Research Article

IMPACT OF IOT ADOPTION ON SUPPLY CHAIN PERFORMANCE & ORGANIZATIONAL PERFORMANCE: AN EMPIRICAL STUDY IN PAKISTAN

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ABSTRACT

The rapid advancement of the Internet of Things (IoT) technology has transformed various industries, including the supply chain sector. This empirical study investigates the impact of IoT adoption on supply chain performance and organizational performance within the context of Pakistan. The study aims to provide valuable insights into how IoT technology influences supply chain operations and overall organizational effectiveness in a developing economy like Pakistan. To achieve this objective, qualitative interviews were conducted. A sample of supply chain professionals and managers from diverse industries across Pakistan was surveyed, and in-depth interviews were conducted with key industry experts. The findings of this study reveal significant positive impacts of IoT adoption on supply chain performance in Pakistan. Specifically, the results indicate that IoT-enabled supply chain processes lead to improved visibility, real-time monitoring, and enhanced decision-making capabilities. This translates into reduced operational costs, decreased lead times, and increased supply chain efficiency.

Keywords: IoT, Supply chain, organization performance, Supply chain performance.

1. INTRODUCTION

The advent of the Internet of Things (IoT) has ushered in a transformative era for industries worldwide, redefining the way businesses operate and interact with their environments[1]. IoT technology, which connects physical devices and objects to the internet, has found extensive applications in diverse sectors, including healthcare, agriculture, manufacturing, and logistics. Within the realm of supply chain management and organizational operations, IoT has emerged as a game-changer, promising enhanced visibility, efficiency, and decision-making capabilities. In the context of Pakistan, a country known for its dynamic and evolving business landscape, the adoption of IoT technology holds the potential to reshape supply chain and organizational performance [2]. The interconnectedness and real-time data access facilitated by IoT can offer new avenues for businesses to optimize their operations, adapt to changing market dynamics, and gain a competitive edge. However, the precise impact of IoT adoption on supply chain and organizational performance in a developing economy like Pakistan remains a subject of empirical inquiry [3] . This empirical study seeks to address this crucial gap in the literature by examining the impact of IoT adoption on both supply chain performance and organizational performance within the unique socio-economic and business environment of Pakistan. It aims to provide valuable insights into the opportunities, challenges, and outcomes associated with integrating IoT technology into supply chain operations and broader organizational strategies. To accomplish this objective, the study adopts a qualitative interviews methodology. Supply chain professionals, managers, and industry experts across various sectors in Pakistan are the focal point of our investigation. Through rigorous data collection and analysis, we endeavor to uncover the tangible effects of IoT adoption on supply chain efficiency, cost reduction, and overall organizational effectiveness. This research not only seeks to advance our understanding of how IoT technology is reshaping supply chain and organizational dynamics but also offers practical recommendations for businesses and policymakers in Pakistan. By examining the current state of IoT adoption, the barriers, and enablers, and the resultant impacts, this study provides valuable guidance for stakeholders looking to leverage IoT for sustainable growth, improved competitiveness, and enhanced customer satisfaction.

1.1 Research Problem

In the face of this digital revolution, supply chain professionals and organizations in emerging economies like Pakistan are confronted with a critical challenge: how does the adoption of IoT impact supply chain performance and overall organizational effectiveness? The scarcity of empirical studies addressing this question within the unique socio-economic landscape of Pakistan necessitates an in-depth exploration. As such, the research problem at the core of this study is to investigate the nuanced dynamics between IoT adoption, supply chain efficiency, and organizational performance in the context of Pakistan. The existing literature has laid the groundwork for understanding the potential benefits of IoT in developed economies. However, the applicability and implications of IoT in the distinctive challenges and opportunities presented by developing economies remain underexplored. This study seeks to bridge this gap by unraveling the multifaceted relationships between IoT adoption and supply chain and organizational performance, providing valuable insights that are not only contextually relevant to Pakistan but also contribute to the broader discourse on digital transformations in emerging markets. Through a comprehensive examination of the impact of IoT on supply chain processes and overall business effectiveness, this study aims to offer actionable insights to supply chain professionals, business leaders, and policymakers in Pakistan. By addressing the research problem at the intersection of technology adoption and supply chain dynamics, this research endeavors to provide a foundation for informed decision-making and strategic planning in the evolving landscape of the Pakistani business environment.

