POMS
PERIODICALS OF MANAGEMENT STUDIES

Periodicals of Management Studies
pISSN 2790-8747, eISSN 2790-8755
Volume. 5, Issue 4, 2025

# Impediments to Adopting Artificial Intelligence for Supply Chain Risk Management: Qualitative Perspectives from the Textile and Clothing Industry of Pakistan

**Kashif Shafiq**
PhD Scholar, Iqra University Karachi Pakistan
kashif.50260@iqra.edu.pk

**Muhammad Muzammil Ghayas**
Associate Professor, Iqra University Karachi Pakistan
muzammil.ghayas@iqra.edu.pk

**Received: October 2025** **Accepted: November 2025** **Published: December 2025**

## Abstract

Exposed to unprecedented internal as well as external levels of uncertainties, supply chains have become much more vulnerable than ever before. Although artificial intelligence holds transformative potential to create resilient supply chains, its adoption remains intricate particularly within the industrial zones of developing economies. Previous studies have indicated that there is paucity of research in connection with artificial intelligence and supply chain risk management. Collecting data from twenty-six participants, this qualitative study revolves seeks to explore the impediments which hinder Pakistani textile and clothing firms from adopting artificial intelligence to control supply chain disruptions. Both thematic and content summative analysis techniques were used to attain interpretative depth as well as empirical substantiation. Lack of general understanding and trust in artificial intelligence, digital infrastructure deficits, high cost of investment, scarcity or substandard quality of operational and supply chain data and confidentiality and security issues are the core constraints The outcomes of the investigation are immensely valuable in developing pragmatic strategies to leverage artificial intelligence effectively in order in addressing supply chain risks.

**Keywords:** Artificial Intelligence, Supply Chain Vulnerability, Supply Chain Resilience, Supply Chain Risk Management, and Adoption, Impediments.

## INTRODUCTION

### Overview

With a potential of contributing USD19.9 trillion to the international economy as well as increasing the global Gross Domestic product (GDP) to 3.5 percent by 2030 (International Data Corporation,2024) and yet far from achieving consensus about its definition (Guida et al.,2023), artificial intelligence (AI) is considered the maximal capacity of an artificial system to use computational algorithms in order to finish a standardized task with veridical scoring (Gignac & Szodorai,2024). It refers to the ability of a machine to carry out cognitive functions which are associated with human brains including perceiving, reasoning, learning, communicating, problem solving, decision making and exhibiting creativity (Rai et al.,2019). As a matter of fact, it is indispensable in providing productive information while processing data without human intervention (Cubic & Li,2024). AI offers prominent opportunities in the field of supply chain management (Richey Jr et al., 2023; Gartner,2024)

Consisting of forty six percent of the total manufacturing sector with forty percent of the total work force nationwide (Board of Investment Pakistan, 2024), Pakistani textile and clothing industry is originating supply chains that are extended across the world. (Frederick & Center 2019). However, at the moment Pakistani textile and clothing industry is experiencing adverse trends of business growth (The Guardian,2023; The Express Tribune, 2023; Business Recorder, 2023) which can render resulting supply chains vulnerable to various supply chain risks (Durugbo & Al-Balushi,2023).

Adoption has been defined as "the action of accepting or beginning to use something (Cambridge University Press,2024). Firms are facing increased pressures in connection with adoption of artificial intelligence (Tursunbayeva & Gal,2024) to enhance business performance (Aljarboa,2024). Supply chain risk management (SCRM) is a coordinated approach among the parties of a supply chain for identification and management of supply chain risks in order to curtail vulnerability of the supply chains (Jüttner et al.,2003). It revolves around implementing fundamental strategies to manage every day and exceptional risks occurring at varies stages of the supply chain by continued risk assessment with the goal of decreasing vulnerability and fostering continuity (Schlegel & Trent,2014). Since the general features of AI makes it ideal for SCRM (Baryannis et al.,2019; Mithas et al.,2022; Wong et al.,2024) Pakistani textile and clothing firms can utilize it to build resilient supply chains. While adoption of AI is integral for SCRM, it is surrounded by various challenges (Morgan et al.,2023; Richey Jr et al., 2023). Academic scholars have urged for qualitative case studies (Richey Jr et al., 2023) focusing on factors that impede the overall process of adoption of artificial intelligence (Duan et al., 2019; Hasija & Esper, 2022 ; Hendriksen, 2023 ; Culot et al 2024) in order to regulate vulnerabilities with the supply chains particularly from standpoint of developing nations (Chourasiya & Pandey 2024). In this context we ask:

