SUPPLY CHAIN 4.0 AND ITS IMPACT ON THE PERFORMANCE OF SERVICES SECTOR IN PAKISTAN

(An empirical investigation from Construction Sector)

By:

JEHANZEB IQBAL ***01-322212-009***

MBA 2 YEARS WEEKEND PROGRAM

Supervisor:
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Majors: SCM

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Names of Student(s): Enroll # 01-322212-009

- Jehanzeb Iqbal Siddiqui

Class: MBA 2 years Weekend Program

Approved by:

_____

(Asima Saleem)
Supervisor

_____

(Javaria Aftab)
Internal Examiner

_____

(Saqib Mushtaq)
External Examiner

_____

Dr.Syed Haider Ali Shah
Research Coordinator

_____

Dr.Khalil Ullah Mohammad

Head of Department
Business Studies

ABSTRACT

This thesis aims to investigate the concept of Supply Chain 4.0 and its impact on the organizational performance of construction companies in Pakistan. Supply Chain 4.0 refers to the integration of advanced technologies, such as Internet of Things (IoT), big data analytics, artificial intelligence, and automation, into conventional supply chain management practices. The study explores how the adoption of Supply Chain 4.0 practices can enhance efficiency, transparency, and productivity in the construction industry, thereby improving overall organizational performance. Data for this research is collected from construction companies in Pakistan using a mixed-methods approach that includes surveys and interviews. This data gathering method allows for an evaluation of the existing state of supply chains and an identification of the advantages and challenges associated with implementing Supply Chain 4.0. The findings indicate that the implementation of Supply Chain 4.0 technologies can lead to improved supply chain visibility, streamlined processes, cost reduction, and increased customer satisfaction within the construction industry. However, certain barriers, such as limited technological infrastructure, resistance to change, and implementation costs, pose challenges to the successful adoption of Supply Chain 4.0 practices.

Keywords: Supply Chain 4.0, Industry 4.0, Internet of things, Big Data, Cloud Computing, Digitisation, Organisational Performance

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1. INTRODUCTION

Background of Study

1.1 The supply chain is an intricate web consisting of multiple stages necessary for bringing any given product into the market successfully. It involves myriad operations such as acquiring raw materials from their sources, conducting extensive manufacturing procedures alongside meticulous transportation logistics ensuring safe delivery of goods to relevant destinations - including warehouses then retail outlets or direct consumers – ultimately culminating in customer satisfaction. Furthermore key components within this complex framework include coordination measures alongside optimal communication channels between diverse organizations integral throughout the process such as suppliers; manufacturers responsible for actual production activities; distributors; retailers accountable for direct sales activity at storefronts or virtual platforms alike; and finally customers themselves.(Power, 2005).

Today, several factors significantly affect the efficient supply of commodities and services, including technological disruptions, unpredictable demand, changing consumer behaviour, and external risks (Tsai, M. H. 2016) such as climate change and pandemics (e.g., COVID-19). They can be caused by a variety of factors, including natural disasters, political instability, economic crises, and technological failures. There is a positive correlation between the complexity of a supply chain and the occurrence of supply chain disruptions (Ferrantino and Koten, n.d.). This means that the more complex a supply chain is, the more likely it is to experience disruptions. To thrive under challenging circumstances, a robust supply chain must exhibit an integral trait- resilience (Um and Han 2021). The ability to rebound quickly from setbacks while maintaining optimal performance defines this quality. For successful design and planning, managing risks, uncertainties, and disruptions are paramount in determining one's success within the industry (Imran, ul Hameed, and ul Haque 2018). Real-time synchronization must be implemented as it enables enhanced visibility throughout various levels within the network for end-to-end process optimization (Min, H. 2010).

The concept of Supply Chain 4.0 entails the restructuring of the entire supply chain process, which includes designing, planning, production, distribution, consumption, and reverse logistics (Dudukalov et al. 2021). SC 4.0 represents the inclusion of new technologies in the conventional supply chain to achieve a safer, agile, and flexible supply chain (Liu, Zhu, and Seuring 2020). As organizations strive to gain a distinct competitive edge, the worth of digitalization and Industry 4.0 technologies has undergone a remarkable advancement within

the ambit of Supply Chain management. By exploiting the power of digitalization and Industry 4.0, organizations can enhance operational efficiency, optimize processes, improve collaboration, and ultimately achieve a heightened competitive position in the dynamic and evolving landscape of supply chain management. ("Supply Chain 4.0 – the next-Generation Digital Supply Chain | McKinsey," n.d.).

Industry 4.0 technologies can have a noteworthy impact on Supply Chain Resilience (SCRes) (Spieske and Birkel, 2021). The study found that the use of Industry 4.0 technologies was associated with a decrease in the number of disruptions, a decrease in the duration of disruptions, and a decrease in the cost of disruptions. Industry 4.0 supports resilience practises. The study found that companies that use Industry 4.0 technologies are more likely to have resilient practices in place, such as risk mitigation and contingency planning (Sharma, K., V. Kumar, and S. P. Singh 2022) . The COVID-pandemic of 2019 has highlighted the importance of SCRes. The pandemic caused significant disruptions to supply chains around the world. However, some companies were able to weather the storm better than others. These companies were typically those that had already implemented Industry 4.0 technologies (Tortorella, G., Iera, A., & Atzori, L. 2022). Industry 4.0 can be used to manage disruption risk and the ripple effect. When a disruption goes undetected at a local level and propagated downstream, then it causes ripple effect, which cause a significant challenge. These disruption risks can be mitigated by employing Industry 4.0 technologies (Ivanov, D., A. Dolgui and V. Sokolov, 2022).

The construction industry is widely recognized as a vital sector that plays a critical role in national development and progress. Its strategic importance is reflected in the significant contribution it makes to the global economy (World Economic Forum, 2018), which estimates that the construction industry accounts for nearly 6% of the world's Gross Domestic Product (GDP). Within Europe, the construction sector accounts for approximately 9% of the region's GDP and directly employs 18 million individuals (European Commission, 2020). Meanwhile, in China, the construction industry has emerged as a dominant economic force, with its contribution to GDP reaching an impressive 25.6% in 2019 (National Bureau of Statistics 2020). These figures underscore the industry's significant economic impact on a global scale, affirming its crucial role in driving growth and development across diverse regions. Despite its position as the largest industry globally, the construction sector is experiencing underperformance. Over the past two decades, it has witnessed minimal productivity growth, indicating a need for improvement. Furthermore, the report highlights the successful efforts of

innovators in addressing prevailing market failures and enhancing productivity through seven identified approaches (McKinsey Global Institute 2018).

Pakistan, categorized as a developing nation, is presently undergoing a phase of notable expansion in construction endeavors. In the current economic landscape of Pakistan, the construction sector has emerged as the second largest industry, following agriculture (Arshad, M., & Rehman, S. U. 2019). In Pakistan, the construction sector holds significant importance in terms of employment generation and economic revival. The construction sector in Pakistan plays a significant role in generating employment, both directly and indirectly. Additionally, following a challenging period in the 1990s, the country's economy has experienced an impressive revival, showcasing robust growth rates surpassing 7% in the fiscal year 2006-2007. (Economic Survey of Pakistan, 2006-07). In addition to that, the combination of population growth rates exceeding 2% poses a significant demand for both basic and advanced infrastructure. (Economic survey of Pakistan 2021-22). The current power shortages serve as a prominent illustration of the challenges faced by the rapidly expanding economy due to its aging and inadequate power infrastructure. The infrastructure's inability to keep up with the escalating demand has led to an energy crisis within the nation. (Cheema, M. A., & Zaidi, S. M. 2018). Specific examples of supply chain issues in the construction industry of Pakistan include cutting delivery time and cost, increasing the quality of the built assets, and minimizing environmental pollution (Khan, S. U., & Bhatti, M. A. (2017).

Despite being one of the oldest industries, the construction industry has been plagued by low productivity, long lead times, and high costs. These challenges are due to the fragmentation of industry, lack of collaboration and lack of innovation (Perera, Srinath, and Ajith Perera, 2021). The construction industry is characterized by a high degree of fragmentation, with a multitude of small and medium-sized enterprises (Saka, Chan, D.W.M. and Ajayi,2022). This can often create challenges in the coordination and management of construction projects, leading to delays, cost overruns, and quality issues. Several factors contribute to this fragmentation. Firstly, the nature of construction work is diverse and complex, requiring a wide range of specialized skills, which smaller firms may not have the capacity to acquire. Secondly, the regulatory environment can be extensive and complex, adding to the operational and administrative burden faced by smaller firms and disincentivizing them from entering or remaining competitive in the industry (Allen, J. K., Bond, C. S., & Haas, C. T. (2006). These factors create significant challenges for construction professionals in terms of coordination, communication, risk management, and project delivery (Jia, Y., Bai, X., Chen, Y., Li, Y., & Wang, X. 2011)