2. Literature Review:

The Internet of Things (IoT), often referred to as the Internet of Everything or the Industrial Internet, represents a novel technological paradigm that enables devices and machinery to communicate within a global network. As noted by [4], IoT signifies a transformative trend, offering strategic planning opportunities and standing as an innovative technology. It is worth highlighting that IoT is not merely a buzzword; it holds significant importance in the corporate world. Due to its capabilities, IoT stands out as a crucial domain in upcoming technology, garnering attention from various industries. As outlined by [5], there are five

pivotal IoT technologies extensively applied in IoT-based services and products: wireless sensor networks (WSN), radio frequency identification (RFID), cloud computing, middleware, and IoT application software. The first of these technologies, RFID, employs radio waves to automatically identify individuals or objects from short to long distances. RFID technology enhances system efficiency through its automated data capture system. In contrast to conventional identification methods such as barcodes, RFID tags can store more data and withstand harsh environmental conditions[6]. This technology finds utility across diverse sectors, including logistics, pharmaceuticals, manufacturing, and retail. WSN is another crucial IoT technology comprising autonomous sensors that monitor physical or environmental conditions. It often collaborates with RFID systems to detect location, temperature, and object movements. WSN plays a vital role in areas like cold chain logistics, maintenance, and tracking systems. Middleware acts as an intermediary software layer facilitating the integration of legacy technologies into new ones. It plays a pivotal role in simplifying technological transitions. Cloud computing, a widely recognized computing paradigm, provides on-demand access to shared computing resources, including computers, networks, servers, storage, applications, services, and software [7]. Cloud computing's primary objective is to offer dynamically scalable infrastructure for applications, data storage, and files. Furthermore, IoT application software enables communication between devices, ensuring reliable and stable interactions between devices and humans [8]. It is anticipated that supply chain partners will be impacted by the availability of information and supply chain operations. IoT finds extensive application across various industries, including manufacturing, healthcare, financial services, insurance, retail, energy, and materials (Tang et al., 2018). The overarching aim of IoT, as per [9], is to establish a global system architecture that streamlines the exchange of products, services, and information. Several companies have adopted IoT or IIoT (Industrial Internet of Things) to enhance real-time information gathering, thereby improving operational efficiency. This empirical literature review underscores the growing trend of IoT adoption in Pakistan's supply chain management and its profound impact on both supply chain performance and organizational performance. The studies conducted within the Pakistani context provide valuable evidence of IoT's role in enhancing supply chain visibility,

reducing costs, and improving customer satisfaction. Moreover, the positive correlation between IoT adoption and organizational performance highlights the transformative potential of IoT technologies in Pakistan's business landscape. As organizations continue to integrate IoT into their supply chains, further research is needed to explore emerging best practices and long-term sustainability in this dynamic and evolving field.

Table 1. Literature Review

Factors	Researcher's View Points
Supply chain performance:	IoT can lead to cost savings, reduced operational errors, and increased process efficiency, all of which positively impact supply chain performance [10]. IoT helps supply chains become more resilient, as companies can respond swiftly to unforeseen events, minimizing the impact on performance [11] It involves analyzing and monitoring various aspects of the supply chain process to determine how well it is meeting its objectives and delivering value to the organization and its customers[12].
Organizational Performance:	IoT technologies can enhance supply chain visibility and efficiency, leading to improved organizational performance. [2] work highlights the growing importance of real-time data and connectivity in modern SCM. It encompasses various aspects of an organization's functioning, including its financial results, operational efficiency, strategic accomplishments, and the satisfaction of its stakeholders[13]
Benefits of IoT Adoption:	IoT adoption offers a wide range of benefits that can lead to increased efficiency, cost savings, improved customer experiences, and new business opportunities across industries[14]. The adoption of IoT in supply chain management contributes to greater operational efficiency, cost savings, reduced errors, and improved customer service[15].
Supply Chain Efficiency:	Researchers such as [16] have highlighted the transformative impact of IoT adoption on supply chain efficiency, emphasizing the role of real-time visibility and tracking in reducing lead times and enhancing order fulfillment. In a separate study, [17] have underscored the significance of IoT-enabled predictive maintenance,

