

ADOPTION OF SCM 4.0 IN PAKISTAN: INVESTIGATING PERCEIVED BENEFITS ON SUPPLY CHAIN OPERATIONS AND ORGANIZATIONAL OUTCOMES

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ABSTRACT

Global supply chains have been changed because of the fast-paced evolution of Industry 4.0 technologies, offering opportunities for efficiency, speed, and competitiveness. This paper discusses how the Supply Chain 4.0 technologies will be integrated into the environment of Pakistani manufacturing organizations, where digital transformation is still in its early stages. Compliance with the established theoretical frameworks and models, the research studies the contribution of such factors to enhanced organizational performance, such as artificial intelligence, big data analytics, and the Internet of Things. Survey data-based quantitative analysis gives the empirical findings regarding the depth of digital adoption and its connection with supply chain performance measures. These results point to the overall effectiveness of technological integration in terms of operational responsiveness and the overall productivity of the firm. Nevertheless, some obstacles are still affecting both small and medium-sized businesses, including poor infrastructure, technical capabilities and change aversion. The research provides viable recommendations to the organizations that seek to reinforce their chain systems by utilizing beneficial investments, strategic engagement, and employees. Secondly, it also highlights the importance of policy support in terms of creating a favorable climate of change to enable the adoption of digital. The study adds to the new stream of knowledge on Supply Chain 4.0 in the developing world and highlights its consideration in terms of national industrial modernization processes.

Keywords: Supply Chain 4.0, organizational performance, digital transformation, industry 4.0

INTRODUCTION

The emergence of Industry 4.0 has dramatically changed the supply chain world by injecting new advanced levels of digital technologies in the supply chain operations, specifically using the Internet of Things (IoT), Artificial Intelligence (AI), Big Data Analytics, Cyber-Physical Systems, and cloud computing. Together, they are known as Supply Chain 4.0, which will improve the efficiency,

transparency, responsiveness, and resilience of the entire value chain (Bag et al., 2021; Queiroz et al., 2022). The advanced economies have led in implementing SCM 4.0 tools, achieving upside in the form of enhanced operations agility, shorter lead times, and the ability to make decisions in real time (Ivanov et al., 2019).

On the other hand, developing economies like that of Pakistan have been sluggish adopters of this technological change because of a variety of factors, including infrastructural constraints, inability to use digital skills, lack of finance, and resistance to change (Rehman et al., 2022). Nevertheless, the re-designing of the supply chains by implementing SCM 4.0 technologies is being encouraged by the recent upsurge in digitalization, policy changes, and global competitors, which are compelling the Pakistani firms to re-strategize their supply chains (Ahmed & Khan, 2023).

Nonetheless, empirical information on the way these technologies are being viewed, embraced, and whether they make a considerable difference to operational and organizational performance in the Pakistani context is lacking. With the entry of more businesses in Pakistan into the digital transformation process, it is of utmost importance to discuss whether the investments in SCM 4.0 are leading to real returns to organizations that operate in a developing economy.

Problem Statement

Although the implementation of Supply Chain 4.0 technologies is on the rise worldwide, the empirical literature that explores their perceived effects on the performance outcomes in developing countries, such as Pakistan, is limited. Most of the available literature is concentrated on the technologically advanced economies, forming a contextual gap in terms of the understanding of the impact of SCM 4.0 on firms in the conditions of infrastructural, economic, and organizational limitations (Kamble et al., 2020). Moreover, Pakistani companies tend to implement technology without a sound analysis of the returns in terms of performance, an issue that is likely to lead to deficiencies in strategic orientation and efficiency. Hence, the research problem of SCM 4.0 acceptance as perceived by Pakistani professionals must be based on an empirical study on its extent of influence in terms of operational and organisational performances.

Research Objectives

- To find out how the adoption of SCM 4.0 impacts the performance outcomes of organizations, such as profitability, customer satisfaction, and competitiveness.

LITERATURE REVIEW

The element of the Supply Chain 4.0 (SCM 4.0) is known to come out of the larger context of Industry 4.0, which involves introducing the advanced technologies of the Internet of Things (IoT), Cyber-Physical Systems (CPS), Artificial Intelligence (AI), Big Data Analytics, and Cloud Computing into the conventional supply chain processes (Ivanov et al., 2019). They are meant to perform the entire supply chain with greater responsiveness, efficiency, and customization in real-time with data processing, predictive analytics, and autonomous decision-making (Queiroz et al., 2022).