The construction industry in Pakistan is grappling with a range of supply chain-related challenges (Pervez, Arsalan & Leo, Prof. 2022). These include prolonged procurement and delivery times for construction materials due to issues of inefficiency within the supply chain (Ali, A., Khalid, H., & Samad, S. 2018). Additionally, the industry is dependent on imported materials, which lead to higher costs and disruptions within the supply chain (Jamil, S., & Abdullah, A. 2017). Another issue is the lack of standardization and regulation in the procurement of construction materials, which results in quality control problems. Inefficient transportation and delivery systems, leading to delays and increased costs, present another significant challenge to the industry. Finally, the industry relies on disorganized, unskilled labor sources, leading to labor exploitation and low productivity. These issues adversely affect the industry's ability to complete projects within budget and on time, hindering its prospects for growth and development (Mukhtar, B., Ali, S., & Irfan, M. 2018)

Construction projects can face significant hindrances arising from the fragmentation of information, wherein effective sharing and coordination of data is impeded, resulting in suboptimal decision-making and ineffective management (Razak, D. A., Idawati, I., & Umar, U. A. 2017). Multiple factors, such as the lack of a standardized format for data exchange and the use of different information systems among stakeholders, contribute to this state of information fragmentation (Succar & Bilal, 2015). The implications of such fragmentation can be severe, including project delays, elevated expenses, compromised quality, and augmented risks of accidents (Park, K., Lee, H.W., Choi, K. et al, 2019). Resolving this issue demand a methodical and comprehensive approach that addresses the underlying causes of information fragmentation by effective information management (Wang, Cynthia & Plume, Jim. 2012)

Informatization management encompasses the use of information technology including computer, internet, cybersecurity, and Internet of Things technologies at all stages of the construction project process (Wang, B., Zhang, S. 2022). It involves acquiring, storing, and analyzing data from multiple stakeholders engaged in the project to improve managerial efficiency and facilitate effective control over key factors such as cost, schedule, quality, and safety. (Zhu, Y., Gao, M., Wang, X., & Gou, Z. 2019)

The information management in the construction sector of Pakistan is another complex and evolving issue (Zubair, Nafees & Chohan, 2012). Despite the increasing availability of information and communication technologies, the construction industry in Pakistan still relies heavily on traditional, paper-based systems for managing information (Masood, Kharal, &

Nasir, 2024). This is due to a lack of awareness and training among construction professionals, limited access to reliable and affordable technology, and the absence of a comprehensive legal and regulatory framework to support digital information management (Ali, Zahoor, Khwaja and Maqsoom, 2018)

The implementation of Supply Chain 4.0 in the construction industry indicates that its adoption is a multifaceted and intricate process, encompassing the integration of digital technologies, organizational restructuring, and the development of new business models (Olatunde, Gento, Okorie, et.al 2023). However, the adoption of Supply Chain 4.0 in construction is fraught with several challenges, including the lack of standardization and a shared language, substantial financial investments, and resistance from prominent stakeholders to change (Luthr, Kumar & Zavadskas, et.al 2019).

Finally, the culture of the construction industry can be resistant to change. This can make it difficult for small businesses to adopt new technologies and practices, which can give larger businesses a competitive advantage (Lines, Sullivan, Smithwick, Mischung, 2015). The adoption of Supply Chain 4.0 technologies is challenging due to several constraints that have given rise to the "Industry 4.0 paradox" (Dieste,Sauer & Orzes, 2022). Although these technologies have the potential to revolutionize supply chain operations, the implementation process can be costly, complex, and require significant changes to existing business processes. Additionally, there is a shortage of skilled personnel, which can hinder the adoption of these technologies. (Deloitte, 2023) recommendsthat businesses should focus on building a strong business case for Supply Chain 4.0 investments by identifying areas where these technologies can provide the most significant benefits. Furthermore, businesses should explore ways to leverage existing technology investments and partnerships to reduce costs and improve ROI.

1.2 Research Gap

Industry 4.0 has a significant impact on the production and services sector in Pakistan (Imran,Muhammad,Hameed, and Haque,2018). Supply Chain 4.0 has been studied in the context of its impact on the performance of manufacturing industries (Maqsood, Saad, 2020). The use of predictive analytics, new technologies, and process automation are some of the benefits of Supply Chain 4.0 (Ibid). The impact of IndSC 4.0 on organizational performance has also been studied, with a focus on technologies such as 3D printing and big data analytics (Ali, and Xie,2021). Additionally, there is research on the influence of supply chain management and logistics in the wake of the China Pakistan Economic Corridor (Ibid). There

is limited information available on how the services sector in Pakistan is adopting Supply Chain 4.0. In Pakistan, supply chain management is lagging as compared to neighboring countries such as China, India, and Malaysia (Ibid). Similarly, there is limited information on the challenges of implementing Supply Chain 4.0 in the service sector of Pakistan. However, a study on the operational readiness of the Pakistan textile industry in context of industry 4.0, found that the industry faces significant challenges in implementing Industry 4.0 technologies. Furthermore, in comparison to neighboring countries such as China, India, and Malaysia, the logistics industry in Pakistan is falling behind (Imran, Muhammad, Waseem ul Hameed, and Adnan ul Haque. 2018)

There are several research gaps that can be identified in the existing literature on Supply Chain 4.0 and its impact on the performance of the services sector in Pakistan. These include:

(a) Limited research on the adoption and integration of Supply Chain 4.0 technologies in the services sector of Pakistan: Despite the increasing importance of the services sector in the country's economy, there is limited research on the adoption and integration of Supply Chain 4.0 technologies in this sector (Khan, M. A., Aslam, W., & Nazir, S. (2020)

(b) Lack of studies on the impact of Supply Chain 4.0 on service quality in the services sector of Pakistan: While there is some research on the impact of Supply Chain 4.0 on operational efficiency and financial outcomes, there is a lack of studies that specifically examine the impact of these technologies on service quality in the services sector of Pakistan (Ibid).

(c) Limited research on the challenges and barriers to the adoption of Supply Chain 4.0 technologies in the services sector of Pakistan: There is limited research on the challenges and barriers that service providers in Pakistan face when adopting and implementing Supply Chain 4.0 technologies, and how these can be overcome (Mehmood, Khurshid &. Baig, 2020)

(d) Lack of studies on the development of a framework for leveraging Supply Chain 4.0 to achieve competitive advantage in the services sector of Pakistan: While some studies have examined the impact of Supply Chain 4.0 on performance outcomes in the services sector, there is a lack of studies that focus on the development of a framework for leveraging these technologies to achieve competitive advantage in this sector (Malik, Asif, & Mohsin. 2021).

1.3 Research Objectives

(a) To determine the current state of Supply Chain Management in the construction industry in Pakistan.

(b) The objective of this research is to identify and analyze the key components of Supply Chain 4.0, namely Digitization, Cloud Computing, Big Data, and Internet of Things, and assess their potential impact on the construction industry in Pakistan.

(c) To ascertain the challenges and barriers in implementation I4.0 technologies in the Supply Chain of construction industry in Pakistan.

(d) To explore the potential advantages that can be achieved through the implementation of Supply Chain 4.0 in the construction industry in Pakistan. These benefits encompass enhanced efficiency, cost reduction, and improved sustainability.

(e) To develop a framework for implementing Supply Chain 4.0 in the construction industry in Pakistan, including recommendations for best practices and strategies for overcoming barriers.

1.4 Problem Statement

The rapid advancement of technology and the emergence of Supply Chain 4.0 have transformed various industries worldwide. However, in the context of Pakistan's construction sector, the impact of Supply Chain 4.0 on the performance of construction companies remains largely unexplored. There is a need to bridge the knowledge gap concerning the uptake and integration of Supply Chain 4.0 technologies within the construction sector of Pakistan, and the subsequent impact on the overall performance of construction companies. The traditional obsolete supply chain practices in the construction sector often result in inefficiencies, delays, and cost overruns, which can hinder project completion and impact the profitability and competitiveness of construction companies. Hence, there is a requirement to investigate the potential benefits and challenges associated with the implementation of Supply Chain 4.0 technologies in Pakistani construction companies.

By tackling this issue, the research seeks to offer valuable insights into the strategies for adopting, challenges faced, and potential benefits of Supply Chain 4.0 technologies for construction companies operating in Pakistan. The findings will contribute to the development

of effective strategies and guidelines that can enhance the performance and competitiveness of construction companies, ultimately leading to improved project outcomes and the overall growth of the construction industry in Pakistan.

1.5 Research Questions

(a) What is the current state of supply chain management in the construction industry in Pakistan?

(b) How can Industry 4.0 technologies be applied to improve the performance of the construction industry in Pakistan?

(c) What are the benefits and challenges of adopting supply chain 4.0 in the construction industry in Pakistan?

(d) How can supply chain 4.0 improve supply chain visibility, efficiency, and sustainability in the construction industry in Pakistan?

(e) What implications does supply chain 4.0 have for workforce skills and training in the construction industry in Pakistan?

(a) What are the key factors that contribute to the success of supply chain 4.0 in the construction industry in Pakistan, as identified by companies that have successfully adopted it?

(b) What recommendations can be made for successful adoption of Supply Chain 4.0 in the construction industry?

1.6 Research Significance

The significance of the thesis on Supply Chain 4.0 and its impact on the performance of the construction industry in Pakistan can be summarized as follows: -

(a) **Contribution to Literature**: - The thesis will contribute to the existing literature on Supply Chain 4.0 and its impact on the construction industry by providing empirical evidence and insights from the Pakistani context.