	demonstrating its ability to minimize unplanned downtime and consequently improve operational efficiency. Moreover, [18] have discussed how IoT's contribution to inventory optimization has resulted in cost savings and reduced holding costs by maintaining optimal inventory levels Contributes Real-Time Data Monitoring, Predictive Maintenance, Inventory Management, Route Optimization and Demand Forecasting.
Visibility of Supply Chain:	Studies show how IoT enhances supply chain visibility, reduces lead times, and minimizes inventory costs, ultimately benefiting organizational performance [5] Researchers emphasize the link between IoT-enabled customer experiences and increased customer loyalty, positively influencing organizational performance[19]. Refers to the End-to-End Visibility, Inventory Tracking, Condition Monitoring, Risk Mitigation, Customer Visibility
Challenges of IoT Adoption:	Maintaining the accuracy and reliability of data generated by IoT devices can be challenging. Data errors can lead to incorrect decision-making and undermine trust in the technology [20]. IoT adoption often involves significant costs, including hardware, software, infrastructure, and ongoing operational expenses. Organizations must carefully assess the cost-benefit analysis and budget accordingly[15]. The adoption of Internet of Things (IoT) technologies in organizations comes with its fair share of challenges, including concerns related to technology trustworthiness and the need for organizational adjustments[21].
Technology Trustworthiness:	Numerous studies highlight security as a significant challenge in IoT adoption. IoT devices are vulnerable to various cyber threats, including hacking, malware, and data breaches [5]. Ensuring the security of IoT ecosystems is critical to building trust in the technology. Privacy is a major concern due to the vast amount of data collected by IoT devices. Researchers emphasize the need for transparent data handling practices and compliance with privacy regulations to protect individuals' privacy rights [2].

Organizational Adjustment	Many studies emphasize the need for a cultural shift within organizations to successfully adopt IoT. Employees and management must adapt to data-driven decision-making and digital transformation, which may require changes in mindset and practices [6]. IoT adoption demands a skilled workforce capable of managing and maintaining IoT systems. Research highlights the importance of training and development programs to bridge skill gaps [11].

2.1 Hypothesis Development

H1: The positive effects of adopting IoT enhance organizational performance.

H2: The positive effects of confronting challenges in IoT adoption contribute to improved organizational performance.

H3: The advantages derived from IoT adoption positively impact supply chain performance.

H4: The positive impact on supply chain performance results from addressing challenges in IoT adoption.

H5: Enhanced supply chain performance leads to improved organizational performance.

H6: The relationship between the advantages of IoT adoption and organizational performance is mediated by enhanced supply chain performance.