*RQ: What factors impede Pakistani textile and clothing firms from adopting artificial intelligence in order to manage supply chain risks?*

## Research Problem

Supply chains are more prone to uncertainty and unpredictability than ever before which can affect their business continuity (Moretto & Caniato , 2021) . Involving numerous variables, SCRM is rather a complex topic (Lochan et al.,2021). Most of the time supply networks involve numerous parties that are geographically dispersed with sub tier supplier bases which makes it very difficult for the focal firms to plan, implement and control the overall supply chain risk management process. The situation becomes even more intricate when the supply chains are extended on global level with high level of depth. Supply chain risk related situations anywhere along the supply chain can render the entire supply chain exposed to these risks

With significant potential to transform supply networks (Sharma et al.,2022; Jackson et al.,2024), AI is considered complementary technology in supply chain management research (Kosasih et al., 2024). The general characteristics of AI makes it ideal for SCRM (Baryannis et al.,2019; Mithas et al.,2022; Wong et al.,2024). AI enable the organizations to address various supply chain risks (Saberi et al. 2019; Ronchini et al.,2024) While AI is considered a robust technique for supply chain resilience (Mentzer2021; Zamani et al.,2023 ; Belhadi et la.,2024), its application for SCRM is limited (Baryannis et al.,2019 ; Ganesh & Kalpana 2022). Existing literature has indicated that research studies with regard to the potential and application of AI in the domain of SCRM are overall insufficient and mostly comprised of quantitative nature only (Baryannis et al.,2019; Jia et al.,2024) While adoption of artificial intelligence offers promising opportunities in the domain of SCRM, it is surrounded by a complex array of challenges or barriers (Morgan et al.,2023; Richey Jr et al., 2023; Ghag et al.,2024) especially in the developing nations (Mehmood et

al.,2024).Therefore, exploratory research studies especially qualitative case studies (Richey Jr et al., 2023) focusing on factors that impede the overall process of adoption of artificial intelligence are crucial (Hasija & Esper, 2022 ; Hendriksen, 2023 ; Culot et al 2024) especially in the context of under developing countries' with noticeable lag (Chourasiya & Pandey 2024).

# LITERATURE REVIEW

## Supply Chain Risk Management

As supply chains have become more complex, the need for a rigorous supply chain risk management (SCRM) has strategy is inevitable. SCRM gained attention among both academic and industrial experts who categorize it as a crucial tool to combat with increased complexity as well as uncertainty in the corporate world (Munir et al.,2020). Considered a tool for effective supply chain management (Pham et al., 2023), SCRM is has achieved great deal of interest from the corporate world (Lohner-Moeslang, 2022). SCRM is a multi-stage process which manage the negative impact of disruptive events along the various stages of the supply chain and the extant literature of supply chain management has depicted numerous SCRM tools. (Ordibazar et al.,2025). A fundamental building block of contemporary businesses (Emrouznejad et al., 2023), SCRM revolves around finding, interpreting and mitigating dangers associated with the overall integrity, reliability and authenticity of products as well as services at various stages of the supply chain (Daneshmand-Meh & Ghane, 2021). SCRM is the system of supply chain risks detection, analysis and management which are linked with the international and scattered information and communication technological structures. (Ganesh & Kalpana, 2022). It revolves around identification, assessment and mitigation of potential danger or losses which can affect the overall credibility, reliability as well as integrity of the products or service which are distributed at any stage of the supply chain (Daneshmand-Mehr & Ghane Kanafi, 2021). A pragmatic strategy of SCRM is comprised of discovering and evaluating both obvious and hidden supply chain risks, creating a robust supply chain risk management design and then implementing all lines of actions to such risks (Kara et al.,2020) Duong & Ha (2021) categorized identification, assessment, mitigation and monitoring as four major pillars of supply chain risk management process.

## Artificial intelligence

AI is described as the science as well as engineering of developing intelligent machines, especially intelligence computer systems which can execute tasks that demand human intellect, for example, visual perception, decision making and language translation (Pellicelli,2022). It is comprised of algorithms, software and hardware which enable the machine to do the tasks that typically need human intelligence (Blut et al.,2021) It refers to systems which imitate cognitive functions which are generally linked to human attributes, for instance, learning, speech and problem solving (Russell & Novig, 2021). AI is considered a group of technology related components which obtain, process and act on data just like humans. AI oriented solutions are capable of applying rules, comprehend over a period of time by collecting current data and adjust accordingly in their respective environment (Russell & Norvig, 2021). Purely software based which act in virtual word or embedded in hardware devices, AI built systems exhibit intelligence behavior by evaluating their environment and taking actions with some level of autonomy in order to attain certain objectives (European Commision,2018). The management of AI revolves around communication, direction, coordination and control of continuing process of computational advancements which require human intelligence in responding intricate issues related to decision making (Berente et al., 2021).