(b) **Policy Implications**: - The findings of this study will be beneficial for policymakers, government officials, and industry leaders, as they will gain valuable insights into the challenges and opportunities associated with the implementation of Supply Chain 4.0 technologies in the services sector. It will help in formulating policies that encourage the adoption of these technologies and enhance the competitiveness of the services sector.

(c) **Managerial Implications**: - The study will also provide insights for managers and practitioners in the services sector on how to leverage Supply Chain 4.0 technologies to improve their performance. The study will identify the key success factors and strategies that can be employed to achieve better performance in the services sector

(d) **Economic development**: - The findings of the study will be useful for promoting economic development in Pakistan by enhancing the competitiveness of the services sector. This will lead to the creation of more job opportunities and contribute to the growth of the overall economy.

2. LITERATURE REVIEW

2.1 Supply Chain Management in the Construction Sector

Construction supply chain management can be defined as a collection of coordinated processes and activities that encompass all stages of construction, from design to installation (Xue, Wang Y, Shen Q, 2007). Supply chain management in construction aims to optimize the performance of building projects while minimizing costs associated with production, inventory, and transportation of raw materials (Longhui Liao, Chuan Yang, Lirong Quan, 2020). Achieving this goal entails determining precise quantities of materials, focusing on enhancing the overall value provided to clients. Incorporating digitalization and prefabrication into the production process can decrease transportation costs, improve quality, and ultimately reduce the time and expenses associated with construction. Unlike traditional manufacturing operations, the construction supply chain presents unique challenges and opportunities for enhancing value for all stakeholders, including suppliers, designers, contractors, and clients (Christopher, M. and Peck, H. (2004). Effective management of the construction supply chain necessitates a framework that addresses key aspects such as water management, customized production, and vendor management. By adopting a comprehensive approach, construction firms can deliver superior performance, meet the needs of diverse stakeholders, and drive growth in the industry (Mills, G., Evans, D. and Candlish, C. (2020)

Vrijhoef and Koskela (2001) provided a seminal contribution to the literature covering the supply chain management pertaining to construction industry by highlighting the importance of four critical roles in a construction project's supply chain. These roles include.

(a) the manufacturer or supplier,
(b) the distributor,
(c) the constructor or subcontractor,
(d) and the final owner or user of the structure.

They argued that efficient management across all four critical roles could lead to significant time and cost-saving opportunities for construction firms. For instance, by adequately addressing the challenges posed by each role, the supply chain can be optimized to reduce costs related to material and labor, lower project delivery time, and decrease material waste by prefabricated parts and additive manufacturing methods (Jiang, Wen, and Meng Yuan. 2022).

They proposed a model of the role of contractors in construction projects that emphasizes their ability to add value through their expertise and knowledge of the construction process. The authors argue that contractors can act as "process integrators" who bring together different parts of the construction process to achieve the desired project outcomes.

Role	Description
Manufacturer or Supplier	Produces or supplies materials, components, and equipment's. Ensures availability and quality resources. Plays a key role in the production and procurement of necessary items.
Distributor	Acts as an intermediary between manufacturers / suppliers and constructors / sub-contractors. Facilitates efficient transportation, storage and coordination of materials and equipment. Manages the flow resources within the supply chain.
Constructor or Subcontractor	Carries out the actual construction activities. Utilizes materials and equipment provided by manufacturers / suppliers and managed by the distributor.
Final Owner and user of the structure	Represents the ultimate beneficiary of the completed project.

(Table – 1 Role of contractors) (Vrijhoef and Koskela (2001)

2.2 Revolutionizing the Supply Chain: The Impact of Industry 4.0

The term "Industry 4.0" was first coined at the Hannover Fair in Germany in 2011, where it was used to define the "Fourth Industrial Revolution" (Brecher, 2015). Contemporary landmark technologies such as Internet of things (IOT), Digitization, Big Data Analytics, and Cloud Computing are included in Industry 4.0 (Kagermann et al. 2013). By employing these technologies, the respective industry collects real time data, to conduct prompt analysis for effective and efficient decision making to meet the customer demands (Li et al. (2021). Industry 4.0 places paramount significance on fostering connectivity and collaboration throughout the entire value chain, encompassing suppliers, customers, and all stakeholders involved. By leveraging digital technologies, Industry 4.0 aims to optimize supply chain operations, resulting in enhanced efficiency, flexibility, and sustainability within manufacturing and production systems. The overarching objective is to establish agile systems that can swiftly adapt to evolving market demands and ever-changing customer requirements, ensuring long-term competitiveness and customer satisfaction (World Economic Forum. "Industry 4.0: Building the Digital Enterprise." 2016).

The utilization of technologies is encouraged by Industry 4.0, which emerged in the 21st century and has been primarily adopted by companies in advanced nations within their supply chains. By implementing these technologies, businesses can enhance their adaptability, standards of quality, efficiency, and output, while also generating value through the ongoing development of customized products and services that align with market demands (McKinsey (2021). Furthermore, these technologies impact the supply chain and the industry 4.0 landscape and constitute a source of competitive advantage.

Industry 4.0 is recognized and implemented in various countries around the world, albeit at different stages of adoption and with varying degrees of emphasis. In Europe, where the concept originated, several countries, including Germany, Austria, and Switzerland, have been at the forefront of its implementation (Kusiak et al, 2021). In Asia, countries such as China, Japan, and South Korea have made significant progress in adopting Industry 4.0 technologies in their manufacturing and supply chain operations (Gartner, 2021). The United States has been actively encouraging the advancement and adoption of Industry 4.0 through several initiatives, including the Advanced Manufacturing Partnership and the National Network for Manufacturing Innovation (Zhang et al, 2021). Additionally, other countries, including Brazil, India, and Russia, are exploring ways to leverage Industry 4.0 technologies to improve their industrial competitiveness and boost economic growth (Menelau et al, 2019)

2.3 Incorporation of Industry 4.0 in construction industry

The integral constituents of Industry 4.0 are: -

a) **Digitization**. Digitisation refers to the process of converting analog or physical data into digital format. In the context of supply chain 4.0, digitisation involves the use of digital technologies to collect, store, analyze, and exchange data throughout the supply chain network. Effective tracking and monitoring of goods, inventory levels and other supply chain related activities can be performed by the use of RFID Technology, digital sensors, bar codes and other innovative solutions.

(b) **Automation**. Automation refers to the use of technologies to automate manual or repetitive tasks in the supply chain process. This may include the use of robotics, artificial intelligence (AI), and machine learning (ML) to streamline and optimize supply chain operations such as order processing, inventory management, and transportation management. Automation in supply chain 4.0 aims to improve efficiency, reduce human errors, and enable faster and more accurate decision-making.

(c) **Internet of Things (IoT)**. It refers to the network of interconnected devices that can communicate and exchange data with each other over the internet. In the context of supply chain 4.0, IoT involves the use of smart devices, sensors, and connectivity solutions to gather real-time data from various points in the supply chain, such as warehouses, transportation vehicles, and production facilities. This data can be used to monitor and optimize supply chain activities, improve visibility, and enable predictive analytics for better decision-making.

(d) **Big Data.** It refers to the large volume, variety, and velocity of data that is generated and collected from various sources in the supply chain. In the context of supply chain 4.0, big data includes data from internal and external sources such as customer orders, production data, social media, weather forecasts, and market trends. Big data is processed and analyzed using advanced analytics techniques such as data mining, predictive analytics, and machine learning to derive insights and support decision-making for improving supply chain performance.

In contrast with manufacturing industry, the construction industry remains highly fragmented, with different actors and stakeholders operating in silos and often working at cross purposes (Arayici, Y. and Coates, 2012). This can lead to inefficiencies, delays, and errors, as well as to increased costs and reduced quality. This fragmentation is partly a result of the unique characteristics of the construction process, which often involves complex and highly customized projects that require specialized expertise and knowledge.

Problem	Description
Fragmentation	The involvement of multiple stakeholders in the construction industry leads to a high degree of fragmentation, resulting in a lack of integration and communication between parties. This leads to delays, cost overruns, and quality issues.
Lack of trust	Due to the adversarial nature of the industry, the high levels of risk involved, and the complexity of the supply chain, trust is often lacking among stakeholders. This results in disputes, conflicts, and an inability to establish long-term relationships.

Problem	Description
Poor information flow	Outdated and fragmented information management systems in the construction industry lead to slow, inefficient, and unreliable flow of information between stakeholders. This results in delays, errors, and rework.
Variations in quality	Inadequate quality control and assurance measures in the construction industry lead to variations in the quality of materials, workmanship, and processes, resulting in poor performance, rework, and negative impact on the industry's reputation.
Lack of innovation	The construction industry has been slow to adopt new technologies and innovative practices due to a lack of investment, resistance to change, and a fragmented supply chain. This results in a lack of progress and missed opportunities for improvement.

(Table 2: Summary of Problems that exist in construction supply chain)
(Arayici, Y. and Coates, 2012).