Frank et al. (2019) have attributed the use of Industry 4.0 in supply chain management to improved operational performance, including reduced lead times, accurate and efficient inventory records, and optimized logistical operations. To be competitive in an ever-competitive world, companies with proper SCM 4.0 practices can leverage these practices to create more value for customers. Nevertheless, the advantages of SCM 4.0 are not universal in all situations and spheres since its implementation depends on the state of the organization, the technological base, management, and the staff (Bag et al., 2021).

Regarding operational performance, several studies have been cited to associate digital supply chain with improving the operational performance within the context of enhanced forecast accuracy, lowering operational costs, and higher process integration. As an example, Kamble et al. (2020) revealed that supply chain visibility and responsiveness of Indian manufacturing companies were notably enhanced by helping them monitor their processes and ensure high levels of visibility due to the implementation of IoT and real-time tracking. In the same line, Wamba and Queiroz (2020) emphasized that Big Data Analytics ensures an excellent level of operational agility by enabling supply chains to respond speedily to fluctuations and customer needs.

Conversely, SCM 4.0 adoption is also beneficial in terms of organizational performance, which involves profitability, innovation, productive and happy employees, and customer satisfaction of the organization. With evidence presented by Muller et al. (2018), projects of the digital transformation in companies carefully aligned with organizational purposes resulted in increased returns on

investment, customer engagement, and market advantage. The authors warn, however, that all the above can be achieved only if effective change management and technological integration within departments are realized.

Although developed nations have been seen to have quantifiable benefits from the implementation of SCM 4.0, the situation in a developing economy such as Pakistan is still unexplored. Rehman et al. (2022) argue that most of the Pakistani companies are in the early stages of digital transformation and that the main challenge includes low IT infrastructure, unawareness towards SCM 4.0 technologies, and poor human capital in terms of expertise. Also, the lack of a digital culture and restricted access to investment capital become additional barriers to the adoption process (Ahmed & Khan, 2023).

Within the Pakistani context, Ahmed and Khan (2023) highlighted that there is an increase in understanding of the technologies that make up the digital supply chain. However, their implementation remains unbalanced in different sectors. The manufacturing industries and retailing industries are in an enhanced situation of being more active, but SMEs are struggling with a lack of resources. These findings suggest the significance of empirical research conducted to examine the perceived influence of SCM 4.0 technologies on firm-level performances in Pakistan, since it can be modified by aspects of organizational dynamics, regulatory environment, and culture that might have different implications in an emerging market than developed markets.

Consequently, the gap in the literature is evident, as most of the global research proves the favorable consequences of SCM 4.0 on performance. However, little contextual knowledge has been available about how these people see and use these technologies in developing countries such as Pakistan. The study in this respect aims to fill this gap by investigating the perceived influence of SCM 4.0 technologies on the operational and organizational performance in Pakistani firms.

Theoretical Framework

The nature of the study is supported by two opposite theories, the Technology-Organization-Environment (TOE) Framework and the Resource-Based View (RBV). Such theories provide a structured framework

for understanding how and why organisations incorporate Supply Chain 4.0 technologies and how their incorporation can be matched to performance outcomes.

According to the Technology- Organization-Environment (TOE) Framework Tornatzky and Fleischer (1990) three context situations affect the adoption of new technologies of a firm; (1) technological context: availability and nature of relevant technologies, (2) organizational context: size of firms, resources, structure, and leadership and (3) environmental context: market factors, competition, and regulatory factors. The framework is especially applicable to the case of Pakistan because of its dynamic regulatory and infrastructural environment to which firms are subjected.

The TOE model has already been widely used to address the area of Industry 4.0 and digital transformation. As an example, Oliveira et al. (2019) applied the TOE framework to study the cloud computing adoption among SMEs and found technological readiness and external pressure to be important predictors. Gangwar et al. (2015) confirmed the TOE model in their research using IT adoption in various industries, highlighting the specific area of validity associated with emerging markets.

Resource-Based View (RBV), presented by Barney (1991), states that the competitive advantage of a firm is the result of its capacity to obtain and exploit resources of value, rare, inimitable, and non-substitutable (VRIN) nature. The technological advancements in SCM 4.0 can be considered as strategic resources under the right circumstances of inclusion into the processes of the firm. They help to improve the capabilities of the supply chains in areas like agility, responsiveness, efficiency and, therefore, performance (Wamba et al., 2020).