### Potential Of Artificial Intelligence To Manage Supply Chain Risks

SCRM revolves around a number of initiatives targeted at recognizing, evaluating, reducing and controlling unanticipated series of situations or circumstances which may have mostly a negative influence on any component of the supply chain. It requires immediate and flexible responsive ability which is based on significantly huge and multilevel sources of data. Such features make SCRM an ideal choice for AI tools and a typical SCRM process seems to be based upon AI has the ability to decide a particular line of action independently which makes possible for form to attain the goals of SCRM successfully in the context of comparatively uncertain landscape of supply chains (Baryannis et al.,2019). Within this specific context, AI methods can range from traditional symbolic AI (depending upon representation based on mathematics or knowledge) to AI which are more sub symbolic comprised of machine learning methods (Jahin et al.,2024) With greater speed, accuracy and potential numbers of inputs as compared the traditional systems, AI has wide range of applications for the domain of SCRM (Lynn et al.,2019).

*2.4 Adoption of artificial intelligence in supply chain risks management*

Intense competition, escalating business costs, increased lead time, globalization and number of other factors urge the organizations to adopt the most innovative set of technologies. This utilization of effective technological advancements enables the firms to increase their profits and ensure continued survival in the market. In fact, latest technologies seem indispensable for the contemporary businesses (Bhandari & Vikhe, 2025). AI is one of the most prominent technologies of the modern world which is transforming the current business practices (Collins et al.,2021) .AI models, trained to handle huge data sets in order to make the most informed as well as intelligent decisions independently, have changed the landscape of many industries and considered a gift for the modern world (Townsend & Hunt, 2019; Rashid & Kausik,2024). Such rising popularity of AI has urged the organizations to adopt AI techniques in various disciplines of business including supply chain management. In fact, almost all sub fields under the wider umbrella of supply chain management are likely to be improved by AI. ANNs, FL/Modelling, ABSs, Gas, Data mining, CBR, swarm intelligence, SVMs are some of the most prominent techniques which are used in supply chain management (Toorajipour et al.,2021). AI adoption can provide a significant opportunity to the firms to develop specific capability in order design the best possible mechanisms to control business and recognize the existence of vulnerabilities resulting from uncertainties (Gupta et al.,2020). At the same time the creativity offered by AI models can assist the organizations to attain the desired integration and collaborative levels in order to improve the overall visibility of the supply chains (Wamba et al.,2021). AI offers a promising avenue for the supply chain professionals to make effective demand forecasting by analyzing the data, maximize the efficiency of the transportation routes, increase the overall performance of logistics and recognize the bottlenecks along the supply chains. Such expertise of AI is crucial to develop responsive supply chains, decrease the lead time as well as operational costs (Mohsen,2023).

## RESEARCH METHODOLOGY

### Research Approach

A research approach is a procedure that assists a researcher to collect, analyze and interpret any set of data. Since this research began from specific to general (Trochim, 2006; Creswell & Clark (2017) and is ideal to express participants' experiences, an inductive research approach was selected for this study.

## Research Strategy

This study revolves around elaborating current dilemmas embedded in various perspectives for which case study design seems to be appropriate (King et al., 2018). This case study design was considered robust because this research had requirement of an in-depth comprehension of the meaning and contextualization of the phenomenon (Eisenhardt, 1989; Yin, 2003). The "CONTEXT" of this study is Pakistan. The researcher lives in Pakistan and has strong industrial contacts which facilitated in data collection While textile and clothing is considered one of the biggest industrial sectors of the world (Shishoo,2012), Pakistani textile and clothing industry was chosen as a "CASE" for this study because of a number of reasons. First, it is one of the major suppliers of textile and clothing products in the world, contributes 55-60 percent of the country's exports (Abbas et al., 2020) and nearly 40 percent of the total labor force in the nation (All Pakistani textile mills association,2024). Second, the researcher got extensive working experience in the textile and clothing industry of Pakistan which enabled the researcher to gain in depth knowledge of the phenomenon (case study) Since the method of enquiry in this study was single case study and the unit of enquiry was also single, a single holistic case study was selected as unit of analysis (Yin,2003). Maximizing of the reliability of the case study, a case study protocol depicts series of procedures with regard to collection of empirical material (Yin,2003). A rigorous case study protocol as suggested by Yin (2003) was followed