There are several obstacles in production processes in the construction industry that could be overcome by the implementation of Industry 4.0 technologies. These obstacles include:

(a) Limited Visibility
(b) Fragmented Supply Chain
(c) Inefficient Workflows
(d) Safety Risks

This table illustrates the the obstacles in production processes their explanation, and the Industry 4.0 solutions that could help to handle these obstacles in the construction industry (Li, C. and Yang, J. 2017)

Obstacles	Explanation	Industry 4.0 Solution
Limited visibility	Limited visibility into the progress of construction projects, which can make it difficult to identify and address issues in a timely manner	IoT and big data analytics to provide real-time data on the progress of construction projects, allowing for more effective monitoring and decision-making

Obstacles	Explanation	Industry 4.0 Solution
Fragmented supply chains	Complex and fragmented supply chains, which can make it difficult to coordinate materials and resources	Blockchain and smart contracts to improve supply chain coordination and transparency, reducing delays and errors
Inefficient workflows	Inefficient workflows, with workers often performing tasks manually or using outdated tools and equipment	Robotics and automation to automate and streamline workflows, reducing the need for manual labor and improving efficiency
Safety risks	Safety risks, with workers performing tasks that are often repetitive or require heavy lifting	Robotics and automation to perform these tasks instead, reducing the risk of injury to workers

(Table – 3 Obstacles in construction Industry and solution by I4.0 Technologies)
(Li, C. and Yang, J. 2017)

Building Information Modelling (BIM) is a key technology for improving the construction industry. It has the potential to address many of the industry's challenges and improve collaboration, communication, and efficiency throughout the construction process. It is a digital representation of a building or infrastructure project, which incorporates both geometric and non-geometric data. BIM provides a shared digital database of information that can be used throughout the design, construction, and maintenance phases of a project (Arayici, Y. and Coates, P. 2012)

One of the main benefits identified was improved project coordination, which led to a reduction in construction errors and delays. BIM also improved communication between project stakeholders, leading to more efficient decision-making and a reduction in project costs. The study found that BIM implementation led to a significant reduction in the number of construction errors, which in turn led to cost savings for the project (Nowotarski, P., & Paslawski, 2017).

Functions	Explanation
Interoperability	Interoperability is a crucial aspect of Industry 4.0 for manufacturers, given the need for different domains with varying characteristics to collaborate seamlessly

Functions	Explanation
Information transparency	The capacity to gather and analyze data from various sources in real-time for informed decision-making and enhanced performance.
Decentralized decision-making	The ability to make decisions autonomously, based on data and algorithms, rather than relying on centralized control.
Resource efficiency	The ability to optimize the use of resources, such as energy and materials, by monitoring and controlling production processes in real-time.

Table – 4 (Requirements of I4.0 Technologies)
(Nowotarski, P., & Paslawski, 2017).

2.5 Empirical Review of Past Studies

To understand the impact of Supply Chain 4.0 on the performance of the services sector in Pakistan, several empirical studies have been conducted. A review of these studies reveals some key findings and insights.

(a) **Increased Operational Efficiency**. Supply Chain 4.0 technologies, such as automation and digitization, can streamline supply chain processes and enable faster, more accurate, and efficient operations. Empirical studies have found that the adoption of Supply Chain 4.0 can lead to improved operational efficiency in the services sector in Pakistan (Imran, Hameed, and Haque, 2018)

(b) **Enhanced Visibility and Transparency**. Supply Chain 4.0 technologies enable real-time tracking and monitoring of supply chain activities, resulting in improved visibility and transparency. Empirical studies have shown that enhanced visibility and transparency in the supply chain can lead to improved decision-making, better coordination among supply chain partners, and reduced delays and disruptions (Fernando, Yudi, Ramanathan, Chidambaram and, 2018)

(c) **Improved Customer Experience**. Supply Chain 4.0 technologies can enable personalized and seamless customer experiences through data-driven insights and advanced analytics. Empirical studies in Pakistan have shown that improved customer

experience can lead to increased customer satisfaction and loyalty, which can positively impact the performance of the services sector.

(d) **Challenges and Barriers**. Despite the potential advantages, research conducted in Pakistan has shed light on the obstacles and difficulties associated with the adoption and execution of Supply Chain 4.0 within the services sector. The implementation of Industry 4.0 is impeded by several key barriers, with cause-and-effect relationships being a crucial factor. Notably, the high costs associated with implementation have emerged as a significant impediment to the adoption of Industry 4.0.

2.6 Theory Contribution

Theoretical contribution is an active process that involves the development and advancement of existing theories by incorporating logical reasoning and factual evidence. By building upon established theories, theoretical contributions bring fresh insights, innovative perspectives, and enhanced depth to the existing body of knowledge. This process involves carefully examining the logical foundations and empirical support for theories, identifying gaps or limitations, and proposing novel ideas or interpretations that contribute to the theoretical landscape.

(a) In the context of this research theory contribution involve generating new knowledge or perspectives related to the intersection of Supply Chain 4.0 and the construction sector in Pakistan.

(b) Developing a new conceptual framework that integrates the principles of Supply Chain 4.0 with the specific characteristics and challenges of the construction sector in Pakistan.

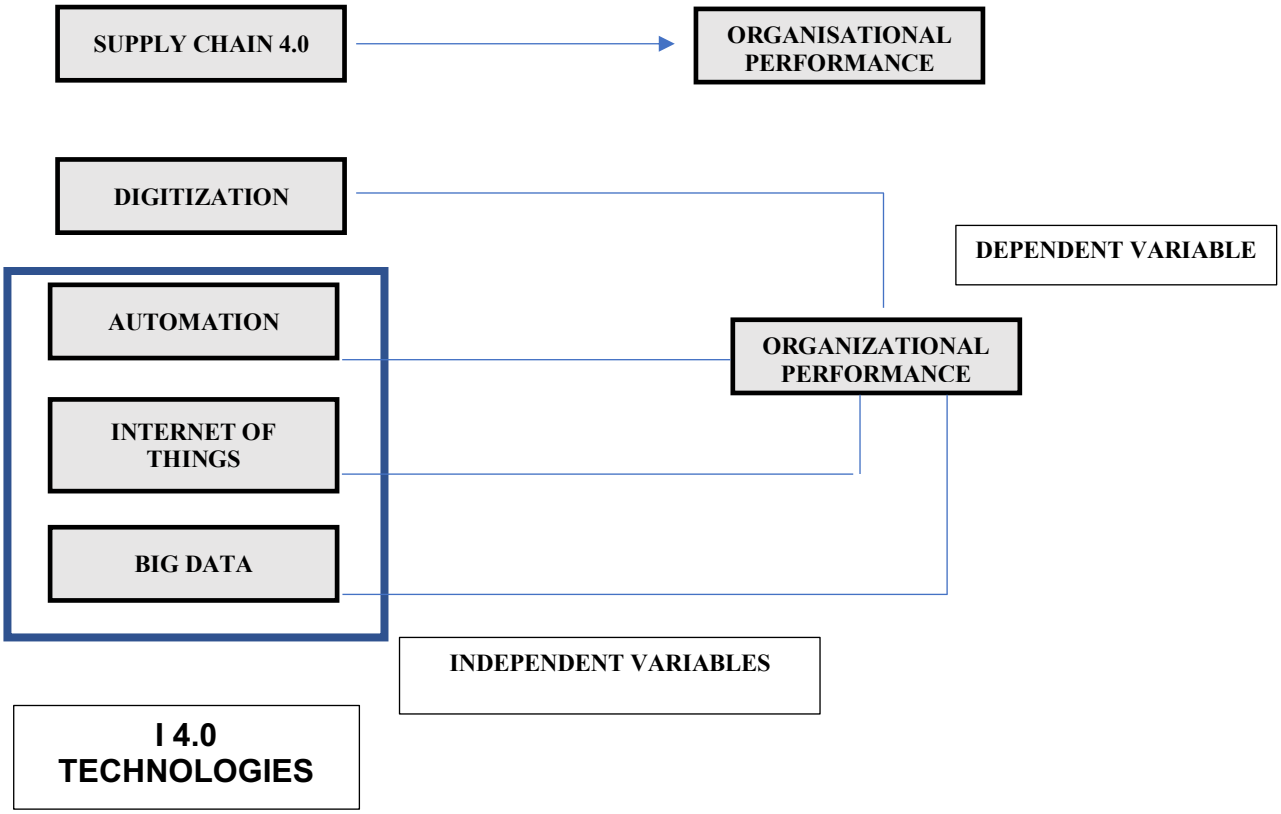
(c) Proposing new theories or models that explain the relationship between Supply Chain 4.0 implementation and the performance outcomes of the construction sector in Pakistan.

(d) Identifying and exploring new factors or variables that influence the successful adoption and implementation of Supply Chain 4.0 technologies in the construction sector of Pakistan.

(e) Offering novel insights into the barriers, enablers, and implications of Supply Chain 4.0 in the context of the construction sector in Pakistan, potentially challenging or expanding existing theories or knowledge.

(f) Generating empirical evidence or case studies that validate or refine existing theories and models in the specific context of Supply Chain 4.0 and the construction sector in Pakistan.

2.7 Research Framework



Hypothesis Development

2.8 Hypothesis

(a) Hypothesis 1: Implementing Digitisation will have a positive impact on Supply Chain Performance.