This research synthesizes TOE and RBV to discuss their enablers of adoption issues and the outcome of adoption. TOE provides an answer as to how SCM 4.0 technologies are adopted, whereas RBV answers as to why their adoption can improve both operative and organizational performance.

Conceptual Framework

Based on the above theoretical foundations, the conceptual framework of this study is structured around the following variables:

Adoption of SCM 4.0 Technologies
→ Organizational Performance
(Direct Positive Relationship)

Hypothesis of the study

H₁: Pakistani firms show a strong positive relationship between the adoption of Supply Chain 4.0 technologies and the performance of the organization.

RESEARCH METHODOLOGY

Research Design

This research employs a quantitative, cross-sectional survey to examine the perceived effect of Supply Chain 4.0 technologies on operations and organizational performance of Pakistani companies. Quantitative methodology is suitable to evaluate the theoretical connections and strength of associations between variables and do it systematically and with a statistically valid procedure (Creswell & Creswell, 2018). This is because the study is cross-sectional, allowing for the sampling of data at one time and providing a snapshot of how SCM 4.0 is being embraced and the perceived results in different industries.

Population and Sample

The target audience includes the supply chain teaching and learning, managers, and decision-makers in manufacturing, logistics, and retail companies in Pakistan. A non-probability sampling technique, called a purposive sample, was chosen because participants possess in-depth knowledge and experience about the topic of supply chain management and digital technologies. This approach is appropriate to the exploratory research on an emerging market where one cannot obtain the full sampling frame (Etikan et al., 2016).

There were 400 valid responses, which were gathered through both online and offline surveys. This sample is sufficient to be analyzed using multivariate analysis and structural modeling and provides a statistical power and a possibility to be generalized in the Pakistani setting (Hair et al., 2021).

Data Collection Instrument

The development of a structured questionnaire was done using validated scales in the literature. The

questionnaire was divided into four parts: (1) demographic profile, (2) the level of SCM 4.0 technology implementation, (3) the level of Operational Performance, and (4) the level of organizational performance.

- The level of adoption of SCM 4.0 consisted of questions designed by our team based on those used by Queiroz et al. (2022): IoT, Big Data Analytics, Cloud Computing, and Automation.
- The efficiency, lead time, flexibility, and cost reduction were used as the operational performance indicators based on scales according to Kamble et al. (2020).
- Performance in the organization was measured based on dimensions such as profitability, customer satisfaction, and competitiveness, as done by MULLER et al. (2018).

Each of the items was measured on a 5-point Likert scale (strongly disagree to strongly agree). It was done in a pilot test with 30 respondents to clarify and ensure the reliability of the instrument.

Data Analysis Technique

The data analysis was performed using IBM SPSS (version 26). The demographic information was summarized using descriptive statistics. The reliability was determined by Cronbach's alpha, whereby an alpha value exceeding 0.70 indicated the right internal reliability (Nunnally & Bernstein, 1994).

To investigate the hypothesized relationships, a multiple linear regression analysis was done. The model evaluated the effect of the use of SCM 4.0 (independent variable) on operational and organizational performance (dependent variables). R-squared, F-stat, and significance levels (p-value) were used to evaluate the model's fitness. The presence of assumptions was also evaluated in terms of normality, linearity, and multicollinearity.

Ethical Considerations

Ethical research was pursued in the study. The respondents were free to take part, and their will was informed before participating; they are anonymous. There was no disclosure or recording of any personal or organizational identifying information.

Analyses and Interpretations

Table 1: Demographic Profile of Respondents (N = 400)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	240	60.0%
	Female	160	40.0%
Age Group	21–30 years	160	40.0%
	31–40 years	150	37.5%
	41–50 years	60	15.0%
	51+ years	30	7.5%
Education	Bachelor's	170	42.5%
	Master's	190	47.5%
	MPhil/PhD	40	10.0%
Experience	Less than 5 years	110	27.5%
	5–10 years	180	45.0%
	More than 10 years	110	27.5%

The demographic analysis reveals that out of 400 respondents, 60% were male and 40% were female, indicating a higher male participation rate in the survey. Most respondents (77.5%) fell between the ages of 21 and 40, representing a young and professionally active population. Regarding education, 47.5% held a master's degree, while 42.5% had a bachelor's degree, and only 10% possessed an Mphil or PhD. This suggests that most

participants had sufficient educational qualifications to understand and respond to questions related to technological adoption. Experience levels were well distributed, with 45% having 5–10 years of experience, and both the categories “less than 5 years” and “more than 10 years” were represented by 27.5% each, showing a balanced mix of early-career and seasoned professionals.

