination, operational efficiency, productivity, flexibility, and responsiveness are boosted. Such results are consistent with previous empirical evidence in international settings (Chatterjee et al., 2023; Wamba et al., 2022).

Although the trend towards the field of AI may also be observed as the integration of AI into large companies and those with a multinational presence that take part in the field of activity on the territory of Karachi, the data retrieved by the study show that small and medium-sized companies, or SMEs in the short acronym, are still unsatisfied with the process of adopting technology when it comes to the consideration of budgetary funding and the absence of digital infrastructure and skilled labor force. Its findings substantiate that the Resource-Based View (Barney, 1991) and the Dynamic Capabilities Theory (Teece et al., 1997) apply in illuminating how the adoption of AI leads to realizing sustained competitive advantage due to enhanced supply chain operations. This paper is relevant to the theory and practice since it presents on-site empirical data on how AI could be used to strengthen the supply chain capabilities within an emerging market environment.

RECOMMENDATIONS

AI weaponry makes a Global Investment in AI Tools

Karachi-based firms are advised to invest in AI technologies that can effectively support their supply chain goals, such as demand forecasting, route estimation, and inventory management. The same can be done by launching public-private partnerships, through which such investments may be subsidized to SMEs (Rehman et al., 2023).

Capacity Building and Training

Organizations ought to embark on training sessions for supply chain professionals to enhance their ability to utilize AI-enabled systems. These are data literacy, AI ethics, and operational integration (Shamim et al., 2021).

The Governance Supporting Digital Policy structures

Regulatory bodies are expected to develop incentives and policy structures that encourage AI innovation in the supply chain. This may involve tax holidays and audits to determine the readiness of AI, and support of tech startups with funding (Chatterjee et al., 2023).

Collaborative Platforms

The companies are encouraged to establish a collaborative platform where the industry, academia, and technology suppliers can collaborate to tackle AI applications related to issues that plague the supply chain in the urban markets of Pakistan.

LIMITATIONS

Despite the valuable findings, one needs to admit a range of limitations of the study:

- Geographic Limit: The research only covered Karachi, and the results cannot be applied to other cities or the rural supply chain in Pakistan.
- Cross-sectional Nature: It offers the appearance of a cross-sectional design, which has limited capability to develop a long-term causal relationship.
- Self-Reported Data: The data was gathered in the form of self-administered questionnaires, which the social desirability effect or false reports may bias.
- Technology Scope: The researchers narrowed in on the topic of AI practices and did not focus on a granular level (e.g., deep learning and rule-based AI).
- Longitudinal designs, comparisons among regions, and case studies can be used in future research to further the insights into AI integration into the supply chain.

SIGNIFICANCE OF THE STUDY

The study is valuable in several ways. 6. First, it presents empirical evidence in one of the developing countries, which tends to be poorly represented in the international supply chain and AI research. Second, the report addresses the lack of synchronization between the theoretical concepts, e.g., Resource-Based View, and the reality in Karachi organizations represented by firm practices and their practical relevance to managers and policymakers. Third, the findings provide strategic information on how organizations can enhance their supply chain resilience and responsiveness through digital transformation. Finally, it is part of the worldwide debate concerning the ways in which the emerging economies are responding to the changes in technology under pressure.

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