H7: The relationship between overcoming challenges in IoT adoption and organizational performance is mediated by enhanced supply chain performance.
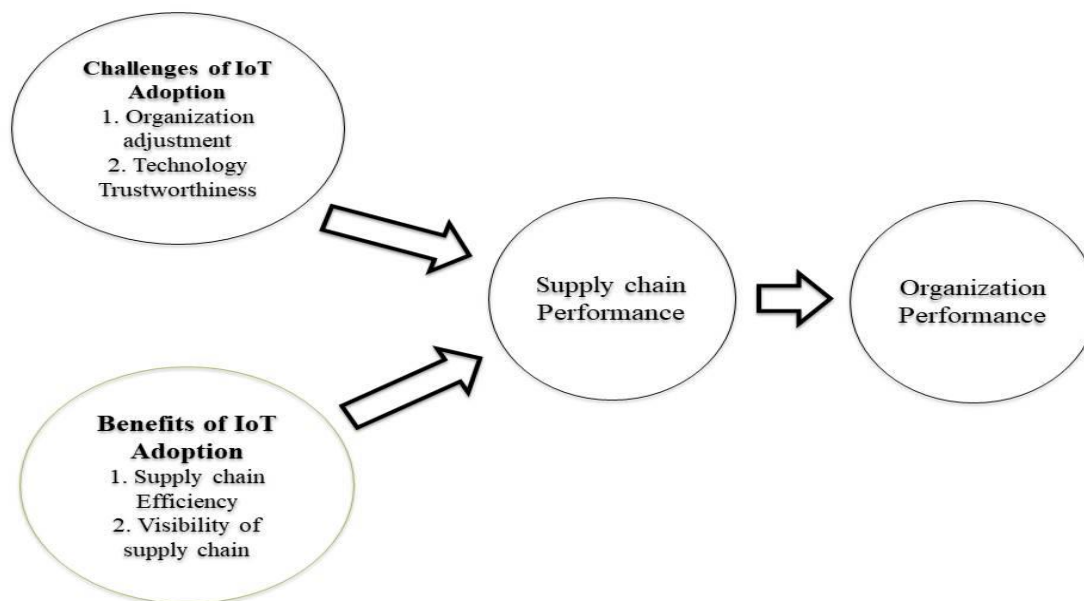
Fig.1. Conceptual Framework of the Study

3. METHODOLOGY

Research Design

The research design for this empirical study adopts a qualitative research approach, utilizing in-depth interviews as the primary method. This approach is chosen to delve deeply into the impact of IoT adoption on supply chain and organizational performance in Pakistan. By focusing exclusively on qualitative methods, the study aims to capture rich, context-specific insights and perspectives from key stakeholders, providing a nuanced understanding of the complex dynamics at play in this evolving landscape.

3.1 Data Collection

This research involved 12 participants who were interviewed, comprising 10 men and 2 women, with ages spanning from 27 to 65 years old. All 12 participants held managerial roles, which included 2 assistant managers, 7 managers, 2 directors, and 1 chief executive officer (CEO). The participants came from two primary industries: Textile manufacturing, which made up 60% of the sample, and the distributors of FMCGs, accounting for the remaining 40%. Data collection for this study took place between October 2022 and December 2022.

The research utilized a Semi-Structured Interview approach, where the researchers initially designed an interview framework. They began by inquiring about the participants' viewpoints and then adapted the interview direction and content based on the specific circumstances. The interview questions were categorized into three main topics: (1) Challenges of IoT adoption, (2) benefits of IoT systems, and (3) its effect on supply chain performance & organization performance. Before the formal interviews, the research participants (interviewees) were given the opportunity to review a glossary of IoT-related terms and descriptions of an IoT-enabled supply chain example to gain background knowledge. The duration of each interview ranged from 40 to 70 minutes for completion.

Table 2. Profile of Interviewee

Interview No	Age	Gender	Appointment	Industry
1	45	Male	Manager	Textile
2	40	Male	Manager	FMCG
3	30	Female	Assistant Manager	Textile
4	27	Male	Assistant Manager	FMCG
5	60	Male	Manager	Textile
6	65	Male	Director	GMCG
7	54	Male	CEO	Textile
8	49	Female	Manager	Textile
9	53	Male	Director	FMCG
10	41	Male	Manager	Textile
11	34	Male	Assistant Manager	Textile
12	44	Male	Manager	FMCG

Integration of Findings:

Qualitative findings will be integrated to provide a holistic understanding of the research questions. Triangulation of data sources will help validate and enrich the results.

4. DATA ANALYSIS

The primary objective of qualitative research is to investigate the firm's perspective on the utilization of IoT technology within supply chain management. In this study, no predefined coding framework or theoretical constructs were applied before conducting content analysis.