Table 2: Reliability Analysis (Cronbach's Alpha)

Construct	No. of Items	Cronbach's Alpha
SCM 4.0 Technology Adoption	8	0.892
Operational Performance	6	0.865
Organizational Performance	5	0.878
Overall Scale Reliability	19	0.910

The reliability analysis of the scales used in the questionnaire shows excellent internal consistency. The SCM 4.0 Technology Adoption scale, composed of 8 items, achieved a Cronbach's Alpha of 0.892. Operational Performance and Organizational Performance scales had values of 0.865 and 0.878,

respectively. The overall reliability of the 19-item scale stood at 0.910, exceeding the commonly accepted threshold of 0.7, indicating the data collection instrument was reliable and consistent in measuring the intended constructs.

Table 3: Model Summary (Regression Analysis)

Dependent Variable: Organizational Performance

Model	R	R ²	Adjusted R ²	Std. Error of the Estimate
1	0.682	0.465	0.462	0.498

The regression model aimed to assess the effect of SCM 4.0 technology adoption on organizational performance. The model summary shows an R value of 0.682 and an R^2 value of 0.465. This indicates that the adoption of SCM 4.0 technologies can

explain 46.5% of the variance in organizational performance. The adjusted R^2 of 0.462 confirms that the model is statistically significant and fits the data well, suggesting a strong predictive relationship between the independent and dependent variables.

Table 4: ANOVA (Model Significance)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	89.412	1	89.412	360.15	.000
Residual	102.998	398	0.259		
Total	192.410	399			

The ANOVA results provide further evidence of the model's significance. The regression model's F-value is 360.15, and the significance level (p-value) is .000, which is well below the conventional alpha level of 0.05. This confirms that the overall regression model

is statistically significant and that the relationship between SCM 4.0 technology adoption and organizational performance is not due to random chance.

Table 5: Coefficients (Predictor: SCM 4.0 Adoption)

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	
(Constant)	1.204	0.148	-	8.135
SCM 4.0 Tech	0.635	0.033	0.682	18.973

The coefficients table shows that the unstandardized coefficient (B) for SCM 4.0 technology adoption is 0.635, with a standard error of 0.033. The t-value of 18.973 and a significance value (p-value) of .000 indicate a strong and statistically significant positive relationship between SCM 4.0 adoption and organizational performance. The standardized Beta coefficient of 0.682 further reinforces the strength of this relationship, suggesting that as the adoption of SCM 4.0 technologies increases, so does the organizational performance among firms surveyed.

DISCUSSION

In this research, the conclusion indicates the existence of a positive relationship between the adoption of Supply Chain 4.0 technologies and organizational performance that is very statistically significant among Pakistani firms. This finding is evidence of the theoretical supposition that, properly absorbed, digital technologies improve organizational functions and performance outcomes.

The positive relationship can be interpreted in line with the Resource-Based View (RBV) that adopts the

perspective that firms are able to achieve competitive advantage through the development and mobilization of valuable, rare, inimitable, and non-substitutable resources (Barney, 1991). The strategic adoption of technologies, namely Internet of Things (IoT), Artificial Intelligence (AI), Big Data Analytics, and Cloud Computing, can be considered as the source of intangible resources to increase efficiency, innovation, and responsiveness. Such digital abilities enable companies to make better decisions, minimize the number of operational failures, and enhance customer satisfaction, which are some of the leading organizational success factors (Wamba et al., 2020).

The results are further in line with recommendations that suggest the Technology-Organization-Environment (TOE) Framework because it focuses on environmental pressure, organizational support, and technological preparedness used to determine the outcomes of the adoption of a particular technology (Tornatzky & Fleischer, 1990). The companies in this research that applied SCM 4.0 innovation demonstrated improved performance outcomes, implying that with proper determination

in both technological readiness and planning methods, the digital transformation can also lead to enhanced competitiveness, profitability, and flexibility.