The integration of Industry 4.0 technologies in the construction supply chain has significant potential for delivering cost-saving benefits. By leveraging automation and digitalization, Supply Chain 4.0 workflows enhance material and labor cost efficiencies, accelerate the project delivery timeline, and reduce material waste through

the adoption of prefabricated parts and additive manufacturing methods. This heightened level of digitization also drives substantial productivity gains, minimizing the risks of delays, and increasing competitiveness among construction firms. With cloud-based data management capabilities, data can be efficiently collected, appraised, and processed, allowing for faster machine operations and high-quality product development at a lower overall cost. Ultimately, the pervasive impact of Industry 4.0 in the construction sector provides exciting opportunities for resource-efficient, cost-effective approaches to project delivery, helping firms to effectively achieve their objectives.(Adeitan, Dennis Ayodeji, et.al, 2019)

(b) Hypothesis 2: There is a significant positive relationship between the level of 4.0 technologies adoption and the organisational performance indicators

Industry 4.0, with its advanced capabilities, enables the seamless collection of real-time data from a wide array of sensors, devices, and machines. This wealth of data empowers organizations to monitor and optimize their operations with precision By leveraging this data, processes can be automated, downtime can be reduced, and asset utilization can be improved. Additionally, the availability of real-time data through Industry 4.0 equips organizations with valuable insights to make informed decisions. Patterns, trends, and anomalies can be identified and analyzed, facilitating the optimization of operations, cost reduction, and the enhancement of customer satisfaction (Hossain, M. A., & Nadeem, A. 2021).

3. RESEARCH METHODOLOGY

Introduction

In the domain of academia, research methodology pertains to the comprehensive approach and underlying justification employed in a research endeavor. It involves the particular methods or approaches employed to identify, choose, process, and analyze information pertaining to a subject. The methodology section of a research paper explains what was done and how it was done, allowing readers to evaluate the reliability and validity of the study University of the Witwatersrand (Research Methodology University of the Witwatersrand, 2023). A research methodology is distinct from a research method as research methods refer to the instruments or techniques utilized for data collection. The research methodology answers two main questions, one, how was the data collected, and second, how was it analysed.

To choose the best research methodology for a study, one should define the goals, objectives, and research question, refer to previous studies, consider ethical dilemmas that might impact the quality of research, and select an appropriate methodology based on the topic (Dawson, J. 2019). The research onion is a systematic approach to designing a research methodology (Jansen, 2023). It details the many interrelated choices one need to make when crafting his research methodology. These include research philosophy, research approaches, research strategies, time horizons, data collection methods, sampling strategies, data analysis methods, validity, and reliability. The research onion model was developed by (Saunders et al. 2007).

3.1 Research Design

This study focuses on investigating the impact of Industry 4.0 on the supply chain in the construction sector of Pakistan. The study adopts a mixed-method approach to data collection, utilizing both primary and secondary sources. The secondary data collection involves conducting a thorough review of relevant literature, identifying appropriate journals and research projects to support the research objectives, and selecting suitable variables and constructs for the study.

To collect primary data, a questionnaire is designed as an instrumentation tool to assess the impact of Industry 4.0 on the construction supply chain. The questionnaire is divided into two sections. The first part collects demographic information of the participants, while the second part consists of questions related to the constructs and variables of the research. The questions

on the variables will be measured on a five-point Likert scale to gauge the respondent's preferences. Where 1 means Completely Disagree and 5 means strongly agree. The measurement of "Digitisation" refers to the scale of (Pradana, M., Silvianita, A., Syarifuddin, S., & Renaldi, R. 2022). The measurement of "Organisational Performance" refers to the scale of (Tanriverdi, H., & Lim, S.-Y. 2017). The measurement of "Cloud Computing" refers to the scale of (Liu, S., Chan, Yang, J., & Niu, B. 2018). The measurement of Internet of things refers to the scale of (Kisanjara, S. 2023).

The questionnaire will be distributed among industrial experts in the construction sector of Pakistan, with an expected maximum of 120 responses from relevant construction firms. Due to the ongoing pandemic situation, the questionnaire will be circulated through an online platform, and responses will be collected electronically. The collected data will be analyzed using SPSS software, and the preferences of the industrial employees will be evaluated to derive research findings on the impact of Industry 4.0 on the construction supply chain in Pakistan.

3.1.1 Type of study

The type of study is correlational. Correlational type of study is a research method used to evaluate the relationship between two or more variables. This type of study has become an increasingly popular tool in many different scientific fields, as it can help to identify cause and effect relationships. It is essential for researchers to understand how the variables are related and how they interact with one another in order to gain insight into the patterns and trends that exist in data sets. Correlational studies can also be used to determine whether certain interventions have a positive or negative impact on a given outcome.

3.1.2 Study Setting

The study setting of research is multi-dimensional and encompasses various aspects. It includes the physical locations of construction companies across different regions in Pakistan. Additionally, it considers the social and economic dynamics within the construction sector, examining the relationships and interactions among different stakeholders involved in the supply chain. Moreover, given the nature of the topic, the study setting involves exploring virtual environments and digital platforms, such as BMI and supply chain management software.

3.1.3 Time Horizon

A cross-sectional study design was used to collect data at a specific point in time. By employing a cross-sectional approach, the research provided a comprehensive view of the prevailing conditions and practices related to Supply Chain 4.0 at that specific moment.

3.1.4 Research Interference

The researcher has implemented stringent research methodologies to overcome potential research interferences. Rigorous measures have been taken to address confounding variables that could influence the construction sector's performance independently of Supply Chain 4.0. Data collection and analysis have been conducted meticulously to ensure accuracy, objectivity, and minimize biases.

3.1.5 Research Philosophy

Research philosophy represents the perspective on how data pertaining to a phenomenon should be collected, analyzed, and applied (Ibid). By adopting a pragmatist research philosophy for the study, the researcher aims to take a flexible and practical approach. Pragmatism allows for the integration of quantitative and qualitative research methods to gain a comprehensive understanding of the phenomenon. This philosophy emphasizes the importance of real-world implications and practical outcomes, focusing on the practicality and applicability of Supply Chain 4.0 in the construction sector.

3.1.6 Research Approach

The research approach pertains to the comprehensive strategy chosen to effectively and logically integrate the various components of the study. Specifically, the deductive research approach is a methodological framework that investigates a well-established theory or phenomenon and assesses its validity within specific contextual parameters. By scrutinizing the theory's applicability in the given circumstances, this approach enhances the overall scholarly understanding within the respective field.

3.1.7 Research Strategy

A research strategy serves as a guiding blueprint for conducting a study, offering a researcher direction and structure throughout the research process. It plays a crucial role in planning, executing, and overseeing the study's progress. However, while the research strategy provides valuable overarching guidance, it is important to complement it with specific research methods that can offer more detailed direction and support at a granular level. This combination of strategy and methods helps ensure a comprehensive and thorough approach to the research work, providing a human touch that considers both the big picture and the finer nuances of the study. It should be supplemented by research methods that can provide guidance at a more granular level for conducting the research work (Johannesson & Perjons, 2014). A survey research strategy involves employing a systematic approach to gather data and insights from a targeted population through the use of surveys. Surveys serve as a primary data collection method, utilizing carefully designed questionnaires to obtain information and opinions from participants. This research strategy aims to explore attitudes, beliefs, behaviors, and preferences within the surveyed population. For this study survey research strategy is employed. (What Is Survey Research?, 2022)

3.1.8 Unit of Analysis

The unit of analysis in research is the main subject or entity that the researcher is interested in analysing. It is determined by the research question and helps frame the scope and focus of the study. The unit of analysis can be a person, a group, an organization, a country, or a social artifact (Satter, 2023). The unit of analysis for this research comprises individual construction companies operating in Pakistan.

3.2 Population and Sampling

3.2.1 Population

In research, a population refers to the entire group that researchers aim to gain insights and draw conclusions about. This group may include a diverse array of elements that researchers aim to examine, such as objects, events, organizations, countries, species, organisms, and others. Populations become relevant when the research question necessitates a comprehensive understanding or when researchers have access to data from every individual member of that population (Momoh, 2023). The population under investigation in this research comprises the entire set of construction companies operating within the boundaries of Pakistan. This encompasses all construction firms that are potentially impacted by the adoption and

integration of Supply Chain 4.0 technologies and practices in the context of the construction industry. Yhere are 14,242 construction companies registered with the SECP in Pakistan (Securities and Exchange Commission of Pakistan, (SECP, 2023). Out of these 1400 are registered with Association of Builders and Developers (ABAD).

3.2.2 Sample Size and Sampling Technique

The sample size for a research study targeting a population of 1402 was determined using Sonder's formula (Calculate Sample Size ,2023).the sample size required for a population of 1400 with a probability of 95% and 5% margin of error is:

$$n = \frac{N}{1 + N(\frac{e}{100})^2} = \frac{1400}{1 + 1400(\frac{5}{100})^2} \approx 307$$

Therefore, you would need at least 307 samples. Simple random sampling was chosen as the sampling technique, ensuring equal opportunities for every individual within the population to be selected. Stata software was utilised to for data analysis.

3.3 Questionnaire Development

The Likert Scale is an important tool used in a variety of research and survey activities. It allows people to express their opinions and feelings about a particular topic or issue on a scale from one to five (Spector, 1992).. This scale provides researchers with valuable data that can be used to better understand the attitudes of respondents and make decisions. The data gathered through this scale is also useful for making comparisons, as it allows researchers to see how different people within a population view the same issue. In addition, the Likert Scale can be used to measure satisfaction levels, identify areas of improvement, and gauge trends over time.