## Research Choice

This layer of the research onion describes the choice of the research that the researcher has to make. Overall, there are three types of research choices which include mono method, mixed method and multimethod (Saunders & Thornhill, 2009). Since we needed to explore the issues in depth and detail, a qualitative research type was chosen for this study (Patton, 2002) in the form of multi method. Both open ended questionnaires and semi structured interviews were used.

## Time Horizon of the Research

Time horizon refers to the timeframe which is relevant for the research. Researches can be based on either cross sectional or longitudinal time horizon (Saunders &Thornhill, 2009). This research study is based on cross sectional time horizon in which phenomenon was to be explored in a specified time.

## Target Population

Population is set of individuals with similar characteristics (Cresswell,2012). The targeted population of this study included "Textile and clothing professionals with hands on experience of artificial intelligence (minimum experience of 5 years)".

## Sampling Technique

In purposive sampling, respondents are selected on the basis of purpose rather than choosing randomly. The power and logic of purposive sampling "makes it very suitable for this study (Patton, 1999). A widely used sampling technique in qualitative researches, purposive sampling can provide better insights and precise research outcomes. It is most suitable with regard to information rich cases. Purposive technique was very suitable in the situation because the study in hand depended upon identification and selection of individuals who were supposed to have knowledge and experience about phenomenon in the research (Creswell & Clark, 2017).

## Sampling Size

Sample size can be described as subset of population which can ensure that there is enough information for the researcher to draw conclusion for the study (Sekaran & Bougie ,2016). Data was collected till the point at which data started to repeat itself and provided no new insights (Glaser & Strauss, 1967). Data saturation was achieved at 17 responses (Q1- Q17) for open-ended questionnaires in contrast to 9 responses (N1- N9) in the case of semi-structured interviews."

## Data Collection

Open ended questionnaires were selected as the instrument of data collection in this research. An indispensable tool in qualitative research, open ended questionnaires enabled the respondents to express their narratives freely. They allowed the researcher to probe much deeper in the insights provided by the respondents. These open-ended questionnaires engaged the respondents more and obtained rich data which is the requirement of the research study in hand. Moreover, they provided the researcher with an opportunity to record narratives of the participants as it is which enhanced the overall reliability. Semi structured interviews provided in depth understanding, flexibility and exploration of complex topics. They facilitated in attaching participant cantered, rich and contextual data. Both Open ended questionnaires and semi structured interviews were selected as the instrument of data collection in this research. While open-ended questionnaires provided rather broader perspective across a larger set of samples, semi structured interviews were integral in offering deeper exploration of experiences as well perspectives of the respondents which resulted into detailed understanding of the research phenomenon. Both hard and soft copies of open-ended questionnaires and semi structured interviews were used to attain the responses from the participants based upon their ease. Relevant instruction/guidance was given in writing for the respondents to fill the questionnaires correctly.

## Data Analysis

A robust as well as flexible method to analyze qualitative data, thematic analysis focuses on identifying recurring patterns within the data (Mirzaei & Shokouhyar, 2023). In case of thematic analysis, meaningful segments of the data were systematically labelled. Resulting codes were then reviewed and grouped on the basis of similarity and patterns. This process facilitated to develop themes which represented the underlying ideas in the data set. Whereas in summative content analysis we started with identification and quantification of some specific words or the content of a text or literature (Wiese et al., 2012). This analysis technique revolved around counting and comparison of keywords (Hsieh, & Shannon, 2005). A single analytical tool could have overlooked the underlying nuances within the narratives of the respondents. Qualitative data collected from twenty-six Respondents were analyzed. We have relied both on thematic analysis and content summative analysis techniques in order to achieve interpretative depth as well as empirical substantiation. Trustworthiness is imperative to evaluate worth of any piece of research (Lincoln & Guba,1985). Confirmability was achieved by triangulation. It was done through cross-checking the findings of the research from other secondary sources including research papers and industrial reviews and reports, etc. Moreover, by utilizing two analytical tools, methodological triangulation was achieved. Participants' connections and experience in the textile and clothing sector were considered to create dependability. Detailed descriptions and interpretations were used to achieve transferability. Whereas, data was returned to the respondents (member check) for accuracy in order to develop credibility.