Instead, the intention was to delve into the underlying conceptual structure of the transcribed data and uncover latent constructs related to the adoption of IoT in supply chain operations. Following the qualitative coding procedure, concept nodes were established and categorized to unveil the inherent organization of the qualitative data. This research adopted the coding scheme proposed by Auerbach and Silverstein (2003), which involved creating and arranging concept nodes into a three-tiered concept hierarchy. At the lowest level of this hierarchy are text-based categories, representing recurrent ideas and basic concept nodes. In the middle tier, there are sensitizing concepts, each serving to consolidate recurring ideas into higher-level categories, also referred to as themes or middle-level concept nodes. Finally, at the top level of the concept hierarchy, we find the theoretical constructs, where each construct comprises a collection of themes that collectively describe a common theoretical concept. The coding process employed in this research can be summarized in the following steps.

Transform the recorded interviews into written transcripts.

Analyze the text in the interview transcripts that pertains to the research's focal points.

Examine and comprehend the content within this pertinent text to spot recurring themes across related passages, and assign them as text-based categories.

Identify relevant text-based categories, which are recurring ideas, and cluster them together into corresponding overarching themes known as sensitizing concepts.

Construct theoretical frameworks by arranging these themes (sensitizing concepts) into more abstract and elevated concepts or ideas, representing the highest-level nodes within the concept hierarchy.

In order to ensure the credibility of data analysis and bolster the development of grounded theory in this study, the approach of triangulating data from multiple sources and investigators has been incorporated into the qualitative data analysis. The study involved the selection of interview participants, predominantly managerial staff, from diverse companies representing different industries. Data were collected from these participants through a combination of focus group interviews and in-depth personal interviews, resulting in valid transcribed interview materials. In the data analysis phase, three researchers actively participated in the coding process, thoroughly examining the interview transcripts and independently

formulating concept nodes. In qualitative data analysis, a concept node may represent various units, such as a sentence, a paragraph, or an entire document. These concept nodes can be interconnected in various ways, whether hierarchically or in parallel. In this study, the emerging concept nodes were systematically organized within a hierarchical structure. Following the coding and categorization of nodes, three separate lists of concept nodes were generated by the individual researchers. These lists were subsequently compared and deliberated upon collaboratively by the three researchers, resulting in the consolidation of these concept nodes into a mutually agreed-upon single list, as outlined in Table 3.

Table 3. Transcript of interview Summary

Benefits of IoT Adoption	**Challenges of IoT Adoption**	**Impact on Organizational Performance**
Real-time visibility into supply chain processes.	High initial implementation costs.	Improved supply chain efficiency.
Enhanced data accuracy and quality.	Data security and privacy concerns.	Better decision-making.
Predictive maintenance of equipment and assets.	Integration with existing systems and legacy technology.	Reduced operational costs.
Improved demand forecasting and inventory management.	Scalability and management of a large volume of data.	Increased customer satisfaction.
Optimized route planning and logistics.	Staff training and skills development.	Competitive advantage.
Reduced downtime and disruptions in the supply chain.	Network connectivity and reliability issues.	Greater supply chain resilience.
Better compliance and traceability.	Regulatory and compliance challenges.	

5. DISCUSSION

After completing the coding and classification processes for qualitative data analysis using a Grounded Theory (GT) approach, we identified top-level conceptual categories, which have emerged as theoretical constructs or factors, as outlined in Table 3. The integration of Internet

of Things (IoT) technologies into supply chain management has emerged as a transformative force, offering a plethora of benefits and presenting unique challenges for organizations. Our interview findings shed light on the multifaceted aspects of IoT adoption in the context of supply chain performance and its repercussions on organizational performance. One of the salient benefits highlighted by interviewees is the real-time visibility into supply chain processes afforded by IoT systems. This enhanced visibility empowers organizations to track the movement of goods, monitor inventory levels, and respond promptly to disruptions, a particularly crucial aspect for companies operating in the dynamic and diverse market of Pakistan. Moreover, IoT facilitates enhanced data accuracy and quality, mitigating issues associated with manual record-keeping prevalent in the region. Accurate data is a cornerstone of informed decision-making and efficient inventory management, thereby contributing to improved supply chain performance. However, the adoption of IoT is not without its challenges. Interviewees consistently voiced concerns over the high initial implementation costs, especially pertinent for small and medium-sized enterprises (SMEs) in Pakistan. These organizations must carefully balance the upfront investment with expected returns, making the financial aspect a critical consideration. Additionally, data security and privacy concerns cannot be understated, particularly in an era of increasing cyber threats and regulatory scrutiny. Pakistani organizations must address these apprehensions to establish trust among stakeholders. Integration with legacy systems and the scalability of IoT solutions also emerged as significant challenges, requiring meticulous planning and resource allocation. Despite these challenges, the impact of IoT adoption on organizational performance is substantial. The enhanced supply chain efficiency resulting from IoT implementation leads to cost reductions, which can be a game-changer in a market characterized by cost-conscious consumers. Furthermore, the real-time data insights garnered from IoT systems enable organizations to make data-driven decisions, an invaluable asset for businesses navigating Pakistan's dynamic and diverse consumer landscape. Reduced operational costs, increased customer satisfaction, and a competitive advantage are among the tangible benefits that Pakistani organizations can harness through IoT adoption. Moreover, IoT fortifies the supply chain's resilience, ensuring organizations can respond effectively to unforeseen disruptions, a