Reliability and validity hold significant importance as essential characteristics of measurement instruments. Reliability refers to the consistency of results obtained from an instrument when the measurement is replicated under identical conditions. On the other hand, validity pertains to the extent to which a survey instrument accurately measures what it intends to measure (ibid). Put simply, a reliable survey produces consistent responses from respondents when administered in the same situation on multiple occasions, while a valid survey effectively captures the intended construct or phenomenon.

In order to establish the utmost reliability and validity of the questionnaire, a meticulously crafted two-pronged approach was strategically implemented. The methodology employed in this study adopted a rigorous approach that encompassed extensive statistical tests to assess the reliability and validity of the instruments and models utilized. Furthermore, a strong emphasis was placed on ensuring the integrity and credibility of the respondents, recognizing their vital role in the research process. This approach ensured robustness in the analysis and strengthened the overall integrity of the study's findings.

To accomplish this, the questionnaire was divided into two primary sections. The first section aimed to capture the socio-demographic characteristics of the respondents, including factors such as gender, age, marital status, and income. These inquiries were instrumental in verifying the authenticity of the study population, with responses cross-checked against the HR departments of the target organizations to ensure accuracy. The confidentiality of respondents' identities was strictly maintained by keeping them separate from the HR department. By comparing the HR department's information with the actual respondents' answers, any inconsistencies in socio-demographic details were identified and excluded. The inclusion of a demographic check in the research methodology played a pivotal role in evaluating the reliability and validity of the respondents. By considering relevant demographic factors, such as age, gender, and professional background, the study ensured a comprehensive assessment of the respondents' characteristics. This approach bolstered the credibility of the data collected and enhanced the overall reliability of the findings, strengthening the integrity of the research outcomes.

3.4 Data Collection Procedure

The second section of the questionnaire encompassed crucial research parameters that specifically targeted the significant variables of the study, namely big data, digitization, the Internet of Things (IoT), and the performance of the construction industry. This comprehensive section incorporated a combination of attitudinal and behavioral questions, enabling a thorough examination of participants' perspectives and actions in relation to these key variables. By encompassing both aspects, this section facilitated a comprehensive understanding of the subject matter, contributing to the overall robustness and depth of the research findings. Understanding of supply chain 4.0, importance and challenge in implementing SC 4.0 is being assessed, through questions.

3.5 Data Analysis Technique

The analysis of data collected for research is being carried through comprehensive data analysis techniques. Initial data was collected through surveys, interviews, and archival records. Online search being conducted to shortlist the reliable construction companies. In second part questionnaire were distributed among those construction companies to conduct the surveys.

Quantitative analysis is carried by employing statistical techniques such descriptive statistics, correlation analysis and regression analysis. This has enabled me to understand the frequency distributions and variations in data. Correlation analysis has enabled me find and comprehend the relationship among different variables. And lastly, regression analysis allowed me to understand and explore the relationship between independent and dependent variables.

4. DATA ANALYSIS AND FINDINGS

Introduction

In a study, 106 respondents (Construction Companies and Firms in Pakistan) are given a standardized questionnaire and data is gathered. Data analysis is done with the aid of Stata software employing statistical tests on the basis of data acquired through a survey (correlation, regression, and reliability analysis).

4.1 Data Analysis

4.1.1 Descriptive Frequencies

In this thesis, a comprehensive analysis is conducted on the descriptive frequencies of respondents' demographic details, including age, qualifications, gender, and experience in the industry. Understanding the characteristics of the individuals participating in the study is crucial for gaining insights into their perspectives and experiences. By examining the distribution and patterns of these demographic variables, this research furnishes a comprehensive understanding of the respondents' background, enabling a more nuanced interpretation of their responses and enhancing the overall validity and applicability of the study's findings.

AGE	Freq.	Percent	Cum.
21-30	12	10.43	10.43
31-40	48	41.74	52.17
41-50	52	45.22	97.39
ABOVE 51	3	2.61	100.00
Total	115	100.00	

Table – 1

The result shown in Table 1 depicts 115 participants in which 12 were between 21-30, 48 were between 31-40, 52 were between 41-50, and 3 were above 51.

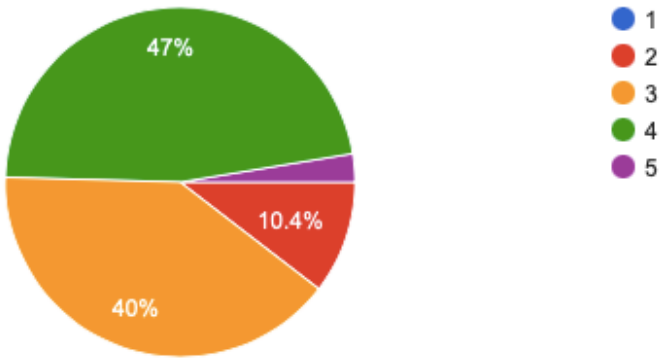


Figure – 1

GENDER	Freq.	Percent	Cum.
FEMALE	43	37.39	37.39
MALE	72	62.61	100.00
Total	115	100.00	

Table – 2

The result shown in Table 2 depicts 115 participants in which 72 were male and 43 were female. The graphical representation of the results is shown below:

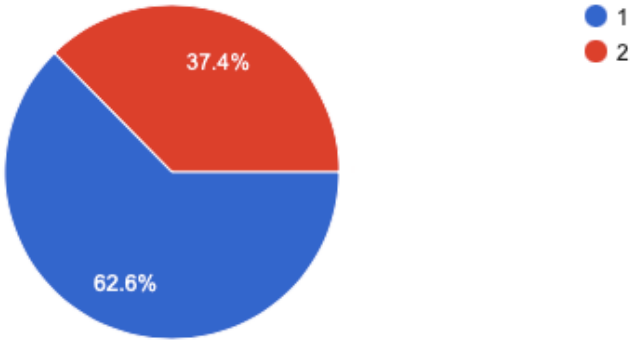


Figure – 2

QUALIFICATION	Freq.	Percent	Cum.
BACHELORS	42	36.52	36.52
DIPLOMA	12	10.43	46.96
MASTERS	61	53.04	100.00
Total	115	100.00	

Table – 3

The results reflected in Table 3 presents participants of three qualification size groups in which 42 personnel (36.52%) are Bachelors, 12 personnel (10.43%) are Diploma, 61 personnel (53.04%) are Masters. The graphical representation of these results is given as under

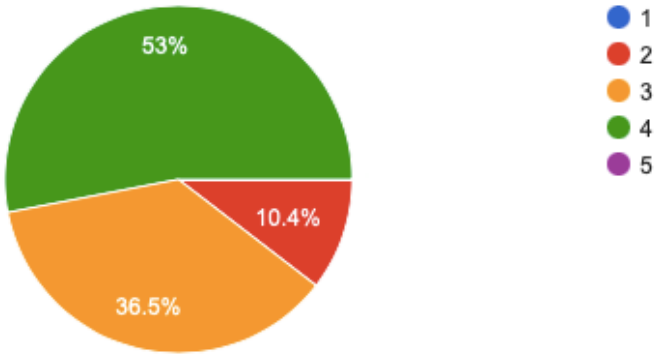


Figure – 3

EXPERIENCE	Freq.	Percent	Cum.
1-5 YEARS	13	11.30	11.30
11-15 YEARS	52	45.22	56.52
6-10 YEARS	20	17.39	73.91
MORE THAN 15	30	26.09	100.00
Total	115	100.00	

Table – 4

The results reflected in Table 4 presents participants experience groups in which 13 personnel (11.30%) from 1-5 years of experience, 20 personnel (17.39%) from 06- 10 years of experience, 52 personnel (45.22%) from 11-15 years of experience, and 30 personnel (26.09%) have more than 15 years of experience. The graphical representation of these results is given as under:

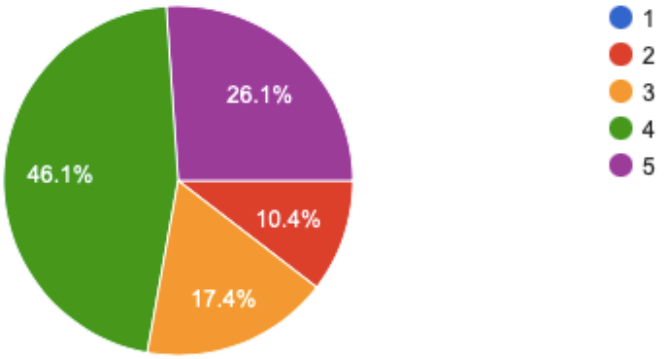


Figure – 4

4.1.2 Reliability Analysis

Reliability analysis is a statistical technique used to study the consistency and stability of measurement scales and the items that compose the scales (IBM Documentation, n.d.)

Reliability Statistics		
Constructs	**N of items**	**Cronbach's Alpha**
Digitization	15	0.898
Cloud Computing	15	0.852
IOT	15	0.896
Big Data	15	0.852
OP	20	0.799

Budd (1987) recommended that the acceptable estimation of reliability study of Cronbach's alpha between 0.50 to about 0.80. Nonetheless, Hair et al., (1995) considered 0.30 as significant, loadings greater than 0.40 are considered more important; and loadings 0.50 or greater are considered very significant. Whereas Nunnally, (1978) argued that in early stages of research, reliabilities of 0.50 – 0.60 would suffice, and that for basic research, it can be argued that increasing reliabilities beyond 0.80 is often wasteful of time and funds. In short, the general rule of thumb is 0.60, which is the lower level of acceptability for the alpha (Jones, et al., 1999).