### Ethical Considerations

Ethical considerations are comprised of various ethical guidelines in order to protect the respondents as well as adhere to ethical standards. Protecting morality, ethical considerations are the guidelines that are of prime consideration for any research. Informed consent was taken from the participants which allowed them discontinue any time upon their discretion. The identities of the participants were kept anonymous in order to protect them. The data attained in the study was used for this piece of research only and was kept confidential. It was made sure that data interpretation is not biased or discriminated on the basis of researchers believes, opinions and experiences. The study was conducted on the basis of respect of honesty, integrity and transparency.

## FINDINGS

Narratives of the respondents of this research have revealed that 1) lack of general understanding and trust in AI 2) digital infrastructure deficits 3) high cost of investment 4) scarcity or substandard quality of operational and supply chain data 5) confidentiality and security issues are some of the core impediments that Pakistani textile and clothing firms face to adopt arterial intelligence in connection with supply chain risk management

### Results of Summative Content Analysis

The results of summative content analysis are shown in Table 1,2 and 3

**Table 1:** Summative Content Analysis Performed on the Data Collected from Questionnaires

| Respondents | (a) Lack of general understanding and trust in artificial intelligence | (b) Digital Infrastructure Deficits | (c) High Cost of Investment | (d) Scarcity or substandard quality of operational and supply chain data | (e) Confidentiality and security issues |
|---|---|---|---|---|---|
| Q 1 | D=1 / I=1 / T=2 | D=1 / I=0 / T=1 | D=0 / I=1 / T=1 | D=0 / I=1 / T=1 | D=0 / I=0 / T=0 |
| Q 2 | D=1 / I=1 / T=2 | D=0 / I=0 / T=0 | D=0 / I=1 / T=1 | D=0 / I=1 / T=1 | D=9 / I=4 / T=13 |
| Q 3 | D=0 / I=0 / T=0 | D=7 / I=4 / T=11 | D=9 / I=4/ T=13 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 |
| Q 4 | D=6 / I=3 /T= 9 | D=1 / I=1 / T=2 | D=0 / I=0 / T=0 | D=2 / I=0 / T=2 | D=7 / I=2 / T=9 |
| Q 5 | D=0 / I=1 / T=1 | D=1 / I=1 / T=2 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 | D=1 / I=0 / T=1 |
| Q 6 | D=0 / I=0 / T=0 | D=1 / I=2 / T=3 | D=0 / I=0 / T=0 | D=7 / I=7 / T=14 | D=0 / I=0 / T=0 |
| Q 7 | D=2 / I=1 / T=3 | D=0 / I=1 / T=1 | D=1 / I=0 / T=1 | D=0 / I=0 / T=0 | D=0 / I=1 / T=1 |
| Q 8 | D=1 / I=0 / T=1 | D=2 / I=2 / T=4 | D=5 / I=6 / T=11 | D=0 / I=0 / T=0 | D=1 / I=0 / T=1 |
| Q 9 | D=0 / I=0 / T=0 | D=1 / I=0 / T=1 | D=1 / I=1 / T=2 | D=0 / I=0 / T=0 | D=0 / I=1 / T=1 |
| Q 10 | D=0 / I=0 / T=0 | D=1 / I=0 / T=1 | D=0 / I=1 / T=1 | D=9 / I=3 / T=12 | D=0 / I=2 / T=2 |
| Q 11 | D=7 / I=4 / T=11 | D=3 / I=1 / T=4 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 |
| Q 12 | D=4 / I=1 / T=5 | D=2 / I=1 / T=3 | D=0 / I=0 / T=0 | D=1 / I=0 / T=1 | D=1 / I=0 / T=1 |
| Q 13 | D=0 / I=0 / T=0 | D=1 / I=1 / T=2 | D=0 / I=0 / T=0 | D=1 / I=0 / T=1 | D=1 / I=1 / T=2 |
| Q 14 | D=0 / I=1 / T=1 | D=0 / I=0 / T=0 | D=1 / I=1 / T=2 | D=0 / I=0 / T=0 | D=0 / I=3 / T=3 |
| Q 15 | D=0 / I=1 / T=1 | D=0 / I=0 / T=0 | D=9 / I=2 / T=11 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 |
| Q 16 | D=0 / I=1 / T=1 | D=1 / I=1 / T=2 | D=1 / I=0 / T=1 | D=0 / I=1 / T=1 | D=1 / I=0 / T=1 |
| Q 17 | D=2 / I=1/ T= 3 | D=8 / I=4 / T=12 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 |
| Total Frequency | D=24 / I=16 / T=40 | D=30 / I=19 / T=49 | D=27 / I=17 / T=44 | D=20 / I=13 / T=33 | D=21 / I=14 / T=35 |