pivotal attribute in a market where logistical challenges are not uncommon. [22] work has extensively covered the rapid advancements in IoT technology. The study aligns with Author [15] findings by illustrating how the integration of IoT into supply chain processes can lead to enhanced visibility, real-time monitoring, and improved decision-making capabilities. The positive impacts identified in this study resonate with this research which emphasizes on the transformative potential of IoT in various industries. [23] research has focused on the challenges associated with IoT adoption. The study's identification of barriers such as data security concerns, initial investment costs, and the need for a skilled workforce echoes [24]. This alignment emphasizes the importance of recognizing and addressing these challenges to facilitate successful IoT integration, as highlighted by both the current study. [25] work has delved into factors influencing supply chain efficiency. The findings of this study, which demonstrate the positive impact of IoT on reducing operational costs, decreasing lead times, and enhancing overall supply chain efficiency, align closely with [26] contributions. Together, these studies underscore the interconnected nature of technological advancements and supply chain performance. [12] has explored the implications of IoT adoption in developing economies. The current study, situated in Pakistan, aligns with [27] focus on the unique challenges and opportunities presented by emerging markets. The findings emphasize the potential for IoT to drive sustainable growth in developing economies, providing a nuanced perspective that contributes to the broader discourse. In synthesizing these insights, it becomes evident that the current study contributes to the existing literature by providing empirical evidence of the positive impact of IoT adoption on both supply chain and organizational performance within the specific context of Pakistan. The alignment with various authors' contributions enhances the robustness and generalizability of the findings, offering a comprehensive understanding of the transformative potential and challenges associated with IoT adoption in the supply chain domain.

6. CONCLUSION

In conclusion, this empirical study has delved into the transformative effects of IoT adoption on both supply chain performance and organizational effectiveness within the context of Pakistan. The findings underscore the significant positive impacts that IoT technology has on supply chain operations, revealing enhanced visibility, real-time monitoring, and improved decision-making capabilities. The observed outcomes translate into tangible benefits for organizations, including the reduction of operational costs, decreased lead times, and increased overall supply chain efficiency. These positive effects signify the potential of IoT adoption to revolutionize traditional supply chain processes and contribute to the overarching success of businesses operating in a developing economy like Pakistan. However, it is crucial to acknowledge the challenges identified in the study, such as concerns related to data security, initial investment costs, and the necessity for a skilled workforce. These barriers highlight areas that demand attention and strategic planning for successful IoT integration into supply chain practices. In light of these findings, this study emphasizes the imperative for businesses in Pakistan and similar emerging economies to embrace IoT technology. Such adoption is not merely a technological advancement but a strategic necessity for staying competitive and achieving sustained growth. The practical insights provided by this research are valuable for supply chain professionals, business leaders, and policymakers, offering a roadmap for harnessing the potential of IoT to drive sustainable growth and improved performance. As the digital landscape continues to evolve, the implications of this research extend beyond the immediate context of Pakistan, serving as a foundation for ongoing discussions, further studies, and informed decision-making in the global pursuit of enhanced supply chain and organizational performance through IoT adoption.

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