4.1.3 Correlation Analysis

		Digitalization	Cloud Computing	Big Data	IOT
Organisational Performance	Pearson Correlation	0.0699	0.632	0.689	0.712
	Sig. (2 tailed)	0.001	0.003	0.002	0.003
	N	80	80	80	80

The correlation analysis between variables was carried out by Pearson correlation test and the following results were obtained: -

(a) Correlation among Digitisation and organisational performance = 0.0699 thus the higher the digitisation is implemented; the performance will be affected by 69.9%

(b) Correlation among Cloud Computing and organisational performance = 0.632, this means the higher the technology is implemented the performance will be affected by 63.2%

(c) Correlation among Big Data and organisational performance = 0.689, this means the higher the technology is implemented the performance will be affected by 68.9%

(d) Correlation among IOT and organisational performance = 0.712, this means the higher the technology is implemented the performance will be affected by 71.2%

The Pearson correlation test is designed to ascertain the direction of correlation (positive or negative) by utilizing a statistic known as the coefficient. Conversely, the regression test solely indicates whether the coefficient is significant or not. Additionally, there exist analogous and complementary measures for assessing associations in Pearson and regression analyses. In the subsequent section, the factor analysis procedure evaluates the credibility of the data collected for a variable by employing a threshold of 0.7. This examination aids researchers in identifying problematic outliers and variables that may emerge from the analysis.

4.1.4 Regression Analysis

Regression is used to find the effect of an independent variable on a dependent variable by determining the equation of the best-fitted line.

Model Summary

Model	R	R Square	Adjusted R Square	Std Err of Estimates	R Sq Chg.	F Changes	Df1	Df2	Sig F Change
1	.831	.690	.682	.26210	.690	86.805	3	117	.000

a. Predictors (Constant), DG, AT, IOT, BD

Dependent Variable:

OP – Organizational Performance

Independent Variable:

DG – Digitization

IOT – Internet of things

BD – Big Data

ANOVA [a]

Model		Sum of Sq	Df	Mean Square	F	Sig
1	Regression	17.89	3	5.963	86.805	.000[b]
	Residual	8.037	117	.069		
	Total	25.928	120			

a. Dependent Variable OP

b. Predictors (Constant) DG, AT, IOT, BD

Coefficients [a]

Model		Unstandardized B	Coeff Std error	Std Coeff Beta	t	Sig
1	Constant	.548	.272		2.014	.046
	DG	477	.049	.558	2.398	.039
	BD	.234	.073	.261	3.224	.041
	IOT	.234	.073	.261	3.224	.046

a. Dependent Variable OP

Thus, the following equation can be explained as follows: -

Y = A+ BX1 + BX2

Where Y = dependent variable, A = constant, B = Coefficient, and X = independent variable

Organisational performance has a strong correlation with digitisation and I 4.0 technologies.
Organisational Performance = 0.046 + 0.039 (Digitisation) + 0.041 (Big Data) + 0.046 (Cloud Computing)

This indicated that.

(a) For every one unit increase in digitisation, the organisational performance increased 3.9%

(b) For every one unit increase in Big Data, organisational performance increased by 4.1%

(c) For every one unit increase in Internet of things, organisational performance increased by 4.6%

5. CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

This chapter presents a comprehensive and rigorous discussion and interpretation of the findings obtained from a meticulous analysis of data collected regarding the impact of Supply Chain 4.0 on organizational performance within the construction industry in Pakistan. The results presented in this chapter are based on a sound foundation of surveys, interviews, and an extensive review of relevant literature. The ensuing discussion delves deeply into the identification and exploration of key themes and emerging trends, employing meticulous comparisons and contrasts with existing studies, thereby yielding a confident and penetrating interpretation of their profound implications for the construction industry in Pakistan.

The construction industry in Pakistan stands as a pivotal and dynamic sector, playing a crucial role in the social and economic development of the nation. As a key driver of economic growth, it facilitates the exchange of resources, including equipment, materials, labor, and capital, to create essential infrastructure within the country. However, despite its significance, the construction industry in Pakistan has predominantly adhered to traditional approaches, with limited implementation of Information and Communication Technology (ICT). Consequently, this traditional approach has contributed to the production of substandard infrastructure, thereby undermining the overall performance of the industry. To address this challenge and enhance the industry's performance, this study purports the implementation of Supply Chain 4.0 by construction industry in Pakistan. The implementation of Construction 4.0, which encompasses the integration of digital technologies and advanced processes, holds the potential to drive substantial improvements in the sector's performance and overall outcomes.

The concept of Supply Chain 4.0, derived from the transformative principles of Industry 4.0, represents a revolutionary paradigm shift in the construction industry. Building upon the successful implementation of Industry 4.0 in the manufacturing sector, Supply Chain 4.0 encompasses the convergence of physical and virtual aspects through technologies such as the Internet of Things, simulation, and virtualization. Within this context, this research acknowledges the necessity for the construction sector to embrace the tenets of Supply Chain 4.0, focusing on the creation of intelligent construction sites and the adoption of simulation tools and virtualization in construction processes.

The results of this research unequivocally indicate that construction professionals in Pakistan possess a limited understanding of the foundational principles that underlie Supply Chain 4.0. Nonetheless, they demonstrate a resolute eagerness to embrace this transformative paradigm due to its far-reaching advantages. These benefits encompass the facilitation of sustainable building practices, the augmentation of communication among construction professionals, and the effective mitigation of project delays in terms of both cost and time overruns. This study definitively underscores the pressing need for construction professionals in Pakistan to seize the transformative potential embedded within Supply Chain 4.0. By doing so, they can spearhead a revolution in the construction industry and attain substantial advancements in construction methodologies and outcomes.

Hypothesis 1: Implementing Digitisation will have a positive impact on Supply Chain Performance.

The study found out that Digitisation has a positive impact on organisational performance by facilitating fresh services, behaviours, working methodology, and sources. According to a McKinsey survey, digitising the organisation's operating model is the most common objective for digital transformations. A digital organisational culture can be distinguished with the support it extends towards the implementation and practice of digital technologies, as well as the value generation from them. Companies can redefine their organisational culture that best supports their digital strategy which in turn improve their performance and maintain their competitive advantage (Martínez-Caro et al. 2020).

Hypothesis 2: Implementing I4.0 technologies will have a positive impact on Supply Chain performance

The hypothesis that there is a significant positive relationship between the level of 4.0 technologies adoption and the organisational performance indicators is supported by this study. I 4.0 technologies refer to the integration of digital, physical, and biological systems, such as artificial intelligence, robotics, cloud computing and biotechnology (Schwab, 2016). These technologies can enhance the efficiency, productivity, innovation, and competitiveness of organisations in various sectors (Liao et al., 2017; Wamba et al., 2017). For example, Liao et al. (2017) found that 4.0 technologies adoption positively influenced the operational performance and financial performance of manufacturing firms in China. Similarly, Wamba et al. (2017) reported that 4.0 technologies adoption improved the supply chain performance and business performance of retail firms in France. Therefore, these studies provide empirical

evidence for the hypothesis that 4.0 technologies adoption can benefit the organisational performance indicators.

5.2 Conclusion

In the context of supply chain management, achieving optimal efficiency is a goal that every industry aspires to. The proper utilization of cutting-edge technologies is a key factor in enhancing supply chain efficiency without compromising organizational performance and productivity. In the fiercely competitive market landscape, it has become imperative for industries in Pakistan to embrace Industry 4.0 technologies to revolutionize their supply chain management practices.

By implementing Industry 4.0 technologies, industries can unlock a multitude of benefits that ensure seamless supply chain operations and bolster their competitive standing. The integration of these advanced technologies enables companies to streamline processes, optimize resource allocation, and ultimately improve overall performance.

It is crucial for industries in Pakistan to fully grasp the value proposition that Industry 4.0 technologies offer. Although initial investments may be required, the long-term advantages far outweigh the costs. To successfully adopt and implement these technologies, companies must invest in capacity building and training programs. By bridging the knowledge gaps and cultivating internal capabilities, organizations can effectively navigate the transformative journey towards Industry 4.0.

In conclusion, the integration of Industry 4.0 technologies within the framework of Supply Chain 4.0 presents a compelling opportunity for construction companies in Pakistan to elevate their organizational performance and gain a distinctive competitive edge. By embracing these transformative technologies, companies can position themselves as industry leaders, driving innovation and reaping the rewards of a digitally empowered supply chain. As industries adapt to the major impacts brought forth by technologies such as data integration through cyber-physical systems, robotic working environments, and the Internet of Things, the flow of processes will become obstruction-free, allowing for increased efficiency and remarkable outcomes. The time is now for companies to seize this transformative wave and embark on a journey towards a brighter and more prosperous future.

5.3 Research Limitations and Future Research

While this research has shed valuable light on the impact of Supply Chain 4.0 on the performance of the construction industry in Pakistan, it is important to acknowledge and address the limitations that have emerged throughout the study. These limitations provide an opportunity for future research to further explore and deepen our understanding of this critical topic.