**Table 2:** Summative Content Analysis Performed on the Data Collected from Semi Structured Interviews

| Respondents | (a) Lack of general understanding and trust in artificial intelligence | (b) Digital Infrastructure Deficits | (c) High Cost of Investment | (d) Scarcity or Sub scarcity or substandard quality of operational and supply chain data | (e) Confidentiality and security issues |
|---|---|---|---|---|---|
| N 1 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 | D=5 / I=7 / T=12 | D=1 / I=1 / T=2 |
| N 2 | D=7 / I=3 / T=10 | D=2 / I=0 / T=2 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 | D=1 / I=2 / T=3 |
| N 3 | D=1 / I=1 / T=2 | D=1 / I=0 / T=1 | D=1 / I=0 / T=1 | D=0 / I=0 / T=0 | D=0 / I=3 / T=3 |
| N 4 | D=0 / I=0 / T=0 | D=1 / I=1 / T=2 | D=1 / I=0 / T=1 | D=1 / I=0 / T=1 | D=1 / I=0 / T=1 |
| N 5 | D=1 / I=3 / T=4 | D=6 / I=6 /T=12 | D=0 / I=0 / T=0 | D=0 / I=2 / T=2 | D=0 / I=0 / T=0 |
| N 6 | D=1 / I=1 / T=2 | D=5 / I=3 / T=8 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 | D=0 / I=2 / T=2 |
| N 7 | D=0 / I=1 / T=1 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 | D=0 / I=1 / T=1 | D=8 / I=2 / T=10 |
| N 8 | D=2 / I=0 / T=2 | D=0 / I=0 / T=0 | D=1 / I=0 / T=1 | D=8 / I=5 / T=13 | D=0 / I=1 / T=1 |
| N 9 | D=0 / I=0 / T=0 | D=7 / I=2 / T=9 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 | D=0 / I=0 / T=0 |
| Total Frequency | D=12 / I=9 / T=21 | D=22 / I=12 / T=34 | D=3 / I=0 / T=3 | D=14 / I=15 / T=29 | D=11 / I=11 / T=22 |

**Table 3:** Summative Content Analysis Performed on the Data Collected from Questionnaires and Semi Structured Interviews

| Data Source | (a) Lack of general understanding and trust in artificial intelligence | (b) Digital Infrastructure Deficits | (c) High Cost of Investment | (d) Scarcity or substandard quality of operational and supply chain data | e) Confidentiality and security issues | Total Frequency per Source |
|---|---|---|---|---|---|---|
| Open-Ended Questionnaires (Q1–Q17) | D=24 / I=16 / T=40 | D=30 / I=19 / T=49 | D=27 / I=17 / T=44 | D=20 / I=13 / T=33 | D=21 / I=14 / T=35 | T = 201 |
| Semi-Structured Interviews (N1–N9) | D=12 / I=9 / T=21 | D=22 / I=12 / T=34 | D=3 / I=0 / T=3 | D=14 / I=15 / T=29 | D=11 / I=11 / T=22 | T = 109 |
| Combined Total Frequency | D = 36 / I = 25 / T = 61 | D = 52 / I = 31 / T = 83 | D = 30 / I = 17 / T = 47 | D = 34 / I = 28 / T = 62 | D = 32 / I = 25 / T = 57 | T = 310 |

## Results of Thematic Analysis

Following are the result of thematic analysis

### Lack of general understanding and trust in artificial intelligence

Although the artificial intelligence market in Pakistan is projected to escalate in future (Statista, 2025), the findings of this investigation have revealed a prevailing lack of general understanding and trust in artificial intelligence as a solution to address supply chain vulnerabilities in the textile and clothing sector. Members Q4, Q11 and N2 of the sample transcribed this predicament by depicting:

*"How many textiles and clothing supply chain experts out there have general understanding or trust about artificial intelligence in connection with mitigation or reduction of supply chain related risks? To be honest, adoption of AI is hampered by lack of general understanding and trust in artificial intelligence"*

The qualitative evidences of the present study have indicated that there is lack of basic awareness or exposure to artificial intelligence in the context of supply chain risk management. Firms may lack the technical capability to analyze its efficacy in pragmatic terms, find it excessively complicated, and ultimately become fearful of anticipated financial setbacks. Misconceptions with no proven local success stories in a society of low technological readiness without institutional support and concerns about employment stability can undermine their trust.