Empirical findings of the previous studies support the conclusions. According to Muller and colleagues (2018), examining examples like Industry 4.0, companies that implemented such technologies have reported an increase in business model innovation and performance. Similarly, Kamble et al. (2020) established that in the case of digital supply chains in emerging economies, not only did operational effectiveness and customer responsiveness increase, but the improved organizational outcomes were reaped. Ahmed and Khan (2023) reported an increased level of awareness among the firms in Pakistan, especially in terms of the potential gains of digital supply chains, with implementation being diverse in different fields.

It is, however, essential to mention that though the correlation between SCM 4.0 implementation and performance is positive, several setting considerations can affect the intensity of this correlation. Barriers were found in developing economies in the form of infrastructure constraints, digital skills deficiencies, and aversion to change in the former studies (Rehman et al., 2022). To a certain extent, the extent to which the implementation of SCM 4.0 can result in better performance in the case of Pakistan can rely on the size of a firm, leadership commitment, and investment in the digital framework.

Finally, this research will contribute to the limited empirical research in Pakistan regarding the Supply Chain 4.0. The relationship between technology adoption and organizational performance is critical, which necessitates firms to be proactive in terms of investment in digital supply chain activities towards attaining competitiveness and sustainability.

CONCLUSION

This paper reflects on the effects of the implementation of Supply Chain 4.0 on the organizational performance of the firms within the Pakistani context. Based on the Resource-Based View (RBV) and the Technology-Organization-Environment (TOE) theory, the study indicated a positive association between digital supply chain technology and better organizational performance to

a high degree. The results indicate that adaptation to Industry 4.0 elements that include AI, IoT, Big Data, and cloud-based platforms has a favorable effect on operational efficiency, responsiveness, and competitiveness. The findings confirm the past empirical research evidence concerning the strategic gains of digital transformation within supply chain management (Wamba et al., 2020; Kamble et al., 2020). Although the relationship was important, the magnitude of the effect depended on the context's preparedness, such as organizational strength, infrastructure, and employee proficiencies. On balance, the present paper contributes to the emerging stream of literature on developing markets by providing empirical evidence in the Pakistani case.

RECOMMENDATIONS

- **Digital Infrastructure Investment:** Companies should first invest in the advancement of their technological infrastructure to allow the incorporation of Industry 4.0 tools. The efficiency will only be achieved through cloud computing, sensor networks and enterprise resource planning (ERP) investments.
- **Upskill Human Resources:** Companies need to provide staff with data analytics, AI, and digital tool training and development activities to prepare their employees as well as possible for the change of transformation (Ahmed & Khan, 2023).
- **Leadership Commitment:** Top management support is vital in the successful adoption. The companies need to incorporate digital transformation into their strategic roadmaps and invest in long-term development of digital capabilities (Wamba et al., 2020).
- **cooperation with Technology Partners:** Firms planning to use technologies should look at partnerships with technology providers, universities, or consultants to reach outside expertise and get support in implementation (Muller et al., 2018).
- **Government Policy Enhancement:** The Government must offer an incentive policy that might be in the form of grants, tax breaks, or government-private collusion in digital components in sectors where there is no swift pace of digitalization.

LIMITATIONS

Notwithstanding the insights stated, this research is also limited in various ways. The sample was restricted to Pakistani firms, which could limit the extent of generalization to other developing or developed economies. Second, the nature of the study is cross-sectional, which limits the inference of causality between the adoption of Supply Chain 4.0 and performance. Third, the social desirability or response bias can be caused by self-reported data collected by managers. Fourth, the researchers did not explicitly differentiate between the sectors, but instead concentrated on the firm-level performance, which could blur the contributive performance patterns based on the industry (Rehman et al., 2022). Finally, technology adoption was dichotomized; it could be beneficial to pull apart the specific technologies and accordingly evaluate their impacts.

SIGNIFICANCE OF THE STUDY

This research work is both theoretical and practical. Theoretically, it applies the RBV and TOE framework to Supply Chain 4.0 in developing countries, enhancing the academic discussion on digital transformation in developing economies. Empirically, it presents one of the earliest quantitative evaluations of the relationship that exists between Industry 4.0 practices and the performance of firms in Pakistan. In practice, the implications of the findings provide relevant information to business leaders, policymakers, and supply chain professionals to compete using digital strategies. Moreover, the results are consistent with the national development objectives to technologically innovate and modernize the economy in terms of industry in the economic policy of Pakistan (Ahmed & Khan, 2023).

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