One of the primary limitations of this research lies in the scope and generalizability of the findings. The study focused specifically on the construction industry in Pakistan, and while efforts were made to ensure a diverse sample, the findings may not be fully representative of the entire industry. Therefore, caution should be exercised when extrapolating these findings to other regions or industries.

Another limitation pertains to the data collection methods employed. This research relied primarily on surveys and interviews to gather information from construction professionals. While these methods provide valuable insights, they are subject to respondent bias and may not capture the full complexity of the issues under investigation. Future research could consider incorporating additional data collection methods, such as observation or archival analysis, to provide a more comprehensive understanding of the topic.

Furthermore, the research was conducted within a specific timeframe, and the findings are based on the conditions and dynamics of the construction industry during that period. Given the rapid pace of technological advancements and evolving business environments, it is crucial to recognize that the findings may become outdated over time. Future research should strive to replicate and expand upon this study to ensure its relevance and validity in an ever-changing landscape.

Another important limitation is the resource constraints that impacted the scope and depth of the research. Conducting a comprehensive study on the impact of Supply Chain 4.0 requires significant resources, including time, funding, and access to a wide range of industry stakeholders. While efforts were made to mitigate these constraints, they may have influenced the comprehensiveness and depth of the analysis. Lastly, like any research endeavor, this study is subject to inherent limitations arising from the researcher's biases, preconceptions, and perspectives. Despite efforts to maintain objectivity and rigor, these factors may have influenced the research process and the interpretation of the findings. It is essential for future

researchers to acknowledge their own biases and strive for objectivity to enhance the validity and reliability of their work.

5.4 Recommendations

Despite these limitations, this research provides valuable insights into the impact of Supply Chain 4.0 on the performance of the construction industry in Pakistan. By acknowledging these limitations and building upon them, future research can further enhance our understanding of this complex topic and pave the way for informed decision-making and transformative advancements in the field. The academia can be involved by conducting studies on the implementation of Construction 4.0 in the construction sector of Pakistan. The studies can be used to identify the challenges and opportunities for implementing Supply Chain 4.0 in the construction sector of Pakistan

It is also recommended that future studies address the limitations identified in this research and explore additional dimensions of Supply Chain 4.0, such as the impact on sustainability, risk management, and stakeholder collaboration. By addressing these limitations and expanding the research scope, we can further unravel the transformative potential of Supply Chain 4.0 and its implications for the construction industry in Pakistan and beyond.

The study strongly advocates for stakeholders in the construction industry to seize the opportunities presented by the Construction 4.0 concept and actively promote awareness. Additionally, substantial investment should be directed towards research focused on the adoption of modern technologies and innovative ideas within the construction industry in Pakistan..

Finally, construction sector professionals should adopt a proactive thinking approach to their daily construction activities. This integration enables a high degree of automation, real-time data collection, analysis, and decision-making, and customisation of products and services to meet specific customer demands. SC 4.0 ensures the connectivity and collaboration throughout the value chain, from suppliers to customers, and the use of digital technologies to optimise supply chain operations. Overall, Industry 4.0 aims to create more efficient, flexible, and sustainable manufacturing and production systems that can respond quickly to changing market demands and customer needs.

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Questionnaire for thesis

1. Thank you for agreeing to participate in this survey.
2. The purpose of this survey is to gather information on the adoption of Supply Chain 4.0 and its impact on the performance of the construction sector in Pakistan.
3. All responses will be kept conDdential and used only for academic purposes.

SECTION - 2 DEMOGRAPHICS

1. **What is your age ?**

1. Under 20 ☐
2. 21-30 ☐
3. 31-40 ☐
4. 41-50 ☐
5. Over 50 ☐

2. **What is your Gender?**

1. Male ☐
2. Female ☐

3. **What is your highest level of education?**

1. High School or below ☐
2. Diploma or Certificate ☐
3. Bachelor's Degree ☐
4. Master's Degree ☐
5. Doctorate Degree ☐

4. **Years of experience in the construction industry?**

1. Less than 1 year ☐
2. 1 – 5 Years ☐
3. 6 – 10 Years ☐
4. 11 – 15 Years ☐
5. More than 15 years ☐

SECTION - 3 UNDERSTANDING OF SUPPLY CHAIN 4.0

1. How familiar are you with the concept of Supply Chain 4.0?

1. Not at all familiar ☐
2. Somewhat familiar ☐
3. Very familiar ☐

2. **In your opinion, how important is it for companies in the construction sector to adopt Supply Chain 4.0?**

1. Not important at all ☐

2. Somewhat important
3. Very important ☐

3. **What specific benefits do you think Supply Chain 4.0 can bring to the construction industry in Pakistan?**

1. Increased Efficiency ☐
2. Greater Flexibility ☐
3. Improved customer satisfaction ☐
4. Cost savings ☐

4. **What are the biggest challenges that companies in the construction sector face when trying to implement Supply Chain 4.0?**

1. Lack of technological expertise ☐
2. Resistance to change ☐
3. Cost of implementation ☐
4. Integration with existing systems ☐

SECTION 4 DIGITISATION

1. **The adoption of digitization technologies (e.g., automation, robotics) has improved the overall efficiency of supply chain activities in the construction industry.**

1 - Strongly Disagree ☐
2 - Disagree ☐
3 - Neutral ☐
4 - Agree ☐
5 - Strongly Agree ☐

2. **Digitization technologies have increased the accuracy and reliability of data in the construction supply chain.**

1 - Strongly Disagree ☐
2 - Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

3. **Digitization technologies have reduced manual errors and improved process consistency in the construction supply chain.**

1 - Strongly Disagree
2 - Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

SECTION 5 CLOUD COMPUTING

1. **Cloud computing has enhanced the accessibility and sharing of real-time information among supply chain stakeholders in the construction industry.**

1 - Strongly Disagree
2 - Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

2. Cloud computing has improved data security and privacy in the construction supply chain.

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

3. **Cloud computing has facilitated seamless collaboration and communication among different stakeholders in the construction supply chain.**

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

SECTION 6 BIG DATA

1. **The utilization of big data analytics in supply chain management has enabled better decision-making and improved operational performance in the construction industry.**

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

2. Big data analytics has improved forecasting and demand planning in the construction supply chain.

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

SECTION 7 INTERNET OF THINGS

1. The implementation of Internet of Things (IoT) technologies in the construction industry has resulted in increased transparency and visibility throughout the supply chain.

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

2. **IoT technologies have improved asset tracking and management in the construction supply chain.**

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

3. **IoT technologies have enabled real-time monitoring and control of construction processes in the supply chain.**

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

SECTION 8 ORGANISATIONAL PERFORMANCE

1. **Overall, the digitization of supply chain processes has positively impacted the organizational performance of construction companies in Pakistan.**

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree
5 - Strongly Agree

2. **The adoption of Supply Chain 4.0 technologies has improved coordination and collaboration between different stakeholders involved in the construction industry.**

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree

5 - Strongly Agree

3. The implementation of Supply Chain 4.0 technologies has reduced the time required to complete construction projects in Pakistan.

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree

4. The use of Supply Chain 4.0 technologies has increased the overall competitiveness of construction companies in Pakistan.

1 - Strongly Disagree
2 – Disagree
3 - Neutral
4 - Agree

5. Overall, do you believe that the adoption of Supply Chain 4.0 is a positive development for the construction industry in Pakistan?

YES
NO

Bahria University
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1st Half Semester Progress Report

Enrolment No.	01-322212-009
Thesis/Project Title	Supply Chain 4.0 and its impact on the organisational performance of Services Sector in Pakistan (An Empirical Investigation from Construction Sector)

Supervisor Student Meeting Record

No.	Date	Place of Meeting	Topic Discussed	Signature of Student
1	20/02	Online	Thesis topic discussion	
2	01/03	Online	Signing of thesis supervisor form	
3	18/03	Office	Submission and verification of Research Proposal	
4	31/03	Online	Chapter – 1 Discussion and guidance	

Progress Satisfactory ☐ Progress Unsatisfactory ☐

Remarks:_____

_____

_____

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_____

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Note: **Students attach 1st & 2nd half progress report at the end of spiral copy.**

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2nd Half Semester Progress Report & Thesis Approval Statement

Enrolment No.	01-322212-009
Thesis/Project Title	Supply Chain 4.0 and its impact on the organisational performance of Services Sector in Pakistan (An Empirical Investigation from Construction Sector)

Supervisor Student Meeting Record

No.	Date	Place of Meeting	Topic Discussed	Signature of Student
5	16/04	Office	Chapter – 2 Discussion and guidance	
6	21/05	Online	Chapter - 3 & 4 Discussion and guidance	
7	28/05	Office	Final Discussion and guidance	

APPROVAL FOR EXAMINATION

I hereby certify that the above candidates' thesis/project has been completed to my satisfaction and, to my belief, its standard appropriate for submission for examination. I have also conducted plagiarism test of this thesis using HEC prescribed software and found similarity index at _____ that is within the permissible limit set by the HEC for thesis/ project MBA/BBA. I have also found the thesis/project in a format recognized by the department of Business Studies.

Signature of Supervisor: _____ Date: _____

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