## Digital infrastructure Deficits

A sophisticated digital infrastructure serves as fundamental prerequisite to unlock the transformative potential of artificial intelligence (Bokrantz et al., 2024; Jia et al., 2025) especially in the underdeveloped countries (United Nations, 2025; Mannuru, et al, 2025)
Respondents Q3 and Q17 recognized systematic insufficiencies in digital infrastructure within Pakistani textile and clothing sector as a prospective constraint to successful adoption of artificial intelligence for managing supply chain risks. They observed:

*"Yes, the digital infrastructure deficits present another foundational barrier to embrace artificial intelligence out there. Unavailability of AI enabling hardware, software, dashboards, visualization tools, unstable or low internet connections, frequent load shedding, unscheduled power outages intensify the intricacies"*
*Similarly responded N5, N6 and N9 mentioned"*
*"Incompatible or outdated information technology, weak internet of things (IOT) and unreliable cloud-based systems, low interoperability among supply chain partners as well as scalability concerns render the current digital infrastructure of Pakistani textile and clothing industry remain suboptimal for AI to operate"*
Participants' testimonies have articulated how under developed technological base in the textile and clothing units of Pakistan makes it quite intricate to utilize the modern and state of the art artificial intelligence methods to make the supply chains more resilient.

## High cost of Investment

A considerable segment of Pakistan's textile and clothing sector consists of SMEs including informal units. High cost of investment which is comprised of acquisition, transitional, technical support (Zhu et al.,2021) along with employee training and upskilling (Dey at al.,2023) components etc., continue to pose a challenge while adopting artificial intelligence (Cannas et al.,2024) notably for the enterprises with limited operations.

Respondent Q3, Q8 and Q15 cited high cost of investment as a deterrent by asserting:

*"With no immediate or clearly discernable returns, initial acquisition, consulting and engineering, continuous maintenance, upgrade and technical support, wage pressures, training and development in inflation driven crises lead to high cost of investment which makes it difficult for the firms to operationalize AI"*

The outcomes of this study have demonstrated that rising operational costs, currency devaluation, delayed fiscal return, lack of governmental financial support urge organizations to prioritize survival over innovation. Investment in AI can by simply unaffordable and ultimately deprioritized over other financial obligations such as purchase of raw material (cotton, synthetic fibers, dyes and chemicals etc.) alongside soaring utility bills to perform energy intensive processes.

### Scarcity or substandard quality of operational and supply chain data

While real – time operational and supply chain data revolves around current as well as live information to detect and respond to supply chain disruptions, the historical data collections are comprised of previous logs which are utilized to analyze patterns in order to predict supply chain risks and control accordingly. Extensive sets of both real-time as well as historical operational and supply chain data are required for effective deployment of AI in order to manage supply chain risks (Cadden et al., 2022). Such data set must be accurate, complete, consistent, up to date, relevant and well-integrated in order to ensure quality.

Our findings corroborate those of Meyer & Henke (2023) and Jia et al (2025) that organizations with scarce or poor-quality operational and supply chain data find it difficult to adopt artificial intelligence. Mentioning this obstacle, Respondent Q 10 and N1 exposited:

*"Yes, scarcity or substandard quality of operational and supply chain data definitely restricts the adoption of artificial intelligence and may require human involvement. Manual record keeping, nonstandard reporting formats as well as missing, inconsistent or non-integrated real-time or historical data complicates the situation"*

Respondent Q6 and N8 added:

"*Fragmented, informal or unregistered business units, legacy technology and resistance to share data along the supply chains leave firms with data which is either insufficient or compromised in quality"*

It is evident from the accounts of the subjects of the enquiry that Pakistani textile and clothing firms are facing constraints with regard to deficiency as well as quality of supply chain data because of which it is complex for them to adopt AI and require human involvement (Burger et al., 2023) in order to manage supply chain risks. Some of reasons identified by the research behind this anomaly include manual and non-unified systems, old tools and machinery, fragmented as well as informal textile and clothing industrial structures (comprised of home-based or unregistered manufacturing or distribution units) along with lack of collaborative mechanisms to share data which affect visibility and predictive accuracy.

### Confidentiality and security issues

While AI facilitates supply chain risk control, its application engenders apprehensions about data confidentiality and security (Wellbrock et al., 2025; Culot et al. 2024). Underscoring these obstacles, Respondent Q2, Q4, and N7 stipulated:

*"Adversarial attacks, malware and ransomware, shadow AI, Intellectual property theft, data breeches, data poisoning misuse, leakage of confidential data, lack of adequately enforced data protection legislations in Pakistan constitute a confluence of confidentiality and security issues which hinder the adoption of AI"*

The expositions of the informants of the research have claimed that Pakistani textile and clothing firms are exposed to a number of confidentiality and security threats with regard to adoption of AI including, violations of restricted supply chain data related to procurement and sourcing, manufacturing and capacity schedules, raw material or finished goods inventory levels or transportation and shipment etc. unauthorized access to proprietary design, algorithm and manufacturing data, utilization of unsanctioned AI tools or malicious software for deception. Not aligned with global standards. Personal Data Protection Bill (PDP- 2023) is still in its drafting phase. The prime focus of Prevention of Electronic Crimes Act (PECA-2016) is cybercrime. Therefore, absence of a properly implemented data protection legal framework, compounds this obstacle substantially.

# DISCUSSION, CONCLUSION AND IMPLICATION

## Discussion

It is evident that Pakistani textile and clothing firms are exposed to declining trends its business performance. In this situation, cutting edge technology of AI can enable the sector to address supply chain vulnerabilities. However, adoption of AI has been challenging for such organizations due a number of obstacles. First, there is lack of general awareness in AI with regard to its application for supply chain risk management. With such limited familiarity managers as well as decisions makers are unable to comprehend the integrate AI into supply chain risk management agenda and subsequently misconceptions are created. An exaggerated level of fears about job displacement in a culture of less technological readiness with no institutional support results into further trust issues. Second, the current digital architecture of Pakistan may not be sufficient or effective enough for AI to be deployed. As a matter of fact, Pakistani textile and clothing sectors are faced with numerous concerns related to digital infrastructure including lack AI enabled hardware, software and other related tools. frequent electricity breakdowns, unreliable internet connectivity along with inadequate cloud -based and internet of things frameworks which ultimately affect scalability and interoperability. Third, high-cost structure seems to have hampered Pakistani textile and clothing firms to adopt AI. These costs are not comprised of not only include acquisition costs but also a number of ancillary expenditures such as consulting and engineering, maintenance, upgradation and technical support, salaries along with training and professional development. Fourth, it has been observed that limited or substandard quality of operational and supply chain data inhibits effective deployment of artificial intelligence as well. The advance technology of artificial intelligence requires sufficient and good quality data. A considerable proportion of textile and clothing industrial units of Pakistan are located on informal platforms. Moreover, suppliers and other parties connected with the supply chain are hesitant to share data. These situations lead to scarcity of data. Manual record keeping practices and non-standardized reporting formats, missing, inconsistent and nonintegrated data sets coupled with outdated technology in a fragmented supply chain system collectively results into deterioration in data quality. Fifth, adoption of artificial intelligence is associated with concerns pertaining to data confidentiality and security risks. Adversarial attacks, malware and ransomware intrusions, data and intellectual property violations, data poisoning, unauthorized use of private information in the absence of rigorous data protections laws in Pakistan may constitute serious confidentiality and security issues which can affect deployment of AI.

## Conclusion

Vulnerable to a myriad of supply chain risks, firms may seek the transformative potential of AI. However, adoption of AI is an intricate task particularly in an emerging economic context. A lack of general understanding and trust in artificial intelligence, digital infrastructure deficits, high cost of investment, scarcity or substandard quality of operational and supply chain data and confidentiality and security concerns restrict Pakistani textile and clothing firms from adopting AI effectively. This research underscores the need for targeted interventions to address these obstacles enabling organizations to enhance supply chain resilience and gain competitive advantage in the contemporary disruptive business environment.

## Implications

Our research extends the literature of AI in SCRM by uncovering the various barriers that can inhibit the adoption of AI in under developed nations particularly within Pakistani textile and

clothing sector. It contributes by depicting that Pakistani textile and clothing firms are exposed to not only technical barriers but also financial, cultural and security challenges. Such understanding enables the experts to concentrate the cultural, human and social dimensions as well while devising AI adoption strategies in this under developed part of the world.

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